November 2005

Draft

Vegetation Treatments Using Herbicides

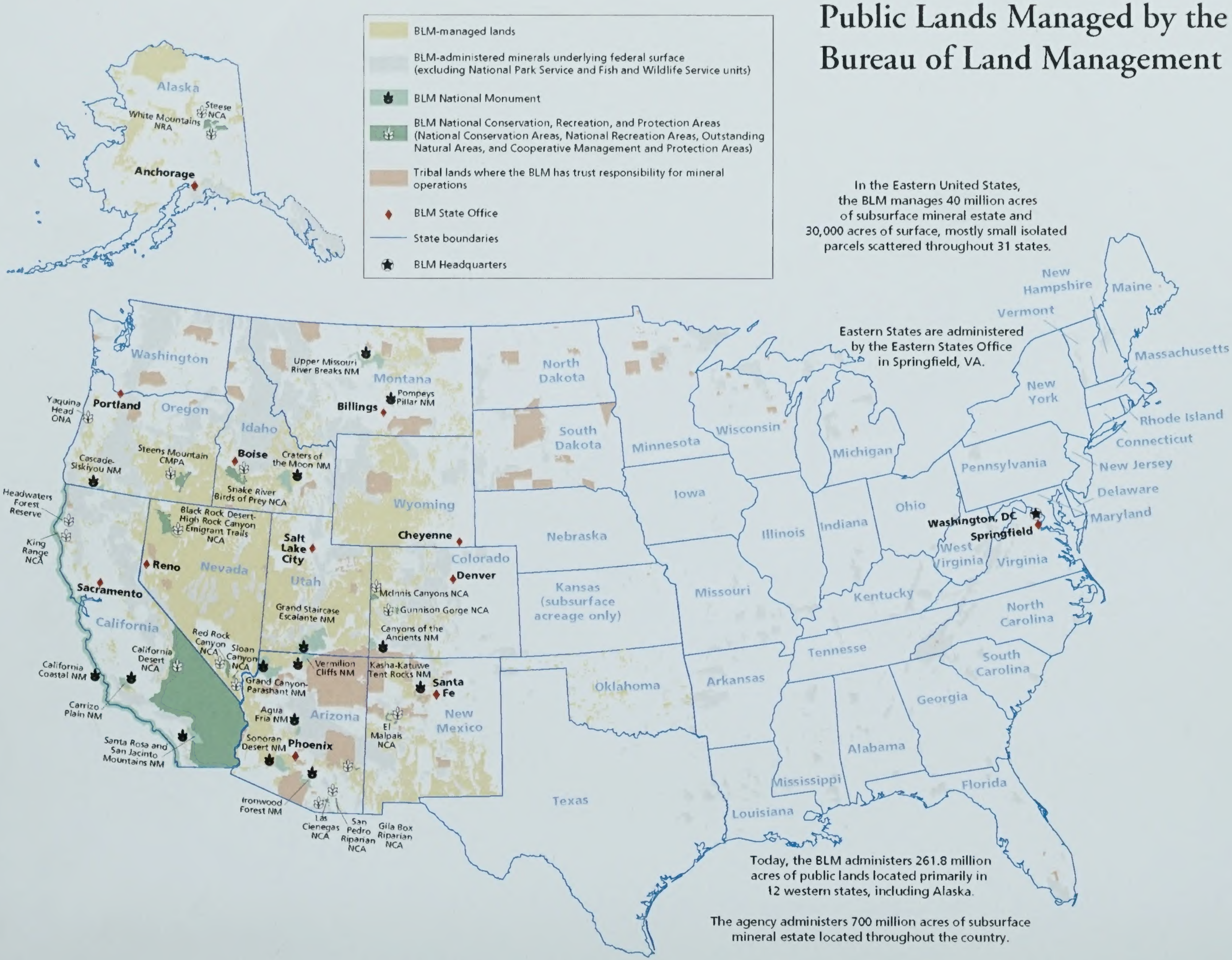
on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement

Volume 1: Abstract, Executive Summary, and Chapters 1 through 8

U.S. Department of the Interior
Bureau of Land Management

DES 05-56

Public Lands Managed by the Bureau of Land Management



In the Eastern United States, the BLM manages 40 million acres of subsurface mineral estate and 30,000 acres of surface, mostly small isolated parcels scattered throughout 31 states.

Eastern States are administered by the Eastern States Office in Springfield, VA.

Today, the BLM administers 261.8 million acres of public lands located primarily in 12 western states, including Alaska.

The agency administers 700 million acres of subsurface mineral estate located throughout the country.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Washington, D.C. 20240
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Dear Reader:

Enclosed for your review and comment is the *Vegetation Treatments Using Herbicides Programmatic EIS on Bureau of Land Management Lands in 17 Western States Programmatic EIS (PEIS)* and the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Report (PER)*. Together these documents assess, on a National level, the BLM's use of herbicides and, describe the environmental impacts of using non-herbicide treatment methods, including fire and mechanical, manual, or biological controls.

The Draft Programmatic EIS details the expected impacts, benefits from the BLM's use of herbicides, and provides analysis to determine which herbicide active ingredients will be approved for use on public lands administered by the BLM in the western United States, including Alaska. In addition to the herbicides currently approved for use, additional active ingredients are being considered for use by the BLM to manage and control unwanted vegetation. The Draft Programmatic EIS also contains a state-of-the-science human and ecological risk assessment methodology in consultation with the Environmental Protection Agency (EPA), the U.S. Fish & Wildlife Service (USF&WS), and the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries). This methodology and protocol will serve as the initial standard for assessing human health and ecological risk when evaluating herbicides for future use.

The Draft Programmatic EIS assesses five alternative approaches to the use of herbicides to treat vegetation on public lands and the Draft Programmatic Environmental Report discloses the predicted impacts of conducting typical vegetation treatments on public lands using other non-herbicide methods as part of an integrated pest management (IPM) approach. Cumulative effects of all methods are assessed in the Draft Programmatic EIS.

Both documents are available for public review and the BLM is interested in your review and comment on the adequacy of these documents. Comments will be accepted during a 60-day comment period ending on January 9, 2006. Public meetings will be announced via regional and local media, including the Federal Register. Comments should be sent to:

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Sincerely

Ed Shepard
Assistant Director

DRAFT

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT VEGETATION TREATMENTS USING HERBICIDES ON BUREAU OF LAND MANAGEMENT LANDS IN 17 WESTERN STATES

(X) DRAFT	( ) FINAL
LEAD AGENCY:	U.S. Department of the Interior Bureau of Land Management Washington Office, Washington, D.C.
PROJECT LOCATION:	Alaska, Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Texas, South Dakota, Utah, Washington, and Wyoming
COMMENTS ON THIS DRAFT PROGRAMMATIC EIS SHOULD BE DIRECTED TO:	Mr. Brian Amme PEIS Project Manager Nevada State Office 1340 Financial Boulevard P.O. Box 12000 Reno, Nevada 89520-0006 Fax: (775) 861-6712 Electronic Mail: vegeis@nv.blm.gov
DATE DRAFT PROGRAMMATIC EIS FILED WITH THE U.S. ENVIRONMENTAL PROTECTION AGENCY:	November 4, 2005
DATE BY WHICH COMMENTS MUST BE POSTMARKED TO THE BLM:	January 9, 2005

ABSTRACT

This Draft Programmatic Environmental Impact Statement (PEIS) analyzes the potential direct, indirect, and cumulative impacts associated with the Bureau of Land Management's use of herbicides on the human and natural environment. An accompanying Draft Programmatic Environmental Report (PER) discloses the potential impacts to vegetation and the environment from utilization of non-herbicide treatment techniques, including, but not limited to, fire, mechanical, manual and biological control methods. Together, herbicide and non-herbicide treatments make up the integrated pest management program that the BLM would apply to approximately 6 million acres annually of public lands in 17 western U.S. states, including Alaska. Alternatives analyzed in the PEIS include the No Action Alternative, or continuation of present management, as outlined in four previous EISs dating from 1986 to 1992. In addition, four action alternatives were evaluated: 1) the Preferred Alternative, which include herbicide treatments on about 932,000 acres annually and adoption of four new herbicides for use on public lands; 2) a no herbicide use alternative; 3) a no aerial spraying alternative; and 4) an alternative that would limit herbicide use to non-acetolactate synthase-inhibiting active ingredients.

RESPONSIBLE OFFICIAL FOR PEIS:	Ed Shepard Associate Director Bureau of Land Management

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Proposed Action and Purpose and Need

The Bureau of Land Management (BLM), an agency of the U.S. Department of the Interior (USDI), administers vegetation on nearly 262 million acres (public lands) in 17 states in the western U.S., including Alaska. Management and control of vegetation on public lands for resource and habitat enhancement is an important function of this agency, including management to reduce the risk of wildfires to people and their property.

The BLM is proposing to treat vegetation on approximately 932,000 acres annually in 17 western states in the U.S., including Alaska, using 14 currently-approved and four new herbicide active ingredients. At present, the BLM treats about 300,000 acres annually using 20 approved herbicides. The proposed action would reduce the risk of catastrophic wildfires by reducing hazardous fuels, restoring fire-damaged lands, and improving ecosystem health by 1) controlling weeds and invasive species; and 2) manipulating vegetation to benefit fish and wildlife habitat, improve riparian and wetlands areas, and improve water quality in priority watersheds.

In recent years, the severity and intensity of wildfires in the West has increased dramatically from levels in the 1970s and 1980s, to a million or more acres annually. Changes in the vegetation on public lands have resulted in increases in hazardous flammable fuels.

Much of the increase in hazardous fuels can be attributed to fire exclusion policies over the past 100 years. Contributors to the change include intermittent- and long-term drought over the past 40 years and an increase in the spread of noxious weeds species and invasive vegetation. Invasive vegetation and noxious weeds are the dominant vegetation on an estimated 35 million acres of public lands. Invasive vegetation and noxious weeds threaten soil productivity, water quality and quantity, native plant communities, wildlife habitat, wilderness values, recreational opportunities, and livestock forage, and are detrimental to the agriculture and commerce of the U.S. and to public health.

In response to the threats of wildfire and invasive vegetation and noxious weeds, the President and Congress have directed the USDI and BLM, through implementation of the *National Fire Plan*, and the *Healthy Forests Restoration Act of 2003*, to take more aggressive actions to reduce catastrophic wildfire risk on public lands. The actions would be taken to protect life and property, and to manage vegetation in a manner that provides for long-term economic sustainability of local communities, improved habitat and vegetation conditions for fish and wildlife, and other public land uses.

The BLM last assessed its use of vegetation treatment methods during the late 1980s and early 1990s, by preparing Environmental Impact Statements (EISs) and Record of Decisions (RODs) that covered vegetation treatment activities in 14 western states in the continental U.S. These EISs evaluated the environmental impacts associated with vegetation control and modification from use of herbicides, in addition to other treatment methods—manual, mechanical, and biological control methods, and use of fire, on approximately 500,000 acres of public lands a year in the western U.S. The EISs also evaluated the human health and non-target species risks of using 20 herbicide active ingredients on these public lands.

This *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS* (PEIS) has two primary objectives:

- Determine which herbicide active ingredients are available for use on public lands in the western U.S., including Alaska, to improve the agency's ability to control hazardous fuels and unwanted vegetation. In addition to the herbicides currently approved for use, additional active ingredients are being considered for use by the BLM in order to address emerging weed problems associated with public lands, such as downy brome (cheatgrass) and invasive aquatic species.

- In consultation with the U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration National Marine Fisheries Service, develop a state-of-the-science human health and ecological risk assessment (ERA) methodology. This methodology would serve as the initial standard for assessing human health and ecological risk for herbicides that may become available for use in the future.

The BLM has also prepared a *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Report* (PER) describing the environmental impacts of using non-herbicide vegetation treatment methods on public lands. This organization was selected because the primary issue of controversy identified through scoping, and which required National Environmental Policy Act (NEPA) review, was the BLM's continuing and proposed increase in the use of herbicides in vegetation treatment programs needed to implement the *National Fire Plan* and related initiatives. The use of herbicides has been affirmed as a central issue for analysis in all past EISs considered in this document. The use of the other non-herbicide techniques in an integrated pest management approach has also been affirmed in all previous EISs, and the BLM is not proposing to make any decisions relative to the use of non-herbicide vegetation treatment methods.

Alternative Proposals

Five program alternatives were developed and evaluated for this PEIS, including the Preferred Alternative and the No Action Alternative. Alternative actions were developed that 1) allow the BLM to continue its current use of 20 active ingredients in 14 western states, as authorized by earlier EIS RODs; 2) allow for the use of 14 active ingredients currently used by the BLM and four new active ingredients; 3) prohibit the use of herbicides; 4) prohibit the aerial application of herbicides; or 5) prohibit the use of sulfonylurea and other acetolactate synthase-inhibiting active ingredients. These program alternatives address many of the concerns raised during scoping, in particular the public's desire to see alternatives that have less emphasis on the use of herbicides, while still meeting the program's purpose and need. Alternatives were also developed to ensure that the BLM complied with federal, tribal, state, and local regulations.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under this alternative, the BLM would be able to continue to use 20 active ingredients approved for use in 14 western states under the earlier EIS RODs for each state. The BLM would also continue activities conducted under Emergency Stabilization and Rehabilitation and hazardous fuel reduction that are evaluated by NEPA compliance documents prepared by local BLM field offices. Under this alternative, an estimated 305,000 acres would be treated annually using herbicides.

Alternative B - Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

This alternative represents the treatment of vegetation using herbicides in 17 western states, including Alaska, Nebraska, and Texas, states that were not included in the earlier EIS assessments. Under the Preferred Alternative, approximately 932,000 acres would be treated annually using herbicides, based on the herbicide use projections developed by BLM field offices. Based on these projections, the majority of treatments would occur in Nevada, Idaho, Oregon, and Wyoming.

Under the Preferred Alternative, the BLM would only be able to use 14 active ingredients in the western U.S., including Alaska, that were approved for use in the earlier RODs and for which an analysis of risks to humans and non-target plants and animals was conducted for this PEIS or by the U.S. Department of Agriculture Forest Service (Forest Service). These active ingredients are 2,4-D, bromacil, chlorsulfuron, clopyralid, dicamba, diuron, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, sulfometuron methyl, tebuthiuron, and triclopyr. The remaining six active ingredients currently approved for use by the BLM—2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine—have not been used by the BLM for several years, or their use has been limited to a very small number of acres. Although the risks to humans from the use of these chemicals are not significant based on evaluations done for the earlier EISs and a review of the literature for this PEIS, the risks to non-target plants and animals, especially species of concern, have not been adequately evaluated. Under this alternative, their use would be discontinued. Should these chemicals be needed by the BLM in the future, the BLM would consult ERAs for these active ingredients, if available, or conduct their own ERAs, to assess the risks to non-target and sensitive species. This analysis would be supported by the appropriate NEPA documentation before these chemicals would be approved for use.

The BLM would approve for use four additional active ingredients in all 17 states included in this PEIS: imazapic, diquat, diflufenzopyr (in formulation with dicamba), and fluridone. In addition, the BLM would approve diflufenzopyr for use in the future as a stand-alone active ingredient if it becomes registered for herbicidal use. These active ingredients and formulations could only be applied for uses, and at application rates, specified on the label directions.

Under the Preferred Alternative, the BLM proposes to use new active ingredients that are developed in the future if: 1) they were registered by the USEPA for use on one or more land types (e.g., rangeland, aquatic) managed by the BLM; 2) the BLM determined that the benefits of use on public lands outweighed the risks to human health and the environment; and 3) they met evaluation criteria to ensure that the decision to use the active ingredient was supported by scientific evaluation through human health and ecological risk assessments and NEPA documentation.

Alternative C - No Use of Herbicides

Under Alternative C, the BLM would not treat vegetation using herbicides and would not use new chemicals that are developed in the future. The BLM would continue to treat vegetation using fire, and mechanical, manual, and biological control methods. A PER has been prepared that accompanies this PEIS and discusses these treatment methods, proposed treatment levels during the next 10 to 15 years, and likely impacts to natural and social resources on public lands from these treatment methods.

Alternative D - No Aerial Applications

This alternative is similar to the Preferred Alternative in that it represents the treatment of vegetation using herbicides in 17 western states, including Alaska, Nebraska, and Texas, and use of the same active ingredients as allowed under the Preferred Alternative. Under Alternative D. However, only ground-based techniques would be used to apply herbicides and no aerial applications of herbicides would be allowed, which would reduce the risk of spray drift impacting non-target areas. Based on information obtained from field offices, an estimated 55% of herbicide treatments would occur using ground-based methods during the next 10 years. Thus, the BLM would treat approximately 530,000 acres annually using herbicides under this alternative. In comparison, during 2001 to 2003, approximately 55% of herbicide treatments were conducted aerially and 45% using ground-based methods.

Similar to the Preferred Alternative, the BLM would use new active ingredients developed in the future if they followed protocols for use of new active ingredients identified under the Preferred Alternative.

Alternative E - No Use of Acetolactate Synthase-inhibiting Herbicides

This alternative was developed based on an alternative proposal for vegetation management on public lands submitted by the American Lands Alliance, an alliance of several environmental and conservation groups.

Under Alternative E, the BLM would not use sulfonylurea and other acetolactate synthase-inhibiting active ingredients approved in the earlier RODs, which are chlorsulfuron, imazapyr, metsulfuron methyl, and sulfometuron methyl. During 1999 to 2000, these active ingredients comprised approximately 28% of the active ingredients used by the BLM. Since 2001, however, these active ingredients have comprised approximately 8% of the active ingredients used by the BLM. The BLM would be able to use 10 active ingredients in the 17 western states that were approved for use in the earlier RODs and for which an analysis of their risks to humans and non-target plants and animals was conducted for this PEIS. These active ingredients are: 2,4-D, bromacil, clopyralid, dicamba, diuron, glyphosate, hexazinone, picloram, tebuthiuron, and triclopyr. The six other active ingredients currently approved for use by the BLM—2,4-DP, atrazine, asulam, fosamine, mefluidide, and simazine—would not be used unless guidelines given for the Preferred Alternative were met.

The BLM would be allowed to use three additional active ingredients in all 17 states: diquat, diflufenzopyr (if it becomes registered for herbicidal use), and fluridone. In addition, the BLM would be able to use a formulation of diflufenzopyr and dicamba. These active ingredients and formulations could only be applied for uses, and at application rates, specified on the label directions. Under Alternative E, the BLM would use new active ingredients developed in the future if they followed protocols for use of new active ingredients identified under the Preferred Alternative and did not contain sulfonylurea and imidazolinone chemistry and other acetolactate synthase-inhibiting compounds.

Under this alternative, the BLM would treat approximately 466,000 acres annually using herbicides. Spot herbicide treatments would be favored over broadcast treatments. Herbicides use would be discouraged in areas populated by amphibians. To protect Native American and Alaska Native resources, the BLM would establish herbicide-free zones around culturally significant plant and wildlife resources. This alternative would place greater emphasis on passive restoration.

Summary of Impacts

The direct and indirect effects of herbicide treatment alternatives on natural and socioeconomic resources are evaluated in this PEIS. The cumulative effects that result from the incremental impact of treatment actions when added to the effects of other past, present, and reasonably foreseeable future actions are also evaluated for herbicide and non-herbicide treatments. Standard operating procedures would be used to reduce impacts, and mitigation measures have been proposed to reduce significant adverse impacts to more reasonable levels.

Direct and Indirect Impacts

In general, potential direct and indirect adverse impacts and benefits would be greatest under the Preferred Alternative and least under Alternative C. Fewer acres would be treated, or treatments would not be conducted aerially, under the other herbicide treatment alternatives, so risks and benefits would be intermediate between the Preferred Alternative and Alternative C.

Impacts from herbicide treatments on local and regional air quality would be minor for all alternatives. Pollutant emissions would be greater under Alternative D than the Preferred Alternative, even though 40% fewer acres would be treated under Alternative D. None of the treatments would result in emissions that exceed Prevention of Significant Deterioration thresholds or National Ambient Air Quality Standards.

None of the herbicides commonly used by the BLM appears to result in adverse impacts to soil. Treatments would benefit soil by restoring natural fire regimes and slowing the spread of weeds, which should reduce soil erosion and improve soil productivity. New herbicides proposed for use have little adverse impact on soil.

Several herbicides used, or proposed for use by the BLM, are known groundwater contaminants. Effects to surface water would be minor and herbicide concentrations in surface water should not exceed safe levels for human health. Herbicide use would improve watershed function and water quality, since many treatments would be targeted for watersheds where water quality does not meet state or tribal standards. Adverse and beneficial impacts of alternatives would primarily be related to number of acres treated. Water quality would not be impacted by herbicides under Alternative C, but land health would deteriorate more rapidly than under the other herbicide treatment alternatives because herbicides could not be used to control some weeds.

Herbicides pose risks to terrestrial and aquatic vegetation. Most aquatic herbicides and several terrestrial herbicides, are non-selective and could adversely impact non-target vegetation. Accidental spills and herbicide drift from treatment areas could be particularly damaging to non-target vegetation, including croplands and other vegetation found on privately-owned lands near treatment areas. Herbicides would help to control aquatic vegetation that chokes waterways and impacts wetland function and values. Upland and riparian area treatments could control weeds and other vegetation to reduce soil erosion and reduce the risk of catastrophic fire. Risks to upland, wetland, and riparian vegetation from proposed herbicides would be similar to, or less than, risks from currently-available herbicides. Adverse impacts from herbicides to terrestrial and aquatic vegetation would be least under Alternative C, while benefits would be greatest under the Preferred Alternative. Buffer zones would be used to reduce the risks to vegetation from herbicide treatments.

Many of the herbicides currently available for use by the BLM pose risks to fish and wildlife. Accidental spills and direct spraying of aquatic organisms could kill or harm animals, or affect the health and behavior of animals. Fish and wildlife could also forage on vegetation that has been treated, or prey on other animals that have been exposed to herbicides, and be harmed. All of the herbicides pose some risk to non-target terrestrial and aquatic vegetation, and damage to these plants could adversely impact habitats used by fish and wildlife. Acetolactate synthase-inhibiting herbicides are highly potent and can damage plants at low application rates, but do not appear to create unnecessary risks to aquatic organisms or wildlife. Of the new herbicides proposed for use, diquat poses low to high risk to aquatic organisms and wildlife, depending upon application rate and receptor scenario; fluridone, imazapic, and Overdrive® (a formulation of dicamba and diflufenzopyr) pose little or no risk to aquatic organisms and wildlife. Threatened, endangered, and sensitive (TES) aquatic organisms and wildlife would be at slightly greater risk from herbicides than non-TES species, especially under accidental spill and maximum application rate scenarios. Buffers would be used between treatment areas and habitats to reduce risks from use of herbicides to aquatic organisms.

Livestock and wild horses and burros could be impacted by herbicides from an accidental spill, direct spray, herbicide drift, or by consuming herbicide-treated vegetation. Effects to animals could include death, damage to vital organs, decrease in growth, decrease in reproductive output and condition of offspring, and increased susceptibility to predation. However, most herbicides currently available for use by the BLM pose little or no risk to these animals. Of the new herbicides proposed for use, only diquat is fairly toxic to livestock and wild horses and burros. However, it would be used by the BLM as an aquatic herbicide, and frequent exposure to these animals would be unlikely. Risks from exposure to herbicides for livestock would be further reduced by restrictions placed on livestock use of treated areas as directed on herbicide labels.

While herbicide treatments could affect cultural or paleontological resources near or on the surface, they would be more likely to affect traditional cultural practices of gathering plants and the health of Native peoples. Cultural and paleontological resources could be impacted by equipment, and to a lesser extent, by the chemicals in herbicides. A risk assessment was conducted to assess the risks to Native peoples from harvesting plants that could be treated with herbicides, or from direct exposure to herbicide spray. Native peoples would be exposed to risk when picking berries in areas treated with diquat. They could also face risk when consuming fish contaminated with 2,4-D, hexazinone, or picloram. Native peoples face risk from diquat or fluridone when they are accidentally spilled or used at maximum application rates.

Herbicide treatments could affect visual, wilderness, and recreation resources. Treatments would remove and discolor vegetation, making it less visually appealing. Over the long term, landscapes should be more appealing as native vegetation was restored. Treatments in wilderness and other special areas would detract from the "naturalness" of the area. Although use of mechanical equipment would be strongly discouraged in these areas, its use would create noise and reduce the wilderness experience. Recreationists could be exposed to herbicides, experience less visually-appealing landscapes, or find fish and game less plentiful as a result of treatments. In addition, recreational areas could be closed for short periods of time after application to ensure treatment success and protect the health of visitors.

Social effects would be minor at the scale addressed in the PEIS. There would be benefits to communities that supply workers, materials, or services in support of treatment activities. Some businesses, such as recreation-based businesses and ranching operations, could be adversely affected if treatments closed areas used for recreation or by domestic livestock. There are potential environmental justice concerns because a large number of Native peoples and other minority groups live in the West and work in industries (e.g., forest products, herbicide applicator) or conduct activities (e.g., gathering of plants for traditional uses, recreation) that could potentially expose these groups to treated areas.

A human health risk assessment was conducted to assess risks to humans from the use of herbicides. At typical application rates, workers would not be at risk from use of herbicides except when using diquat, 2,4-D, 2,4-DP, atrazine, bromacil, diuron, fosamine, hexazinone, mefluidide, simazine, or tebuthiuron. At maximum application rates, there are also risks associated with the use of chlorsulfuron, fluridone, and triclopyr. Public receptors would be at less risk. The BLM would not use 2,4-DP, atrazine, fosamine, mefluidide, or simazine under the action alternatives. Except for diquat, new herbicides proposed for use pose few or no risks to workers or the public. To reduce risks from diquat, treatments would occur away from high residential and subsistence use areas.

Cumulative Impacts

Treatments would contribute only minor amounts of pollutants to the air. Fire use would increase particulate matter in the air, but the amount of pollutants generated by fire use, and their effects on human health, should be less than those from wildfire, resulting in fewer pollutants accumulating than would occur without treatments. Treatments would lead to cumulative loss of soil from removal of vegetation and erosion, but improvement in vegetative quality should slow soil loss on public lands. Erosion has led to poor water quality on portions of public lands. Treatments that slow erosion would also benefit water quality and slow the cumulative loss of water quality. Over half of wetlands in the U.S. have been lost since settlement by Europeans. Treatments would improve wetland and riparian area functions and values and slow erosion, which contribute to wetland degradation on public lands. As these areas improved, habitat for fish and other aquatic organisms would also improve. However, many anadromous fish spend part or most of their lives off of public lands, and thus would potentially have to cope with poorer quality habitat while off of public land.

Fire suppression and the spread of weeds have degraded vegetation function and quality on public land and have led to a cumulative loss of vegetative productivity. Treatments would restore ecosystem processes and slow this loss. Improvement in vegetation characteristics would benefit wildlife. Some species that have adapted to degraded ecosystems could lose habitat as native vegetation was restored, but most species would benefit. Factors that have led to the loss of native vegetation and ecosystem health have also adversely impacted rangelands used by domestic livestock and wild horses and burros. Although the number of domestic livestock and wild horses and burros that public lands can support has declined from historic levels, treatments should improve rangelands for these animals, and ensure that public lands can support viable populations of wild horses and burros and a healthy ranching industry.

Treatments could add to the cumulative loss of paleontological and cultural resources, but risks would be low. Treatments could impact plants used by Native peoples for traditional lifeway uses, and the health of Native peoples. However, the BLM would use herbicides that are generally safe for use around people, and would conduct pre-treatment surveys to identify areas of cultural concern before conducting treatments to reduce the cumulative loss of these values.

Treatments would result in some short-term and temporary loss of visual, recreational, and wilderness and other special area values due to vegetation being killed or discolored. In some cases, areas may be closed to visitors during and after treatments; however, these impacts would be short-term and any values affected would be restored within two growing seasons in most cases.

Treatments would benefit local communities by providing jobs and income, and by reducing the risk of catastrophic wildfire that could harm people and destroy property. These gains would be minor in the context of the western economy, but would still be a cumulative benefit for many rural communities.

Treatments could harm the health of workers and the public. Most herbicides, however, would pose few risks to workers, and even fewer risks to the public, when applied at the typical application rate. New herbicides proposed for use pose few or no risks, except for diquat. If treatments restored natural fire regimes, reduced the risk of catastrophic fire, and slowed the spread of weeds, human health would benefit.

Treatments could result in short-term irreversible loss of some resources, including soil, vegetation, wildlife, and livestock forage opportunities. Over the long term, loss of resource values would be slowed, and in some cases, would be reversed. Short-term losses in resource functions would be compensated for by long-term gains in ecosystem health.

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CHAPTER 1

PROPOSED ACTION AND PURPOSE AND NEED

Introduction

The Bureau of Land Management (BLM), an agency of the U.S. Department of the Interior (USDI), administers vegetation on nearly 262 million acres (public lands) in 17 states in the western U.S., including Alaska (Map 1-1). These lands encompass approximately 1 out of every 5 acres from the Rocky Mountains to the Pacific Ocean. Management and control of vegetation for resource and habitat enhancement is accomplished using a variety of treatment methods, including, but not limited to: herbicides, prescribed fire and wildland fire use for resource benefit (collectively termed "fire use"), manual and mechanical methods, and biological controls such as insects, pathogens, fish, and domestic grazing animals.

In recent years, the severity and intensity of wildfires in the West has increased dramatically from levels in the 1970s and 1980s. Although the recent increase in wildfires is directly related to drought conditions throughout the western U.S., it is also influenced by changes in the vegetation on public lands that have occurred during the past 50 years and have resulted in increases in hazardous flammable fuels. As the population has increased in the western U.S., the loss of life and property has also increased as more people live in close proximity to public lands in areas now referred to as the wildland urban interface (WUI).

Much of the change in the vegetation on public lands and increase in hazardous fuels can be attributed to fire exclusion policies over the past 100 years. Contributors to the change include intermittent- and long-term drought over the past 40 years and an increase in the spread of noxious weeds species and invasive vegetation. Invasive vegetation and noxious weeds are highly competitive and can often out-compete native vegetation, especially on recently disturbed sites. Invasive vegetation and noxious weeds are the dominant vegetation on an estimated 35 million acres of public lands (USDI BLM 2000a). Invasive vegetation and noxious weeds threaten soil productivity, water quality and quantity, native plant communities, wildlife habitat, wilderness values, recreational opportunities, and livestock forage, and are detrimental to the agriculture and commerce of the U.S. and to public health (National Academy of Sciences 1968, USDI BLM 2000b).

In response to the threats of wildfire and invasive vegetation and noxious weeds, the President and Congress have directed the USDI and BLM, through implementation of the *National Fire Plan* (USDI and U.S. Department of Agriculture [USDA] Forest Service 2001), and the *Healthy Forests Restoration Act of 2003*, to take more aggressive actions to reduce catastrophic wildfire risk on public lands. The actions would be taken to protect life and property, and to manage vegetation in a manner that provides for long-term economic sustainability of local communities, improved habitat and vegetation conditions for fish and wildlife, and other public land uses.

As a result of these actions, the amount of hazardous fuels reduction and other vegetation management work conducted by the BLM are expected to increase from current levels, and about 15% of this work will involve the use of herbicides.

The BLM last assessed its use of vegetation treatment methods during the late 1980s and early 1990s, by preparing Environmental Impact Statements (EISs) and Record of Decisions (RODs) that covered vegetation treatment activities in 14 western states in the continental U.S. (all states shown on Map 1-1, except Alaska, Nebraska, and Texas; USDI BLM 1985a; 1987a, b; 1988a, b; 1989a; 1991a, b; 1992a). The previous EISs primarily focused on vegetation control of competing and unwanted vegetation for resource enhancement (forestry and rangelands), noxious and invasive weed control related to surface use activities (oil and gas, rights-of-way [ROW]), and reduction of hazardous fuels to protect resources at risk from wildfire damage. These EISs evaluated the environmental impacts associated with vegetation control and modification on approximately 500,000 acres of public lands a year in the western U.S. The EISs also evaluated the human health and non-target species risks of using 22 herbicide active ingredients on these public lands.

The impacts of the proposed increased level of vegetation treatments related to the use of herbicides are likely to be greater in magnitude than the impacts assessed in earlier vegetation treatment assessments prepared by the BLM for the western states. In addition, the BLM has identified several new herbicides that it would like to use that are more effective in treating certain types of vegetation than currently approved herbicides. Thus, the BLM has determined that the potential for increased use of herbicides, and approval for use of additional herbicides on public lands, requires further assessment under the National Environmental Policy Act (NEPA).

Organization of the Vegetation Treatments Assessments

The BLM's assessment of vegetation treatment activities on public lands consists of two inter-related parts—a *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS* (PEIS) addressing the BLM's use of herbicides, and a *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Report* (PER; USDI BLM 2005a) describing the environmental impacts of using non-herbicide vegetation treatment methods on public lands. This organization was selected based on the fact that the primary issue of controversy identified through scoping, and which required NEPA review, was the BLM's continuing and proposed increase in the use of herbicides in vegetation treatment programs needed to implement the *National Fire Plan* and related initiatives. The use of herbicides has been affirmed as a central issue for analysis in all past EISs considered in this document.

The use of the other non-herbicide techniques in an integrated pest management approach has also been affirmed in all previous EISs, and the BLM is not proposing to make any decisions relative to the use of non-herbicide vegetation treatment methods.

Specifically, this PEIS analyzes the effects of herbicide use on humans, plants, and animals and other environmental and social resources associated with public lands. This analysis will provide the basis for a programmatic Endangered Species Act (ESA) Section 7 consultation with the U.S. Fish and Wildlife Service

Terminology

Active ingredient (a.i.) is the chemical or biological component that kills or controls the target pest.

Fire use is the combination of prescribed fire and wildland fire use for resource benefit to meet resource objectives.

Hazardous fuels include living and dead and decaying vegetation that form a special threat of ignition and resistance to control.

Herbicide is a chemical pesticide used to treat vegetation.

Invasive plants are plants that are not part of (if exotic), or are a minor component of (if native), the original plant community or communities that have the potential to become a dominant or co-dominant species on the site if their future establishment and growth are not actively controlled by management interventions, or are classified as exotic or noxious plants under state or federal law. Species that become dominant for only one to several years (e.g. short-term response to drought or wildfire) are not invasive plants.

Native species historically occurred or currently occur in a particular ecosystem and were not introduced.

Noxious weeds are designated by federal or state law as generally possessing one or more of the following characteristics: aggressive and difficult to manage; parasitic; a carrier or host of serious insects or disease; or non-native, new, or not common to the U.S.

Prescribed fires are management ignited wildland fires that burn under specified conditions and in predetermined areas, and that produce the fire behavior and fire characteristics required to attain fire treatment and resource management objectives.

Undesirable plants are species classified as undesirable, noxious, harmful, exotic, injurious, or poisonous under state or federal law, but not including species listed as endangered by the ESA, or species indigenous to the planning area.

Weeds are plants that interfere with management objectives for a given area at a given point in time.

Wildfires are unplanned fires in wildlands.

Wildland fires occur on the wildlands, regardless of ignition source, damages, or benefits, and include wildfire and prescribed fire.

Wildland fire use for resource benefit is a fire ignited by lightening but allowed to burn within specified conditions of fuels, weather, and topography, to achieve specific objectives.

Wildland urban interface (WUI) is an area where structures and other human development intermingle with undeveloped wildlands or vegetative fuels.

(USFWS) and National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) on herbicide use, and the potential impacts of herbicide use on plant and animal species of concern.

The PER discloses the general impacts on the environment of using non-herbicide treatment methods, including fire use, and mechanical, manual and biological control methods, to treat hazardous fuels, invasive species, and other unwanted or competing vegetation. The PEIS provides an updated analysis of impacts (direct, indirect, and cumulative) to public land environmental and socioeconomic resources from proposed vegetation treatment activities utilizing herbicides. The PER is linked to the PEIS in the cumulative impact analysis of the PEIS, where all methods of treatment, including the use of herbicides, are assessed.

Proposed Action

To maintain and improve the effectiveness of its vegetation management practices, the BLM proposes to:

- Determine which herbicide active ingredients are available for use on public lands in the western U.S., including Alaska, to improve the agency's ability to control hazardous fuels and unwanted vegetation. In addition to the herbicides currently approved for use, additional active ingredients are being considered for use by the BLM in order to address emerging weed problems associated with public lands, such as downy brome (cheatgrass)[1] and invasive aquatic species; and
- In consultation with the U.S. Environmental Protection Agency (USEPA), USFWS, and NOAA Fisheries, develop a state-of-the-science ecological risk assessment (ERA) methodology. This methodology will serve as the initial standard for assessing human health and ecological risk for herbicides that may become available for use in the future.

Actions related to the use of herbicides are addressed in this PEIS. Actions related to the use of other treatment methods are addressed in the PER.

[1] Common and scientific names of plants and animals given in this EIS are provided in Appendix A.

In order to ensure that the agency fulfills its responsibility for protection of the public, Native American and Alaska Native subsistence practices, public land workers, and federally-listed species, species proposed for listing, and BLM special status species, a risk assessment was conducted (see appendices B and C). The assessment consisted of a comprehensive literature search, and in some cases new toxicological analyses, for (1) active ingredients currently in use to determine if there are new human health and ecological health risks that have been identified since the chemicals were last assessed (1988–1992); and (2) active ingredients proposed for use by the BLM. This risk assessment was used in the assessment of the human health and environmental effects of the various alternatives. In addition, the BLM developed a risk assessment methodology to be used for analyses of herbicides proposed for use in the future (Appendix D). This methodology is based upon the methodology used for the risk assessments for this PEIS.

Purpose and Need for the Proposed Action

The purposes of the proposed action are to provide BLM personnel with the herbicides available for vegetation treatment on public lands and to describe the conditions and limitations that apply to their use. The need for the proposed action is to reduce the risk of catastrophic wildfires by reducing hazardous fuels, restoring fire-damaged lands, and improving ecosystem health by 1) controlling weeds and invasive species, and 2) manipulating vegetation to benefit fish and wildlife habitat, improve riparian and wetlands areas, and improve water quality in priority watersheds.

Additional benefits accruing from implementation of the proposed action directly relate to restoration of fish and wildlife habitat and improvement of forest and ecological condition, which would meet BLM and USDI objectives set forth in the *Healthy Forests Restoration Act of 2003* and BLM Handbook H-4180-1 (*Rangeland Health Standards*) to improve the health of the nation's forests and rangelands.

Decisions to be Made and Scope of Analysis

This PEIS analyzes the effects of using herbicides for treating vegetation on public lands in the western U.S., including Alaska. These lands include Oregon and

California Land Grant lands, Coos Bay Wagon Road lands, and lands administered by the BLM through its National Landscape Conservation System (NLCS), such as Wilderness Study Areas (WSA), designated Wilderness Areas, National Monuments, National Conservation Areas, National Recreation Areas, and areas of critical environmental concern.

Decisions expected to be made through this PEIS process include:

- Which USEPA-registered herbicides will be available for use by the BLM and under what circumstances?
- Which vegetation management practices could be used with applications of herbicides and under what circumstances?

This PEIS makes broad assumptions on the numbers of acres to be treated annually by herbicides by each state or in aggregate on a national scale to assist with the impacts analysis. Because of the broad nature of this PEIS and the uncertainty associated with timing and location of treatments on a national scale, specific levels of acres to be treated by any method are appropriately assessed at the regional, state, or local level. For meaningful NEPA analysis, the BLM assesses the overall acres to be treated by each resource program in its land use plan (LUP) EISs (see description of BLM resource programs in Chapter 2), thus these decisions will be made at a later time and at a more site-specific level.

Scope of Analysis

The focus of this PEIS is to provide an analysis of the expected increased use of herbicides related to implementing mandates to reduce hazardous fuels and manage and control vegetation affecting other resources. This PEIS does not, however, evaluate vegetation treatment activities involving herbicides that are not directly related to the need to reduce hazardous fuels, or to modify the vegetation community to improve rangeland and/or forestland health.

Thus, this PEIS does not evaluate vegetation management that is primarily focused on commercial timber or other forest product enhancement or use activities that are not related to improving forest or rangeland health or work authorized under the *Healthy Forests Restoration Act of 2003*.

Commercial timber activities conducted with the primary purpose of providing a sustained yield of timber volume to commercial industries are not included in this PEIS or the associated PER. Rather, they represent a manner of vegetation harvest (i.e., the species [product] is removed and replanted for future harvest). Commercial timber allocations and sustainable harvest were previously analyzed in BLM LUP EISs for the field offices with timber programs.

This PEIS does not evaluate policies and programs associated with land use activities authorized by the BLM, such as livestock use, off-highway vehicle (OHV) use, and timber harvesting, and does not make land use allocations nor amend approved LUPs (Federal Register 2002).

Although this PEIS addresses herbicide use in relation to vegetation treatments, it does not address vegetation treatments exclusively designed to increase forage production or the effects of livestock grazing on vegetation. The effects on vegetation that result from livestock forage use on public lands were analyzed in previous EISs, both programmatically at the national level (USDI BLM and USDA Forest Service 1994) and at the local land use planning level, in either LUP EISs or as individual EISs or Environmental Assessments (EAs) at the field office level, as well as at the allotment-specific level.

This PEIS does not address abandoned mine land reclamation, or energy production. Abandoned mine land reclamation is a form of site stabilization and remediation that does not necessarily involve vegetation treatment activities, although in some cases vegetation treatments may be associated with site stabilization. The scope of analysis for the overall use of herbicides, and other methods of control outlined in the PER associated with this PEIS, would sufficiently cover their use in these types of activities.

This PEIS addresses the use of chemical herbicides in general. Herbicides are also commonly used to control vegetation by those authorized to use public lands for ROW, lease holdings, oil and gas facilities, and other mineral developments. In many cases, the control of vegetation is stipulated in the ROW, lease, or authorizing permit. These permits and authorizations are issued in conjunction with a site-specific NEPA compliance document (EA or EIS), which assess the impacts of the control method, and identifies mitigation to reduce development impacts on the environment.

At least 30 days after the USEPA publishes the Notice of Availability (NOA) of the final PEIS, the BLM decision-maker will evaluate public comment on the draft and final PEIS and prepare a ROD. The decision may be to select one of the alternatives in its entirety, or to combine features from several alternatives that fall within the range of alternatives analyzed in the PEIS. The ROD will address significant impacts, alternatives, environmental preferences, and relevant economic and technical considerations.

Documents that Influence the Scope of the PEIS

Much of the scope of this PEIS is based on several EISs that were prepared from 1985 through 1992 to evaluate the use of herbicides for vegetation treatment activities on public lands. These EISs include: *Northwest Area Noxious Weed Control Program EIS* (USDI BLM 1985a), *Supplement to the Northwest Area Noxious Weed Control Program* (USDI BLM 1987b), *California Vegetation Management Final EIS* (USDI BLM 1988a), *Final EIS Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a), and *Final Record of Decision Western Oregon Program-Management of Competing Vegetation* (USDI BLM 1992a).

These documents identify vegetation treatment activities involving the use of herbicides in 14 western states and evaluate the risks of using 22 herbicide active ingredients. Where appropriate, information in these documents that is relevant to analysis of the current proposal is cited and incorporated by reference.

Other documents and policies that influence the scope of this PEIS include: *Protecting People and Sustaining Resources in Fire Adapted Ecosystems: A Cohesive* Strategy (USDA Forest Service 2000); *National Fire Plan* (USDI and USDA 2001); *Interagency Burned Area Emergency Stabilization and Rehabilitation Handbook* (H-1742-1; USDA and USDI 2001); *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-Year Comprehensive Strategy Implementation Plan* (USDI and USDA 2002); and Chapter 3 (Interagency Burned Area Emergency Stabilization and Rehabilitation in BLM Manual 620 *Wildland Fire Management* (USDI BLM 2004b). These documents provide policy and guidance for hazardous fuels reduction and land restoration activities to reduce the risk of wildfires and restore fire-adapted ecosystems, and to rehabilitate and restore lands damaged by wildfires. The *Meeting the Invasive Species Challenge Management Plan* (National Invasive Species Council 2001) and *Partners Against Weeds-An Action Plan for the BLM* (USDI BLM 1996) identify appropriate actions to control weeds on public lands.

Numerous other BLM manuals and handbooks were also consulted when developing the PEIS. These are listed in Appendix E.

Relationship to Statutes, Regulations, and Policies

Federal Laws, Regulations, and Policies that Influence Vegetation Treatments

Several federal laws, regulations, and policies guide BLM management activities on public lands. The ***Federal Land Policy and Management Act of 1976 (FLPMA)*** directs the BLM to manage public lands "in a manner that will protect the quality of scientific, scenic, historic, ecological, environmental, air and atmospheric, water resources and archeological values" and to develop resource management plans (RMP) consistent with those of state and local governments to the extent that BLM programs also comply with federal laws and regulations. The ***Taylor Grazing Act of 1934*** introduced federal protection and management of public lands by regulating grazing on public lands. The ***Oregon and California Grant Lands Act of 1937*** provides for the management of the revested Oregon and California and reconveyed Coos Bay Wagon Road grant lands for permanent forest production under the principle of sustained yield and for leasing of lands for grazing. Two weed control acts, the ***Carlson-Foley Act of 1968*** and the ***Plant Protection Act of 2000*** (Public Law 106-224; includes management of undesirable plants on federal lands) authorize the BLM to manage noxious weeds and to coordinate with other federal and state agencies in activities to eradicate, suppress, control, prevent, or retard the spread of any noxious weeds on federal lands. The ***Public Rangelands Improvement Act of 1978*** requires the BLM to manage, maintain, and improve the condition of the public rangelands so that they become as productive as feasible.

The BLM must comply with numerous federal laws that govern activities on public lands. ***The Clean Air Act***, as revised in 1990, would primarily govern prescribed fire smoke emissions, and requires the USEPA and states to carry out programs to assure attainment of the National

Ambient Air Quality Standards (NAAQS). ***The Clean Water Act*** regulates discharges into waters of the United States, including wetlands. The ***Safe Drinking Water Act*** is designed to protect the quality of public drinking water and its sources. The ***Wilderness Act of 1974*** provides management directions to protect wilderness values and guides activities and permitted uses within these areas.

Several laws pertain to the use of herbicides by the BLM. The ***Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)*** establishes procedures for the registration, classification, and regulation of all pesticides. Before any pesticide may be sold legally, the USEPA must register it. The USEPA may classify a pesticide for general use if it determines that the pesticide is not likely to cause unreasonable adverse effects to applicators or the environment, or for restricted use if the pesticide must be applied by a certified applicator and in accordance with other restrictions. All the herbicides evaluated in this PEIS are registered with the USEPA, and all applicators that apply them on public lands (i.e., certified applicators or those directly supervised by a certified applicator) must comply with the application rates, uses, and handling instructions on the herbicide label, and where more restrictive, the rates, uses, and handling instructions developed by the BLM. The ***Resource Conservation and Recovery Act (RCRA)*** regulates the disposal of toxic wastes, including the disposal of unused herbicides, and provides authority for toxic waste cleanup actions when there is a known operator. ***The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)*** regulates how to clean up spills of hazardous materials and when to notify agencies in case of spills.

Several laws pertain to the protection of plants and animals and their habitats. The ***Migratory Bird Conservation Act of 1929, as amended,*** makes it unlawful to directly, or indirectly, harm migratory birds. If the USFWS determines that migratory birds could be harmed by BLM vegetation treatment actions, the two agencies would develop a site-specific assessment and mitigation to prevent harm to these birds. ***The Endangered Species Act (ESA) of 1973*** provides for conserving endangered and threatened species of plants and animals. The ESA also requires that federal agencies consult with the USFWS and NOAA Fisheries to ensure that any actions that they authorize, fund, or carry out are not likely to jeopardize the continued survival of a listed species or result in the adverse modification or destruction of its critical habitat. The ***Wild Free Roaming Horse and Burro Act of 1971, as amended by the Public Rangelands Improvement Act of 1978*** provides for the management, protection, and control of wild horses and burros on public lands and authorizes the "adoption" of wild horses and burros by private individuals. The ***Fish and Wildlife Conservation Act of 1980*** encourages federal agencies to conserve and promote the conservation of non-game fish and wildlife species and their habitats. The ***Sikes Act of 1974*** authorizes the USDI to plan, develop, maintain, and coordinate programs with state agencies for the conservation and rehabilitation of wildlife, fish, and game on public lands.

Laws and acts that pertain to the protection of historic and cultural resources and the rights of Native American tribes and Alaska Native groups include the ***Historic Sites Act of 1935***, which provides for the preservation of historic American sites, buildings, objects, and antiquities of national significance. The ***National Historic Preservation Act (NHPA) of 1966***, which requires federal agencies to take into account the potential affects of their actions on properties that are listed or are eligible for listing on the National Register of Historic Places (NRHP), and to consult with State Historic Preservation Officers (SHPOs) and local governments regarding the effects of federal actions on historic properties. The ***Archeological Resources Protection Act of 1979*** prohibits the excavation, removal, damage, or other alteration or defacement of archaeological resources on federal or Indian lands without a permit. ***The American Indian Religious Freedom Act of 1978*** requires federal land managers to include consultation with traditional Native American or Alaska Native religious leaders in their management plans. The ***Native American Graves Protection and Repatriation Act of 1990*** recognizes the property rights of Native Americans and Alaska Natives in certain cultural items, including Native American and Alaska Native human remains and sacred objects. ***Section 810 of the Alaska National Interest Lands Conservation Act*** addresses the effects of proposed activities on Alaska Native subsistence uses.

This PEIS follows the guidelines in several Executive orders (EOs). ***Executive Order 11990, Protection of Wetlands***, ensures that federal agencies minimize the destruction, loss, or degradation of wetlands, and enhance and preserve the natural and beneficial values of wetlands, when carrying out actions on federal lands. ***Executive Order 12898, Environmental Justice***, requires that federal agencies address the environmental justice of their actions on minority populations and on low-income populations. ***Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks***, ensures that federal agencies identify and assess the environmental health and safety risks that may disproportionately affect children. ***Executive Order 13084, Consultation and Coordination with Indian Tribal Governments***, direct federal agencies to respect tribal self-government and sovereignty, tribal rights, and tribal responsibilities whenever they formulate policies "significantly or uniquely affect Indian tribal governments." ***Executive Order 13112, Invasive Species***, directs federal agencies to prevent the introduction of invasive species and provide for their control, and to minimize the economic, ecological, and human health impacts that invasive species cause. ***Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds***, requires that federal agencies that have, or are likely to have, a measurable negative effect on migratory bird populations develop a Memorandum of Understanding (MOU) with the USFWS that shall promote the conservation of migratory bird populations.

NEPA Requirements of the Program

Federal agencies are required to prepare an EIS under NEPA when the proposed action is likely to have a significant impact on the quality of the human environment (42 U.S.C 4321 et seq.; USDI BLM 1988c). An EIS is intended to provide decision-makers and the public with a complete and objective evaluation of significant environmental impacts, beneficial and adverse, resulting from the proposed action and all reasonable alternatives.

The intent of this PEIS is to comply with NEPA by assessing the program impacts of using herbicides to treat vegetation on public lands administered by the BLM. Additional guidance for NEPA compliance and for assessing impacts is provided in the Council on Environmental Quality (CEQ) *Regulations for Implementing the Procedural Provisions of NEPA* (40 Code of Federal Regulations [CFR] Parts 1500-1508), and the BLM *National Environmental Policy Act Handbook* H-1790-1 (USDI BLM 1988b).

To the extent practicable, existing environmental analyses were used in analyzing impacts associated with the proposed action and alternatives, including information contained in documents listed in a previous section, Documents that Influence the Scope of the PEIS.

This PEIS provides a broad, comprehensive background source of information on which any necessary subsequent environmental analyses can be tiered. In general, the NEPA process may be done at multiple scales depending on the scope of the proposal, as shown in Figure 1-1. The broadest level, which this PEIS represents, is a national-level programmatic study. This level of study contains broad regional descriptions of resources, provides a broad environmental impact analysis, including cumulative impacts, focuses on general policies, and provides Bureau-wide decisions on herbicide use and other available tools for vegetation management. Additionally, it provides an umbrella ESA Section 7 consultation for the broad range of activities described in the PEIS.

The next scale of analysis represents a regional level of analysis, and may be prepared for regional or statewide programs. A regional level of analysis would typically focus on methods to be used, options, regional or statewide issues, and provide an ESA Section 7 consultation focused on regional issues. Examples of these types of analyses are found in such documents as the *Interior Columbia Basin Ecosystem Management Plan* (USDA Forest Service and USDI BLM 1997), and the *Northwest Area Noxious Weed Control Program EIS* (USDI BLM 1985a).

Below the regional scale of analysis, there is the option to prepare a field office level of analysis. This analysis may be prepared for district or field office-wide programs. The analysis is tiered to either or both of the two higher scales of analysis and focuses on impacts of methods and options for a single program, such as a field office invasive and noxious weed program or prescribed fire and wildland fire use program. Local LUPs such as RMPs, and Management Framework Plans (MFPs) guide analysis at this level. Collectively, these LUPs outline the specific resource goals and objectives and use allocations for a specific geographic area. The uses and allocations allowed by the LUP are analyzed in an EIS associated with the development of the LUP. Land use plans are developed to include the proposed action and alternatives that identify specific management strategies to meet particular national, regional, and local goals and objectives. This scale provides ESA Section 7 consultation focused on local issues and species of concern that occur within the field office's administrative jurisdiction.

The local scale provides project level analysis and is prepared for site-specific proposals. The analysis may be tiered to any or all of the above scales of analysis.

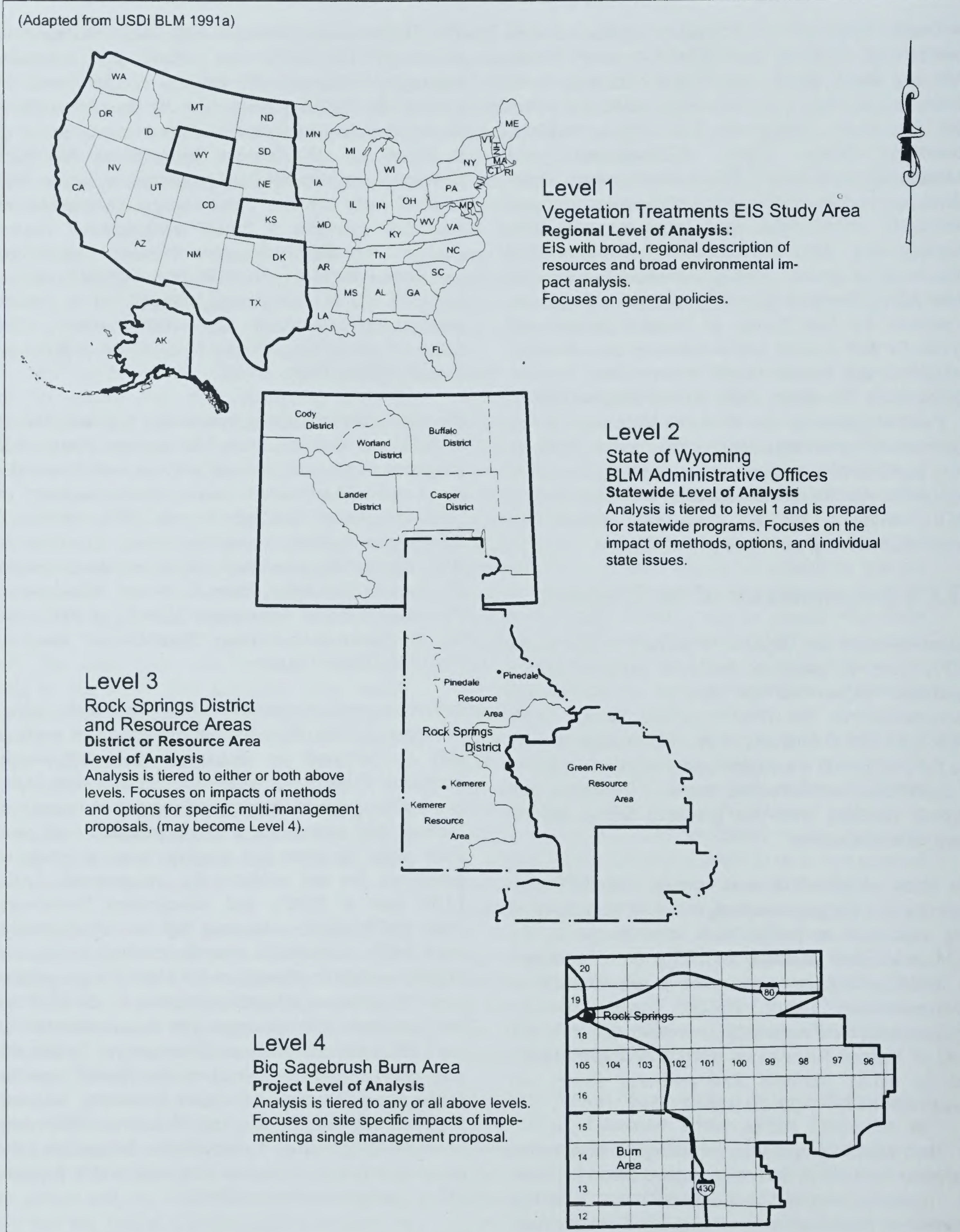


Figure 1-1
Relationship of the PEIS to BLM Field Offices

The analysis focuses on site-specific impacts of implementing a single management proposal as identified through local planning. Examples include, but are not limited to, weed control, prescribed fire, hazardous fuel reduction, and WUI projects. Section 7 consultation under the ESA focuses on the implementing actions.

Tiering allows local offices to prepare more specific environmental documents without duplicating relevant portions of this PEIS. Analyses done by local BLM offices will be prepared in accordance with NEPA guidance and will include public involvement as regulated by the CEQ, as well as follow USDI and BLM manual and handbook guidance and pertinent instruction memoranda.

Interrelationships and Coordination with Agencies

In its role as manager of nearly 262 million acres in the western U.S., including Alaska, the BLM has developed numerous relationships with federal, state, and local agencies, and conservation and environmental groups with an interest in resource management, as well as members of the public that use public lands or are affected by activities on public lands.

As noted earlier, several federal agencies administer laws that govern activities on public lands. Federal agencies, including the Department of Defense, the Department of Energy, the National Park Service, the USFWS, and the Forest Service, administer lands adjacent to or in close proximity to public lands administered by the BLM, and have similar vegetation management issues as the BLM. These agencies, and the BLM, regularly coordinate on vegetation management and control efforts to benefit all federally-administered lands. Other coordination includes the sharing of equipment, training, and financial resources, and developing vegetation management plans that cross administrative boundaries. For example, the Invasive Species Council was formed among several federal agencies to develop strategies to control invasive species on federal lands.

The BLM is required to coordinate with state and local agencies under several acts, including the Clean Air Act, the Sikes Act, FLPMA, and Section 106 of the NHPA. The BLM coordinates closely with state resource management agencies on issues involving the management of public lands and the protection of fish and wildlife populations, including federal- and state-listed threatened and endangered species. Local and state agencies work closely with the BLM to manage weeds on local, state, and federal lands, and local agencies often are responsible for weed treatments on public lands. Prescribed burning is coordinated with state and local air quality agencies to ensure that local air quality is not significantly impacted by BLM activities.

The BLM coordinates at the national and local level with several resource advisory groups, including BLM Resource Advisory Councils, the Western Governors Association, the National Association of Counties, the Western Area Power Administration, the National Cattleman's Association, the National Wool Growers Association, the Society of American Foresters, and the Forest and Paper Association. The BLM also solicits input from national and local conservation and environmental groups with an interest in land management activities on public lands. Information provided by these groups includes strategies to use domestic animals to control weeds, methods to ensure that prescribed burning does not impact the safe operation of power transmission lines, and techniques to restore land health.

As demonstrated at public scoping meetings for this PEIS, the public is deeply interested in BLM vegetation treatment activities, especially those individuals that live in close proximity to public lands, have commercial operations dependant on vegetation on or adjacent to public lands, or use public lands for recreation. The BLM strives to keep the public informed about its vegetation treatment activities through regular coordination and communication. The BLM also encourages the public to participate in the environmental review process during the development and analysis of local vegetation management programs.

Consultation

As part of this PEIS, the BLM consulted with the USFWS and NOAA Fisheries as required under Section 7 of the ESA (see Chapter 5; see Appendix F). The BLM prepared a formal initiation package that included: 1) a description of the program, listed threatened and endangered species, species proposed for listing, and critical habitats that may be affected by the program; and 2) a Biological Assessment (BA). The BA evaluated the likely impacts to listed species, species proposed for listing, and critical habitats from the proposed use of herbicides and other treatment methods in its vegetation treatment program and identified management practices to minimize impacts to these species and habitats.

The BLM initiated consultation with Native American tribes and Alaska Native groups to identify their cultural values, religious beliefs, traditional practices, and legal rights that could be affected by BLM actions. This included sending out letters to all tribes and groups that could be directly affected by vegetation treatment activities, and requesting information on how the proposed activities could impact Native American and Alaska Native interests, including the use of vegetation and wildlife for subsistence, religious, and ceremonial purposes (see Appendix F).

The BLM also consulted with SHPOs as part of Section 106 consultation under the NHPA to determine how proposed vegetation treatment actions could impact cultural resources. Formal consultations with SHPOs also may be required during implementation of projects at the local level (see Appendix F).

Public Involvement, Scoping, and Issues

The purpose of scoping is to focus the analysis in an EIS on the significant issues and reasonable alternatives in order to eliminate extraneous discussion and to reduce the length of an EIS (USDI BLM 1988b). Scoping is an ongoing process that involves the public in developing an EIS.

The BLM published a Federal Register (FR) Notice of Intent (NOI) on October 11, 2001, notifying the public that the BLM had formed a team to prepare a PEIS on the treatment of vegetation on public lands in the western U.S., including Alaska. The NOI also stated that comments on the proposal would be accepted from October 12 through November 11, 2001.

A second Federal Register Notice of Intent was published on January 2, 2002, notifying the public of the location of public scoping meetings, and extending the public comment period until March 29, 2002.

A third Federal Register Notice of Intent was published on January 22, 2002, notifying the public of changes to the meeting schedule.

All affected states issued public notices of the scoping period, which were placed in newspapers in or near locations where public meetings were held. In addition, information on the location of scoping meetings was provided by electronic mail in early December 2001, and again in early January 2002, to all members of the public that had placed their names on the electronic mailing list for the project before the date of the announcements.

Public Scoping Meetings

Eighteen public meetings were held in 12 western states, including Alaska, and one meeting was held in Washington, D.C. The scoping meetings were conducted in an open-house style. Informational displays were provided at the meeting, and handouts describing the project, the NEPA process, and issues and alternatives were given to the public. A formal presentation provided the public with additional information on program goals and objectives. This presentation was followed by a question and answer session.

The BLM received 1,034 requests to be placed on the project mailing list from individuals, organizations, and government agencies, and 381 written comment letters or facsimiles on the proposal. In addition, the public provided comments on the project at the public scoping meetings; over 2,800 catalogued individual comments (written and oral) were given during public scoping. In many cases, multiple respondents submitted the same comment. A *Scoping Comment Summary Report for the Vegetation Treatments Programmatic EIS* (ENSR 2002) was prepared that summarized the issues and alternatives identified during scoping. This document was made available to the public in July 2002.

Issues and Concerns

A wide range of issues was identified during scoping. Issues accounting for over 80% of the comments considered in the PEIS and PER are listed in Table 1-1.

The primary issue of controversy identified through scoping, and which required NEPA review, was the BLM's continuing and proposed increase in the use of herbicides in vegetation treatment programs needed to implement the *National Fire Plan* and related initiatives. The use of herbicides has been affirmed as a central issue for analysis in all past EISs considered in this document.

After scoping, the BLM determined that a NEPA review was not required to assess the impacts of other treatment activities on environmental and social resources on public lands at the national programmatic level. The use of these techniques has been affirmed in all previous EISs, and the BLM has authority under existing statutes to utilize these methods of treatment as necessary. Program- and project-specific NEPA analysis of the use of these techniques, and under what circumstances, will occur at the land use planning and project level.

Development of the Alternatives

The public comments influenced the development of several vegetation management alternatives. As noted in Table 1-1, numerous respondents suggested that the BLM reduce or eliminate the use of herbicides, avoid aerial applications of herbicides, or avoid the use of sulfonylurea and other acetolactate synthase (ALS)-inhibiting active ingredients. Based on these comments and NEPA-review requirements, alternatives addressing the use of herbicides are evaluated in the PEIS. The effects of other non-herbicide vegetation treatments are described in the PER.

Issues Not Addressed

Approximately 16% of comments received were not addressed in the PEIS or PER because they were beyond the scope of the document or did not meet the basic purpose and need of the project. The following are examples of comments not addressed in the PEIS or PER:

- Address the impacts of livestock grazing on aquifer recharge and wildlife habitat
- Amend the Mining Act of 1872
- Have scoping meetings in each district and extend the scoping period
- Classify wild horses as big game for sportsmen
- Increase penalties for violators of OHV rules
- The BLM is unconstitutional

Limitations of this PEIS

This PEIS is a programmatic document that addresses the broad impacts associated with the proposed action and alternatives to the proposed action. Environmental impacts are assessed at a general level because of the broad land area analyzed in the PEIS. Site-specific impacts would be assessed in NEPA documents prepared by local BLM offices and tiered to this document.

The analyses of impacts of the use herbicides in this PEIS are based on the best and most recent information available. As is always the case when developing management direction for a wide range of resources, not all information that might be desired was available. The Council on Environmental Quality Regulations provide direction on how to proceed with the preparation of an EIS when information is incomplete or unavailable:

"If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement: 1) a statement that such information is incomplete or unavailable; 2) a statement of the relevance of the incomplete or unavailable information to evaluating. reasonably foreseeable significant adverse impacts on the human environment; 3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and 4) the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes "impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason" (40 Code of Federal Regulations 1502.22 b).

For this PEIS, the primary effect of unavailable information is the inability to quantify certain impacts. Where quantification was not possible, impacts have been described in qualitative terms. A summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable adverse impacts on the human and socioeconomic environment and support the BLM's evaluation of such impacts have been included in chapters 3 and 4, in the appendices that accompany this PEIS, and in supporting documents that were prepared for this PEIS that have been included on the accompanying CD or are available on the BLM website at www.blm.gov. A copy of the PER and its supporting documents are also available at this website.

If changes in the proposed vegetation treatment activities and levels occur in the future, they would be reviewed to determine whether additional environmental documentation was needed, including an EA or EIS. This PEIS would serve as a source document that would be used to support any additional documentation that may be required. Any new or additional actions would also be evaluated for compliance with federal, state, and local laws and regulations prior to implementation, and the public would be informed of any major actions that may be considered for implementation by the BLM as part of the NEPA compliance process.

Preview of the Remainder of the PEIS

The format of this PEIS follows guidance provided by the CEQ and BLM *National Environmental Policy Act Handbook* H-1790-1 (USDI BLM 1988b). Because this PEIS contains a broad range of information, Figure 1-2 shows the types of information found in the PEIS, and where it is located.

TABLE 1-1
Key Issues (and Number of Comments) Identified During Scoping and Location Where Issues Are Addressed in the PEIS and PER

Issue	Where Addressed in PEIS and (PER)
Program Purpose and Need	
Focus on long-term ecosystem sustainability and biological diversity; clearly define restoration objectives (39)	1-1, 1-3, 2-2, 2-4, 2-14, Ch. 4.
Need to address all invasive plants, not just weeds (34)	1-1, 2-3, 2-14
Evaluate land use impacts, such as grazing and fire suppression, on the decline of ecosystem health (377)	1-1, 2-15
Focus on addressing the causes rather than treating the symptoms (102)	2-4, 2-13, 2-15
Address how PEIS will impact Resource Management Plans and other local planning (23)	1-7
Work closely with agencies, conservation groups, and private landowners on vegetation management (93)	1-9, 1-10, 2-16, 2-21, Ch. 5
Proposed Action	
Ensure that adequate funds are available to treat enough land and monitor treatment success (45)	2-21
Consider all treatment methods (11)	2-3, 2-15 (Ch. 2)
Naturally-occurring fires should be allowed to burn and restored to public lands (38)	1-1, (Chs. 2, 3, 4)
Use newer, less toxic herbicides where feasible, and limit use or avoid use of herbicides (75)	2-4, Ch. 4, App. B, C
Describe how herbicides were chosen and evaluated in the PEIS (33)	2-4, Ch. 4, App. B, C
Describe where acres will be treated and the method of accounting for acres that receive multiple treatments (28)	2-4, 2-10
Other Potential Alternatives	
Reduce or eliminate the use of herbicides; apply from the ground rather than from the air (206)	2-13
Fuels reduction should only occur in WUI or where there is a threat of significant wildfire (39)	2-1 (Ch. 2)
Treat more acres; treat fewer acres (8)	2-14
Develop a no-grazing alternative; develop a no-logging alternative; develop a no-OHV alternative (12)	1-4
Develop restrictions on motorized vehicle use on public lands (72)	1-4
Develop an alternative based on an ecosystem management approach (2)	2-13
Restoration Goals and Best Management Practices	
Identify restoration objectives and focus on preventative measures to eliminate the causes of land degradation (103)	2-3, Ch. 4 (Ch. 2)
Restoration efforts should focus on restoring natural disturbance regimes and ecosystem processes (11)	2-3, Ch. 4 (Chs. 2, 4)
Improve management of public lands for multiple use and maximum public benefit (22)	2-3 (Ch. 2)
Use native plants and certified native seed, where practical, for revegetation (59)	2-15, 2-17 (Ch. 2)
Restrict grazing on lands that are being rehabilitated or that have not been impacted by livestock (10)	2-14
Monitor success of treatments and establish performance measures to determine treatment success (42)	2-21
Include public education as part of the vegetation treatment program (39)	2-21
Environmental Consequences	
Address the impacts on air quality from prescribed burning (18)	(Ch. 4)
Address the impacts of herbicides on water quality (39)	4-21
Assess the role of fire in contributing to weed growth (44)	(Chs. 1, 2, 3, 4)
Evaluate the effects of herbicide treatments on non-target species (28)	4-45
Address the role of grazing in controlling weeds and other invasive vegetation and hazardous fuels (27)	(Ch. 4)
Vegetation treatments should focus on restoring habitat and natural ecological processes (25)	1-1, 1-3, 2-2, 2-4, 2-14, Ch. 4.
Address the impacts of treatments on species of concern (55)	4-69, 4-91, 4-117 (Ch. 4)
Describe how treatments will occur in wilderness areas (26)	2-16, 4-154 (Ch. 4)
Address the impacts of prescribed fire on powerline operations and safety (12)	(Ch. 4)
Evaluate the impacts to subsistence crops used by Native Americans and Alaska Natives (10)	4-145, 4-171 (Ch. 4)
Address the risks to humans and fish and wildlife from use of herbicides and smoke from prescribed fire (54)	4-74, 4-97 (Ch. 4)
Address how will vegetation treatments will affect the local economy (40)	4-161 (Ch. 4)

VOLUME 1

Chapter 1 Proposed Action and Purpose and Need
Summarizes the proposed action, purpose of and need, and decisions to be made in this PEIS

Chapter 2 Alternatives
Describes and compares the proposed management alternatives

Chapter 3 Affected Environment
Presents existing natural and socioeconomic resources on public lands in the western U.S.

Chapter 4 Environmental Consequences
Evaluates the impacts of the alternatives on public land resources in the western U.S. and describes mitigation proposed for program-related impacts to resources.

Chapter 5 Consultation and Coordination
Describes the scoping process, agencies contacted, and government-to-government consultation, and lists the preparers of this PEIS.

Chapter 6 References
Lists the documents and other sources used to prepare the PEIS.

Chapter 7 Glossary
Provides definitions for important terms used in the PEIS.

Chapter 8 Index
Lists where significant issues, resource descriptions, NEPA terms, and agencies and groups discussed in the PEIS are located.

Acronyms, Abbreviations, and Symbols (fold-out at end of Volume 1)
Lists the acronyms, abbreviations, and symbols used in this PEIS.

VOLUME 2

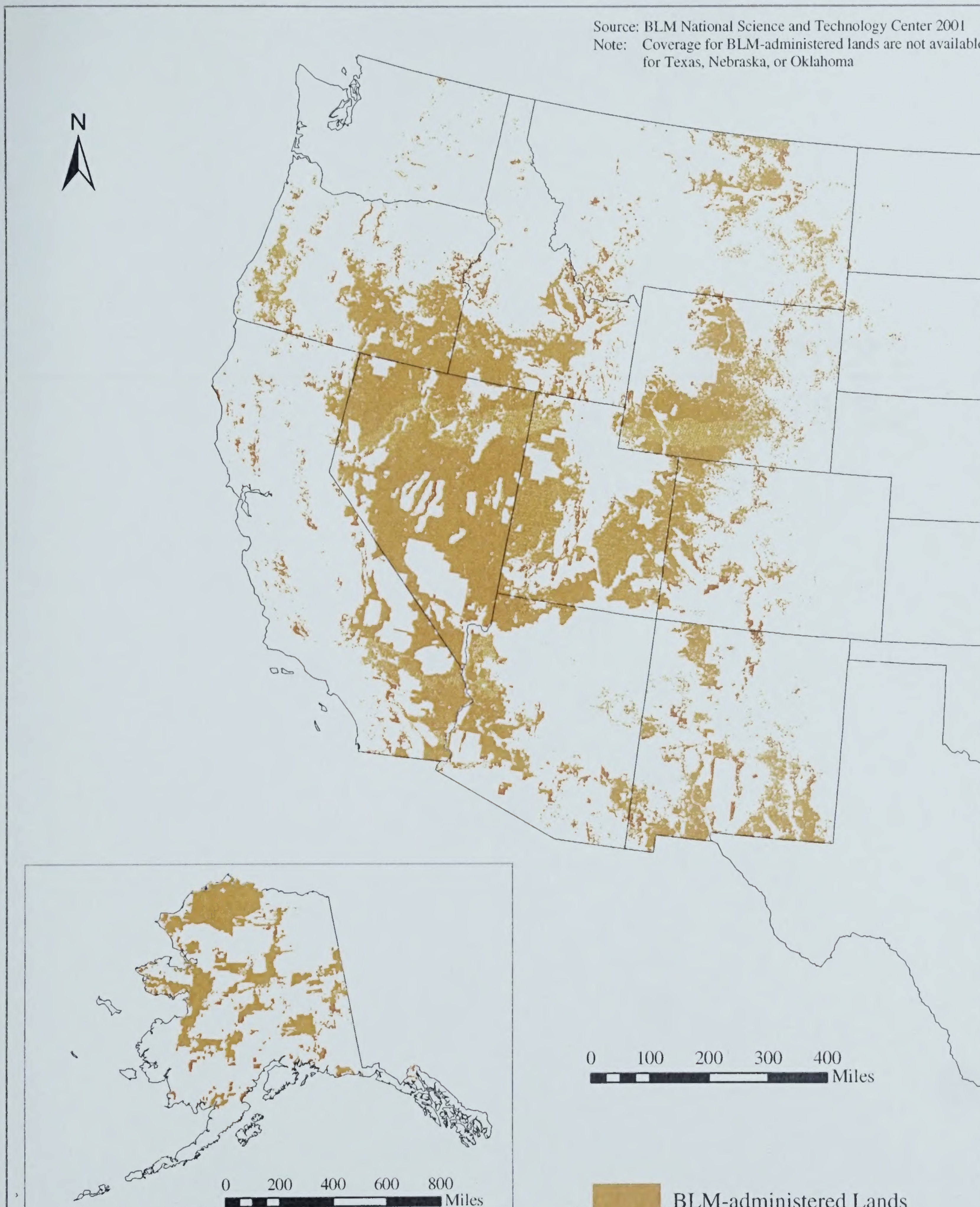
Appendixes

A. Common and Scientific Names of Plants and Animals Given in the PEIS
B. Human Health Risk Assessment
C. Ecological Risk Assessment
D. Protocol for Identifying, Evaluating, and Using New Herbicides
E. BLM Reference Manuals and Handbooks
F. Consultation Agreements
G. American Lands Alliance Alternative
H. Special Status Species List

Related Reports
(on the CD located in the back pocket of the PEIS)

1. Biological Assessment
2. Human Health Risk Assessment Final Report
3. Ecological Risk Assessments for Each Herbicide Evaluated by the BLM
4. Ecological Risk Assessment Protocol

Figure 1-2
How This Programmatic EIS is Organized.



Map 1-1
Public Lands Administered by the Bureau of Land Management

CHAPTER 2

ALTERNATIVES

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CHAPTER 2

ALTERNATIVES

Introduction

This chapter discusses the proposed and alternative actions that have been developed to treat vegetation using herbicides on public lands in the western U.S., including Alaska. Alternative actions are those that could be taken to feasibly attain, or approximate the BLM's objectives for vegetation management, as expressed in its programs, policies, and land use plans.

Alternatives were developed to respond to the various significant issues and alternative proposals raised during scoping, yet still meet the project's purpose and need described in Chapter 1. Alternatives were also developed to ensure that the BLM complied with federal, tribal, state, and local regulations. This evaluation includes mitigation measures for the proposed action and alternatives.

As described in the *Scoping Comment Summary Report for the Vegetation Treatments Programmatic EIS* (ENSR 2002), alternative proposals generated during scoping primarily focused on the types of herbicides that would be used by the BLM, methods of application, and amounts of herbicides applied. To help the reader better understand the alternative proposals, this chapter (1) lists the herbicides evaluated in the PEIS, their mode of action, and their methods of application; (2) identifies BLM programs primarily responsible for treatment of vegetation using herbicides; and (3) describes the types of planning and project implementation that must occur before herbicides can be used on public lands. These sections are followed by a description of the five alternatives developed for this PEIS, followed by a summary of (1) standard operating procedures (SOPs) and special precautions that would apply for all alternatives; (2) additional protective (mitigation) measures developed during preparation of the PEIS; and (3) a summary of environmental and socioeconomic impacts that would result from implementation of the alternatives.

BLM Programs Responsible for Herbicide Treatments

Vegetation treatments using herbicides are primarily conducted by the Wildland Fire Management, Rangeland Management, Public Domain Forest Management, Riparian Management, and Wildlife and Fisheries Management programs. Each program, as described below, has its own objectives for vegetation management. Types of herbicide treatments conducted by these programs could include hazardous fuels reduction, weed control, fish and wildlife habitat improvement, habitat improvement for threatened and endangered species, and restoration of riparian habitats.

Wildland Fire Management

Efforts to reduce the risk of wildfire are primarily the responsibility of the Wildland Fire Management program. During 2004, the Wildland Fire Management program conducted hazardous fuel treatments on nearly 500,000 acres of public land and treated about 200,000 acres in WUI areas, and conducted Emergency Fire Rehabilitation (EFR) activities on over 1.9 million acres. Together, the USDI and Forest Service conducted over 3 million acres of hazardous fuels treatments and treated nearly 1.8 million acres in the WUI during 2004 (USDI BLM 2005c, d). Prior to 1998, the BLM managed hazardous fuels on approximately 57,000 acres annually. Historically, approximately 70% of acres were managed to restore fire-adapted ecosystems, while the remaining 30% were managed to reduce wildfire risks to communities. Under current direction, the number of acres treated annually by the BLM to reduce wildland fire risk would increase significantly, to about 3.5 million acres in the western U.S., including Alaska, and most treatments would occur in the WUI.

Although all treatment methods would be used, prescribed fire and mechanical treatments would account for most fuels reduction in the continental U.S., and wildland fires for resource use would account for most fuels reduction in Alaska.

The Wildland Fire Management program is guided by the policies expressed in the following national policy documents: *Protecting People and Sustaining Resources in Fire Adapted Ecosystems: A Cohesive* Strategy (USDA Forest Service 2000); *National Fire Plan* (USDI and USDA 2001); *Interagency Burned Area Emergency Stabilization and Rehabilitation Handbook* (H-1742-1; USDA and USDI 2001); *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-Year Comprehensive Strategy Implementation Plan* (USDI and USDA 2002); and Chapter 3 (Interagency Burned Area Emergency Stabilization and Rehabilitation) in BLM Manual 620 *Wildland Fire Management* (USDI BLM 2004b).

Rangeland Management

Approximately 165 million acres of public lands are upland rangeland, of which approximately 160 million acres are open to livestock grazing (USDI BLM 2005d). The Rangeland Management program in Alaska is responsible for reindeer grazing on approximately 5 million acres in western Alaska. The Rangeland Management program is responsible for upland health assessments, rangeland improvement planning and implementation, allotment planning and administration, and resource monitoring. Management of rangeland ecosystems is conducted on a landscape basis through land use plans.

Vegetation treatment activities conducted by this program are designed to promote compliance with the state and regional rangeland health standards, but specific benefits of these projects often include livestock forage improvement, wildlife habitat improvement, suppression of plants that are toxic to wildlife and livestock, removal of plants that compete with more desirable vegetation, and improvement of watershed conditions on rangelands.

Vegetation treatments on public lands also include activities to control invasive species such as noxious and invasive weeds. The BLM uses an integrated pest management approach, more specifically integrated vegetation management. Integrated vegetation management is a key component of the program. The goal of invasive vegetation management is to control invasive and unwanted vegetation, to prevent the spread of noxious weeds, to eradicate early-detected noxious weed species in areas where certain weeds have not been introduced or established, and to control weeds where they have become established. Vegetation control methods include physical and biological controls, and use of herbicides. The policy, direction, and requirements for planning and implementing integrated weed management are given in BLM Manual 9015, *Integrated Weed Management* (USDI BLM 1992b).

A total of 317,959 acres were treated to prevent the spread of noxious weeds and invasive plants in fiscal year (FY) 2004, and an estimated 297,723 acres were treated in FY 2003 (USDI BLM 2005c). In addition, 8.9 million acres were inventoried for weeds during FY 2004.

Currently, the funding and labor resources available to combat weeds dictate a containment strategy. Actions will continue to be targeted at preventing the spread of weeds' into the most vulnerable areas (USDI BLM 2000b).

Public Domain Forest Management

Fifty-five million acres of public domain woodland and forestland are managed by the BLM within the western states and Alaska. Of these, 44 million acres are woodlands, 11 million acres are forestlands, and 2.4 million acres are managed under Oregon and California Grant Lands program.

Woodland is defined as land with 10% or more cover in tree species not typically used in commercial wood products, including land that formerly had such tree cover and would be naturally or artificially regenerated. Forestland is defined as land that has 10% or more cover in tree species typically used in commercial wood products, including land that formerly had such tree cover and will be naturally or artificially regenerated.

This program is responsible for timber and non-timber special forest product sales, reforestation efforts, fish and wildlife habitat improvement, and forest vegetation composition and structure improvements intended to increase productivity and resilience to disease, insects, and fire. FLPMA and BLM Manual 5000-1, Forest Management (Public Domain; USDI BLM 1991c), direct the policy, direction, and requirements for planning and implementing forestry and woodland management projects.

Projects include reducing plant competition to enhance the growth of desired timber species, managing forest stands to provide habitat for wildlife and prevent epidemic insect or disease outbreaks, and managing vegetation that could serve as fuel for wildfires. In 2004, the program implemented forest restoration treatments on 19,075 acres and forest management treatments on 42,587 acres. Sales of timber, wood products, and non-timber special forest products totaled nearly $22.2 million during FY 2004 (USDI BLM 2005d).

Riparian Management

The BLM manages over 23 million acres of riparian and wetland areas, comprising about 9% of public lands, and providing habitat for roughly 80% of the fish and wildlife species on public lands. This program's responsibilities include watershed, riparian, and wetland inventories, assessments, maintenance, restoration, and reconstruction. During 2004, the program assessed the condition of nearly 2,900 miles of streams, implemented enhancement projects on approximately 2,000 acres of wetlands and 675 miles of streams, and monitored over 9,700 acres of lakes, streams, and wetlands (USDI BLM 2005c).

Wildlife and Fisheries Management

The Wildlife and Fisheries Management program is responsible for managing and protecting habitats on public lands for wildlife, fish, and plant species that are federally-listed as threatened, endangered, or special status, as well as the more common fish and wildlife. Activities conducted by the program include wildlife, fish, and plant inventories; habitat management plan development; habitat restoration projects, such as restoring vegetation along streambanks; and weed control.

The Wildlife and Fisheries Management program provides supports the Great Basin Restoration and the Conservation of Prairie Grasslands initiatives. In 2000, the BLM implemented the Great Basin Restoration Initiative, a regional restoration strategy to restore and enhance nearly 70 million acres of sagebrush habitat in Nevada, Utah, Oregon, and Idaho. The same year, the BLM initiated the Conservation of Prairie Grasslands initiative to protect and maintain important grasslands on approximately 15 million acres of short- and mixed-grass prairie in a 7-state area that extends from Canada to Mexico. The focus of these efforts is to better manage these habitats to benefit healthy landscapes and wildlife and to prevent much of the burned land from being overwhelmed by annual grasses and noxious weeds. The Wildlife and Fisheries Management program supports these strategies. The program is also responsible for managing subsistence uses on public lands in Alaska.

Other Programs

Several other programs within the BLM also treat vegetation using herbicides, although to a lesser extent than the programs listed above (USDI BLM 2004a). These include the Cultural Resources, Recreation, Wilderness, Energy and Minerals, Transportation, and Realty and Ownership Management programs. Herbicides are used to manage vegetation on recreation and wilderness areas and on lands disturbed by energy and mineral development. The Realty and Ownership Management program issues ROW, and herbicides are often preferred for use on ROW over other treatment methods or in conjunction with other treatments because they are often most effective at controlling or removing vegetation before, or shortly after, it emerges.

Vegetation Treatment Planning and Management

The BLM's *Strategic Plan* (USDI BLM 2000a); *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-Year Comprehensive Strategy Implementation Plan* (USDI and USDA 2002); and *Partners Against Weeds: An Action Plan for the Bureau of Land Management* (USDI BLM 1996) identify broad objectives for management of vegetation on public land, while treatment activities at the local level are guided by the goals, standards, and objectives of land use plans developed for each BLM field office.

Although vegetation management actually occurs at the local level, policies established at the national level help direct those local level vegetation management efforts. Examples of national level policy direction designed to improve vegetation management efforts have included development of rangeland health standards and development of assessments and evaluations for land, water, air, and vegetative health (USDI BLM 2002b). These assessments provide information that is used to ascertain achievement of land health standards and to identify causes for not meeting standards. These assessments would be used to help identify restoration activities and establish restoration priorities.

Land use plans guide land use and vegetation management decisions within the geographic area they cover and provide specific goals, standards, and objectives to apply to vegetation treatment projects and activities. These plans identify important local resources to be protected, identify historic, current, and future desired conditions for vegetation, and describes land use activities and levels that are appropriate to maintain healthy vegetation. Wise planning also considers the importance of other natural resources, such as water and soil, when developing vegetation restoration strategies. In addition, BLM land use plans identify transportation facilities, utility corridors, and other infrastructure development on the public lands that are likely to receive some form of vegetative treatment.

To assist with vegetation management planning, key resource elements, such as plant community types, aquatic habitats, sensitive areas, and invasive species concentration areas, are inventoried and mapped regionally and district-wide. Inventories and maps allow field managers to identify areas of high ecological integrity; to ensure that there is suitable habitat for wide-ranging species; to identify areas where land uses may be incompatible with long-term ecosystem health; and to identify areas that could benefit from improved management. Inventories and mapping are also done at the local level to help managers better understand how proposed projects fit in with vegetative conditions on a larger scale, such as within ecoregions or watersheds. The BLM also cooperates with other agencies, organizations, and landowners in regional planning efforts, including establishment of Cooperative Weed Management Areas.

Site Selection Priorities

Upon approval of a land use plan, subsequent implementation decisions are often put into effect by developing implementation plans. Implementation plans tend to focus on multiple resources and include vegetation treatment activities within a BLM field office. Implementation plans are made with the appropriate level of NEPA analysis, and BLM field managers usually make implementation decisions.

Several factors influence the implementation strategy (e.g., areas to be treated), and include: (1) statutory mandates, including FLPMA, the Clean Air Act, ESA, and Taylor Grazing Act; (2) goals of the Strategic and Annual Performance plans; (3) present risks to resources; (4) likelihood of success in restoring natural biotic communities; and (5) cost effectiveness of actions.

Vegetation treatment priorities identified in the *EIS Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a) still apply today. They are: (1) take actions to prevent or minimize the need for vegetation controls where feasible; (2) use effective nonchemical methods of vegetation control where feasible; and (3) use herbicides only after considering the effectiveness of all potential methods.

The overriding goal is to treat vegetation on lands only where necessary, and to prioritize treatment methods based on their effectiveness and likelihood to have minimal impacts on the environment. Under all alternatives presented in this PEIS, the land manager would be able to use the treatments that have been shown to have the greatest success in controlling unwanted vegetation or restoring degraded lands given local constraints and values. This PEIS focuses on the use of herbicides to treat vegetation, but other vegetation treatment methods include fire use, mechanical, manual, and biological control methods. The PER, which accompanies this PEIS, describes these other treatment methods and activities proposed on public lands during the next 10 to 15 years.

Herbicide Active Ingredients Evaluated under the Proposed Alternatives

In the previous EISs, a total of 25 herbicide active ingredients were reviewed, 22 were evaluated, and 20 are presently approved for use in one or more states (Tables 2-1 and 2-2). The decision to approve these herbicides for use on public lands was based on a detailed analysis of the risks to human health and non-target species from the use of these chemicals.

Since the majority of these assessments were completed in the late 1980s, a comprehensive literature review was conducted as part of this PEIS to determine whether there was any significant new information relevant to environmental concerns regarding the continued use of these herbicides (McMullin and Thomas 2000). Local BLM field offices were also consulted to determine if they had information from field applications that would suggest that any of these chemicals should be re-analyzed. If so, a new risk assessment for that active ingredient was completed as part of this PEIS in order to assess whether the BLM should continue its use.

Based on the literature review and information from the field, sulfometuron methyl (Oust®) was found to have potential significant impacts on non-target vegetation when carried on soil to untreated areas, effects that were not evaluated earlier. Thus, the toxicity and environmental fate of sulfometuron methyl were

TABLE 2-1

Herbicides Evaluated by the Bureau of Land Management and Their Current Availability

Active Ingredient	EIS in Which Herbicide Evaluated				Summary of Evaluations for all EISs		
	Northwest Area Noxious Weed Control Program (1986)	California Vegetation Management (1988)	Vegetation Treatment on BLM Lands in 13 Western States (1991)	Western Oregon Program – Management of Competing Vegetation (1992)	Active Ingredients Considered	Active Ingredients Evaluated	Active Ingredients Approved for Use
2,4-D	Yes (Esteron-99; DMA-4)	Yes	Yes	Yes	Yes	Yes	Yes
2,4-DP		Yes			Yes	Yes	Yes
Ammonium sulfamate				Proposed, not evaluated	Yes	No	No
Amitrole		Yes	Evaluated, but not included		Yes	Yes	No
Asulam		Yes		Yes	Yes	Yes	Yes
Atrazine		Yes	Yes	Yes	Yes	Yes	Yes
Bromacil		Yes	Yes		Yes	Yes	Yes
Chlorsulfuron			Yes		Yes	Yes	Yes
Clopyralid			Yes		Yes	Yes	Yes
Dalapon		Yes	Evaluated, but not included	Proposed, but not evaluated	Yes	Yes	No
Dicamba	Yes (Banvel)	Yes	Yes	Yes	Yes	Yes	Yes
Diquat				Proposed, but not evaluated	Yes	No	No
Diuron		Yes	Yes	Proposed, but not evaluated	Yes	Yes	Yes
Fosamine		Yes		Proposed, but not evaluated	Yes	Yes	Yes
Glyphosate	Yes (Rodeo)	Yes	Yes	Yes	Yes	Yes	Yes
Hexazinone		Yes	Yes	Yes	Yes	Yes	Yes
Imazapyr			Yes		Yes	Yes	Yes
Mefluidide			Yes		Yes	Yes	Yes
Metsulfuron methyl			Yes		Yes	Yes	Yes
Monosodium methanearsonate				Proposed, but not evaluated	Yes	No	No
Picloram	Yes (Tordon 2K, Tordon 22K)	Yes	Yes	Yes	Yes	Yes	Yes
Simazine		Yes	Yes		Yes	Yes	Yes
Sulfometuron methyl			Yes		Yes	Yes	Yes
Tebuthiuron		Yes	Yes		Yes	Yes	Yes
Triclopyr		Yes	Yes	Yes	Yes	Yes	Yes
Active Ingredients Available for Use	4	16	17	8	25	22	20

TABLE 2-2
States in which Herbicides are Approved for Use on Public Lands[1]

Chemical	AZ	CA	CO	ID	MT	NV	NM	ND	OK	OR East	OR West	SD	UT	WA	WY
2,4-D	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
2,4-DP		•													
Asulam		•									•[2]				
Atrazine	•	•	•	•	•	•	•	•	•	•[2]	•[2]	•	•	•	•
Bromacil	•	•	•	•	•	•	•	•	•	•[2]		•	•	•	•
Chlorsulfuron	•		•	•	•	•	•	•	•	•[2]		•	•	•	•
Clopyralid	•		•	•	•	•	•	•	•	•[2]		•	•	•	•
Dicamba	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Diuron	•	•	•	•	•	•	•	•	•	•[2]		•	•	•	•
Fosamine		•													
Glyphosate	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Hexazinone	•	•	•	•	•	•	•	•	•	•[2]	•[2]	•	•	•	•
Imazapyr	•		•	•	•	•	•	•	•	•[2]		•	•	•	•
Mefluidide	•		•	•	•	•	•	•	•	•[2]		•	•	•	•
Metsulfuron methyl	•		•	•	•	•	•	•	•	•[2]		•	•	•	•
Picloram	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Simazine	•	•	•	•	•	•	•	•	•	•[2]		•	•	•	•
Sulfometuron methyl	•		•	•	•	•	•	•	•	•[2]		•	•	•	•
Tebuthiuron	•	•	•	•	•	•	•	•	•	•[2]		•	•	•	•
Triclopyr	•	•	•	•	•	•	•	•	•	•[2]	•[2]	•	•	•	•

[1] These chemicals have not been approved for use in Alaska, Oklahoma, and Texas.
[2] Chemicals not currently approved for use in Oregon per court injunction (Southern Oregon Citizens Against Toxic Sprays (SOCATS) v. Watt, No. 79-1098 (District Court of Oregon. October 20. 1982). 13 Environmental Law Report 20. 176.

analyzed in this PEIS. It was determined that the remaining 19 herbicides did not require further analysis for human health risks. However, the BLM determined that the level of analysis contained in the non-target species assessments for fish and wildlife for the previous EISs were inadequate to characterize the risks to species of concern, including anadromous fish.

During the mid- to late 1990s, the Forest Service conducted ecological risk assessments (ERAs) for nine herbicide active ingredients also used by the BLM: 2,4-D, clopyralid, dicamba, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, and triclopyr. In addition, the Forest Service prepared interactive spreadsheets that allowed the BLM to determine exposure concentrations for plants and animals under different application rates and exposure scenarios for these herbicides. The ERAs and spreadsheets are available on the Internet at the Forest Service Pesticide Management and Coordination website at http://www.fs.fed.us/foresthealth/pesticide/risk.htm.

Information contained in the ERAs was used by the BLM to characterize risks to non-target species from the specific chemicals and is incorporated by reference into this PEIS.

The Forest Service did not conduct ERAs for tebuthiuron, diuron, bromacil, and chlorsulfuron. Thus, the BLM conducted new ERAs for these herbicides as part of this PEIS.

The remaining six active ingredients currently approved for use by the BLM—2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine—have not been used, or their use has been limited to a very small number of acres, by the BLM for several years, primarily due to the availability of other, more effective approved active ingredients.

Herbicide Terminology

Active ingredient (a.i.) is the chemical or biological component that kills or controls the target pest.

Adjuvant(s) are chemicals that are added to the pesticide formulation to enhance the toxicity of the active ingredient or to make the active ingredient easier to handle.

Formulation is the commercial mixture of both active and inactive ingredients.

Herbicide is a chemical pesticide used to treat vegetation.

Herbicide resistance occurs when naturally occurring heritable characteristics allow individual weeds to survive and reproduce, producing a population, over time, in which the majority of the plants of the weed species have the resistant characteristics.

Other ingredient(s) are those ingredients that are added to the commercial product (formulation) and are not herbicidally active. In the past, these were referred to as inert ingredients.

The BLM also proposes to use four new herbicide active ingredients that are registered and available for use—diflufenzopyr (as a formulation with dicamba), diquat, fluridone, and imazapic. These herbicides have been registered for use by the USEPA, are deemed effective in controlling vegetation, and have minimal effects on the environment and human health if used properly.

The new active ingredients were selected based on: (1) input from BLM field offices on types of vegetation needing control; (2) studies that indicated these active ingredients would be more effective in controlling noxious weeds and other unwanted vegetation targeted for control than active ingredients currently used by the BLM; (3) USEPA approval for use on rangelands, forestlands, and/or aquatic environments; (4) responses from herbicide manufacturers to a request from the BLM in October 2001 to submit a list of herbicides not currently approved for use on public lands that may be appropriate to control vegetation; (5) the ability of the herbicide formulations to be applied on a variety of plant species needing control; (6) their level of risk to human health and the environment; and (7) the funds available to the BLM to conduct human health and ecological risk assessments of the proposed herbicides.

Diflufenzopyr, which is used in combination with dicamba for weed control, inhibits the transport of auxin in the plant. The result is an abnormal accumulation of auxin or auxin-like compounds in the growing points of susceptible plants and an imbalance in growth hormones in the plant.

Diquat is a post-emergence, nonselective herbicide that can be applied directly to vegetation or to ponds, lakes, or drainage ditches for the management of aquatic weed species. Diquat is a cell membrane disrupter, whose mode of action is to intercept electrons from photosynthesis and transfer the energy from photosynthesis to various free radicals that damage cell membranes.

Fluridone, a systemic, selective, aquatic herbicide that can be applied to the water surface or subsurface, or as a bottom application just above the floor of the water body. Fluridone is absorbed from the water by the plant shoots and taken up from the soil by the roots. In susceptible plants, fluridone inhibits the formation of carotene, which is essential in maintaining the integrity of chlorophyll in plants.

Imazapic, a selective, systemic herbicide, can be applied both pre-emergence and post-emergence for the management of selective broadleaf and grassy plant species. Its mode of action is associated with the synthesis of branch-chained amino acids.

In order to ensure that the use of these active ingredients is appropriate for public lands, the BLM conducted human health risk assessments (HHRAs) and ERAs to assess the potential for risks to humans and non-target plants and animals, including sensitive species, from using these active ingredients. An analysis of the toxicity and environmental fate of each active ingredient, and for a formulation of diflufenzopyr and dicamba (Overdrive®), are provided in Chapter 4, Environmental Consequences, and in appendices B and C.

For new and currently available herbicides that may be proposed for use in the future, the BLM would follow the steps for conducting risk assessments used in this PEIS. These steps are: (1) assess a product's or a technology's effectiveness for use on target vegetation on public lands; (2) identify the level of data and analysis needed to conduct a human health and ecological risk assessment for that chemical; (3) determine the level of NEPA documentation required to support a decision to use a new product or technology; and (4) consult with the ESA regulatory agencies. These steps are discussed in more detail in Appendix D.

Herbicide Modes of Action and Treatment Methods

Herbicides are chemicals that kill or injure plants. Some herbicides are derived from plants, while others are manufactured synthetically. Herbicides can be classified by their mode of action, and include growth regulators, amino acid inhibitors, grass meristem destroyers, cell membrane destroyers, root and shoot inhibitors, and amino acid derivatives, which interfere with plant metabolism in a variety of ways (Table 2-3; Bussan and Dyer 1999).

Herbicides can be categorized as selective or non-selective. Selective herbicides kill only a specific type of plant, such as broadleaved plants. Many herbicides used for noxious weed control are selective for broadleaved plants, so that they can be used to control weeds while maintaining grass forage species. Glyphosate is non-selective, so it must be used carefully around desirable and non-target plants (Rees et al. 1996).

Herbicides are most effective on pure stands of a single weed where desirable and non-target plants are scarce or absent (Colorado Natural Areas Program 2000). Herbicides are also effective for rhizomatous weed species that are unpalatable to livestock, require repeated cutting or pulling for control, or are located in remote areas where pulling and cutting are not feasible. Herbicides often work well in combination with other control treatments. For example, tamarisk, Russian olive, and Siberian elm can be controlled by cutting stems close to the ground in the fall and then spraying or painting the stems with an herbicide registered for that use.

Herbicide treatments would follow BLM procedures outlined in BLM Handbook H-9011-1 (*Chemical Pest Control*), and manuals 1112 (Safety), 9011 (*Chemical Pest Control*), and 9015 (*Integrated Weed Management*), and would meet or exceed states' label standards (USDI BLM 1991a). Several herbicide application methods are available. The application method chosen depends upon the treatment objective (removal or reduction); accessibility, topography, and size of the treatment area; characteristics of the target species and the desired vegetation; location of sensitive areas and potential environmental impacts in the immediate vicinity; anticipated costs; equipment limitations; and meteorological and vegetative conditions of the treatment area at the time of treatment.

Herbicide application schedules are designed to minimize potential impacts to non-target plants and animals, while remaining consistent with the objective of the vegetation treatment program. The application rates depend upon the target species, the presence and condition of non-target vegetation, soil type, depth to the water table, presence of other water sources, and the label requirements.

Herbicides can be applied aerially with helicopters or fixed-wing aircraft, or on the ground with vehicles or manual application devices. Operation of helicopters is more expensive than operation of fixed-wing aircraft, but helicopters are more maneuverable and more effective in areas with irregular terrain. Helicopters also are more effective for treating target vegetation in areas with multiple vegetation types.

Manual applications of herbicides are used only in small areas or in areas inaccessible by vehicle. Herbicides may be applied with a backpack applicator or spray bottle, wick (wiped on), or wand (sprayed on). Herbicides can be applied to trees around the circumference of the trunk on the intact bark (basal bark), to cuts in the trunk or stem (frill, or "hack and squirt"), to cut stems and stumps (cut stump), or injected into the inner bark (Tu et al. 2001).

Herbicides can be used selectively to control specific types of vegetation, or non-selectively to clear all vegetation on a particular area. Herbicides can be applied over large areas and/or in remote locations using aircraft, or applied using spot applications in smaller, easily accessible locations.

There are several drawbacks and limitations to herbicide use. Herbicides can damage or kill non-target plants. Weeds may develop a resistance to a particular herbicide over time. Herbicides can be toxic or cause health problems in humans, other animals, and other plants. Restricted use herbicides must be applied by someone with the appropriate certification identified in state laws and BLM policy (Colorado Natural Areas Program 2000). Herbicides would be applied according to the label.

Description of the Alternatives

Five program alternatives were developed and evaluated for this PEIS, including the Preferred Alternative and the No Action Alternative. Alternative actions are those

TABLE 2-3
Herbicides Approved and Proposed for Use on Public Lands

Herbicide	Herbicide Characteristics	Areas Where Registered Use is Appropriate					
		Rangeland	Forestland	Riparian and Aquatic	Oil, Gas, and Minerals	ROW	Recreation and Cultural Resources
Herbicides Approved for Use on Public Lands							
2,4-D	Selective; foliar absorbed; postemergent; annual/perennial broadleaf weeds.	•	•	•	•	•	•
2,4-DP	Selective; foliar absorbed; postemergent; broadleaf weeds and woody species.	•	•		•	•	•
Asulam	Inhibits mitosis; controls growing grasses and certain broadleaf weeds.				•	•	
Atrazine	Selective; mostly root absorbed; inhibits photosynthesis.		•			•	
Bromacil	Non-selective; inhibits photosynthesis; controls weeds and brush.				•	•	•
Chlorsulfuron	Selective; inhibits enzyme activity; broadleaf weeds and grasses.	•			•	•	•
Clopyralid	Selective; mimics plant hormones; annual and perennial broadleaf weeds.	•	•		•	•	•
Dicamba	Growth regulator; annual and perennial broadleaf weeds, brush, and trees.	•			•	•	•
Diuron	Preemergent control; annual and perennial broadleaf weeds and grasses.				•	•	•
Fosamine ammonium	Inhibits bud and leaf formation; broadleaf weeds, brush, and trees.				•	•	•
Glyphosate	Non-selective; annual and perennial grasses and broadleaf weeds, sedges, shrubs, and trees.	•	•	•	•	•	•
Hexazinone	Foliar or soil applied; inhibits photosynthesis; annual and perennial grasses and broadleaf weeds, brush, and trees.	•	•		•	•	•
Imazapyr	Non-selective; preemergent and postemergent uses; absorbed through foliage and roots; annual and perennial broadleaf weeds, brush, and trees.	•	•	•	•	•	•
Mefluidide	Growth inhibitor; suppresses seed production of grasses, brush, and trees.				•	•	•
Metsulfuron methyl	Selective; postemergent; inhibits cell division in roots and shoots; annual and perennial broadleaf weeds, brush, and trees.	•	•		•	•	•
Picloram	Selective; foliar and root absorption; mimics plant hormones; certain annual and perennial broadleaf weeds, vines, and shrubs.	•	•		•	•	•
Simazine	Used selectively or as complete vegetation killer; requires much moisture for activation; inhibits photosynthesis.				•	•	•
Sulfometuron methyl	Broad-spectrum pre- and post-emergent control; inhibits cell division; grasses and broadleaf weeds.		•		•	•	•
Tebuthiuron	Relatively non-selective soil activated herbicide; pre- and post-emergent control of annual and perennial grasses, broadleaf weeds, and shrubs.	•			•	•	•
Triclopyr	Growth regulator; broadleaf weeds and woody plants.	•	•	•	•	•	•
Herbicides Proposed for Use on Public Lands							
Diflufenzopyr + Dicamba	Postemergent; inhibits auxin transport; broadleaf weeds.	•			•	•	•
Diquat	Non-selective and foliar applied.			•	◘	◘	◘
Fluridone	Aquatic herbicide to control submersed aquatic plants.			•			
Imazapic	Selective postemergent herbicide; inhibits broadleaf weeds and grasses.	•	•		•	•	•

• = Areas where USEPA approved registration exists and the BLM has approval to use, or proposes to use, the herbicide on public lands; ◘ = Areas where USEPA approved registration exists, but where the BLM does not propose to use on public lands.

that could be taken to feasibly attain, or approximate the BLM's objectives for herbicide use, as expressed in its programs, policies, and land use plans.

Alternatives were developed that (1) allow the BLM to continue its current use of 20 active ingredients in 14 western states, as authorized by earlier EIS RODs; 2) allow for the use of 14 active ingredients currently used by the BLM and four new active ingredients; 3) prohibit the use of herbicides; 4) prohibit the aerial application of herbicides; or 5) prohibit the use of sulfonylurea and other acetolactate synthase-inhibiting active ingredients. These program alternatives address many of the concerns raised during scoping, in particular the public's desire to see alternatives that have less emphasis on the use of herbicides, while still meeting the program's purpose and need. Alternatives were also developed to ensure that the BLM complied with federal, tribal, state, and local regulations.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under this alternative, the BLM would be able to continue to use 20 active ingredients approved for use in western states under the earlier EIS RODs for each state (Table 2-1; USDI BLM 1987a, 1988b, 1991b, 1992a). The BLM would also continue its activities conducted under Emergency Stabilization and Rehabilitation (ESR) and hazardous fuel reduction and that are evaluated by NEPA compliance documents prepared by local BLM field offices.

Based on recent (1999 through 2003) herbicide usage rates, approximately two-thirds of acres were treated with just three active ingredients: picloram, tebuthiuron, and 2,4-D, and the majority of treatments were in Idaho, Montana, and Utah (Table 2-4 and Figure 2-1). During that period, the BLM did not report treating any acres with 2,4-DP, asulam, atrazine, mefluidide, or simazine, and treated less than 50 acres annually using fosamine, and it is unlikely that the BLM would use these herbicides in the future since there are more suitable active ingredients available and approved for use to meet current needs.

Under this alternative, an estimated 305,000 acres would be treated annually using herbicides (Table 2-5), approximately twice the number of acres that have been treated in recent years (Figure 2-2). Estimates of the number of acres that would be treated under the No Action Alternative were developed based on information provided by BLM field offices throughout the western U.S., including Alaska, during summer 2002.

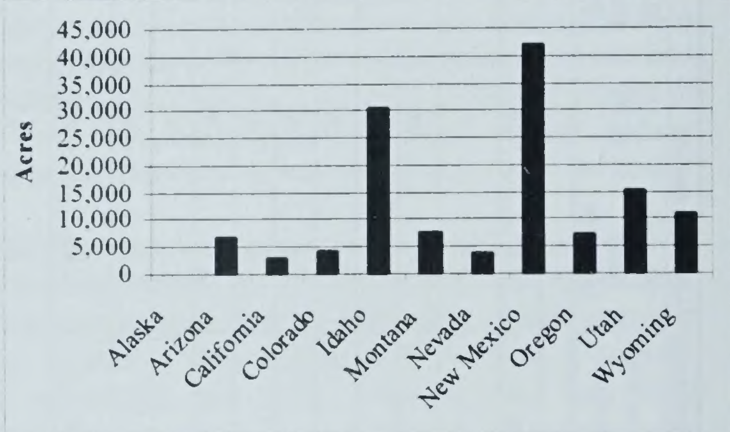

Figure 2-1. Average Number of Acres Treated Annually for Each BLM State Jurisdiction during 1997-2003.

In developing acreage estimates for all alternatives, it was assumed that if an acre was treated more than once using the same type of treatment during the same year, it would be counted once. If the acre was treated using two or more different methods during the same year (for example, fire use followed by herbicide treatment), each treatment would count as one acre. Thus, if an acre was treated using fire and herbicides during the same year, two acres would be counted as treated.

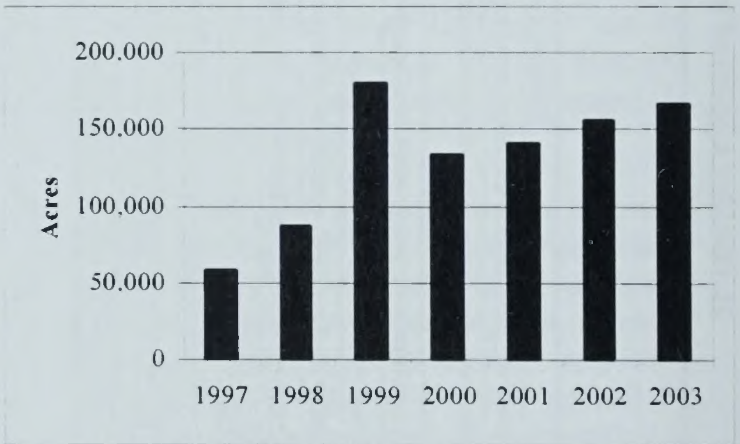

Figure 2-2. Summary of Acres Treated Using Herbicides during 1997-2003.

TABLE 2-4
Historic Use of Herbicides by the BLM and Projected Future Use of Herbicides by the BLM under Each Alternative (as a percentage of all acres treated using herbicides)

Active Ingredient	Historic Use (1999-2003)	Projected Use Under Each Alternative				
		No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
Herbicides Approved for Use on Public Lands						
2,4-D	15.1	18	18	0	33	20
2,4-DP	0	0	0	0	0	0
Asulam	0	0	0	0	0	0
Atrazine	0	0	0	0	0	0
Bromacil	0.3	<1	<1	0	<1	<1
Chlorsulfuron	0.5	1	1	0	1	0
Clopyralid	3.4	8	7	0	5	9
Dicamba	2.6	2	<1	0	<1	<1
Diuron	0.8	<1	<1	0	1	<1
Fosamine ammonium	0.01	0	0	0	0	0
Glyphosate	7.2	16	10	0	11	19
Hexazinone	0.1	<1	<1	0	<1	<1
Imazapyr	0.8	2	2	0	2	0
Mefluidide	0	0	0	0	0	0
Metsulfuron methyl	4.9	5	5	0	9	0
Picloram	16.2	16	15	0	26	16
Simazine	0	0	0	0	0	0
Sulfometuron methyl	11.0	<1	<1	0	2	0
Tebuthiuron	34.5	25	25	0	<1	25
Triclopyr	2.6	5	5	0	4	7
Herbicides Proposed for Use on Public Lands						
Diflufenzopyr + Dicamba	0	0	2	0	5	2
Diquat	0	0	<1	0	1	<1
Fluridone	0	0	<1	0	1	<1
Imazapic	0	0	8	0	5	0

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

This alternative represents the treatment of vegetation using herbicides in 17 western states, including Alaska. Under the Preferred Alternative, approximately 932,000 acres would be treated annually using herbicides based on the herbicide use projections developed by BLM field offices and funding projections for BLM vegetation treatment activities during the next decade. Based on field office projects, the majority of treatments would occur in Nevada, Idaho, Oregon, and Wyoming.

Under the Preferred Alternative, the BLM would only be able to use 14 active ingredients in the western U.S., including Alaska, that were approved for use in the earlier RODs and for which an analysis of their risks to humans and non-target plants and animals was conducted for this PEIS or by the Forest Service. These active ingredients are: 2,4-D, bromacil, chlorsulfuron, clopyralid, dicamba, diuron, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, sulfometuron methyl, tebuthiuron, and triclopyr.

The remaining six active ingredients currently approved for use by the BLM—2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine—have not been used, or their use has been limited to a very small

TABLE 2-5
Comparison of the Alternatives

Analysis Element	Alternative A (No Action)	Alternative B (Preferred Alternative)	Alternative C (No Use of Herbicides)	Alternative D (No Aerial Spraying of Herbicides)	Alternative E (No ALS-inhibiting Herbicides)
Approximate Number of Acres Treated Annually Using Herbicides:	305,000	932,000	0	530,000	466,000[1]
Treatment Planning:					
Focus of vegetation treatments[2]	Active	Active	Active	Active	Passive
Cost of treatment used as a selection criteria	No	No	No	No	Yes
Width of WUI	Variable	Variable	Variable	Variable	500 meters
Use of Treatments:					
Restrictions on acres treated using herbicides	Yes	No	Yes	No	Yes
Restrictions on types of herbicides used	Yes[3]	No	No	No	Yes[3]
Restrictions on use of herbicides in amphibian habitats[4]	No	No	No	No	Yes
Restrictions on use of herbicides in areas with culturally significant plant and wildlife resources[5]	No	No	No	No	Yes

[1] Assumes that the number of acres treated using herbicides is about half the number treated for Alternative B. although not explicitly stated in the proposal.
[2] Passive treatments involve suspension of activities that cause the loss of ecological integrity: all other treatments are active.
[3] Under Alternative A. limited to herbicides approved for use in each state based on earlier EIS RODs. Under Alternative E. sulfonylurea and other acetolactate synthase-inhibiting herbicides would not be used.
[4] Restrictions on use of herbicides in areas with amphibian use would be based on the ecological risk assessment. on federal. state. local. and tribal regulations. and on local experience in using herbicides.
[5] Use of herbicides in areas with culturally significant plant and animal resources would be based on human and ecological risk assessments: on federal. state. local. and tribal regulations. and on local experience in using herbicides.

number of acres, by the BLM for several years. Although the risks to humans from the use of these chemicals are not significant based on evaluations done for the earlier EISs and a review of the literature for this PEIS, the risks to non-target plants and animals, especially species of concern, have not been adequately evaluated. Should these chemicals be needed by the BLM in the future, the BLM would consult ERAs for these active ingredients prepared by the Forest Service or other agencies, if available, or conduct their own ERAs, to assess the risks to non-target species. This analysis would be supported by the appropriate NEPA documentation before these chemicals would be approved for use.

The BLM would be allowed to use four additional active ingredients in all 17 states included in this PEIS: imazapic, diquat, diflufenzopyr (in formulation with dicamba), and fluridone. In addition, the BLM would be able to use diflufenzopyr in the future as a stand-alone active ingredient if it becomes registered for herbicidal use. These active ingredients and formulations could only be applied for uses, and at application rates, specified on the label directions. Under the Preferred Alternative, the BLM would also be able to use new active ingredients that are developed in the future if: (1) they are registered by the USEPA for use on one or more land types (e.g., rangeland, aquatic, etc.) managed by the BLM; (2) the BLM determines that the benefits of use on public lands outweigh the risks to human health and the environment; and (3) they meet evaluation criteria to ensure that the decision to use the active ingredient is supported by scientific evaluation and NEPA documentation. These evaluation criteria are discussed in more detail in Appendix D.

Alternative C – No Use of Herbicides

Under Alternative C, the BLM would not be able to treat vegetation using herbicides and would not be able to use new chemicals that are developed in the future. The BLM would be able to treat vegetation using fire, and mechanical, manual, and biological control methods. A PER has been prepared that accompanies this PEIS and discusses these treatment methods, proposed treatment levels during the next 10 to15 years, and likely impacts to natural and social resources on public lands from these treatment methods (USDI BLM 2005a).

Alternative D – No Aerial Application of Herbicides

This alternative is similar to the Preferred Alternative in that it represents the treatment of vegetation using herbicides in 17 western states, including Alaska, and use of the same active ingredients as allowed under the Preferred Alternative. Under Alternative D, however, only ground-based techniques would be used to apply herbicides and no aerial applications of herbicides would be allowed; this would reduce the risk of spray drift impacting non-target areas. Based on information obtained from field offices, an estimated 55% of herbicide treatments would involve use of ground-based methods during the next 10 years. Thus, the BLM would treat approximately 530,000 acres annually using herbicides under this alternative. In comparison, during 2001 to 2003, approximately 55% of herbicide treatments were conducted aerially and 45% using ground-based methods.

Similar to the Preferred Alternative, the BLM would be able to use new active ingredients that are developed in the future if: (1) they are registered by the USEPA for use on one or more land types (e.g., rangeland, aquatic, etc.) managed by the BLM; (2) the BLM determines that the benefits of use on BLM lands outweigh the risks to human health and the environment; and (3) they meet evaluation criteria to ensure that the decision to use the active ingredient is supported by scientific evaluation and NEPA documentation.

Alternative E – No Use of Sulfonylurea and other Acetolactate Synthase-inhibiting Active Ingredients

This alternative was developed based on an alternative proposal for vegetation management on public lands submitted by the American Lands Alliance, an alliance of several environmental and conservation groups. The full text of the proposal is in Appendix G.

Under Alternative E, the BLM would not use sulfonylurea and other acetolactate synthase-inhibiting active ingredients approved in the earlier RODs, which are chlorsulfuron, imazapyr, metsulfuron methyl, and sulfometuron methyl. During 1999 to 2000, these active ingredients comprised approximately 28% of the active ingredients used by the BLM. Since 2001, however, these active ingredients have comprised approximately 8% of the active ingredients used by the BLM. The BLM would be able to use 10 active ingredients in the 17 western states, including Alaska, that were approved for use in the earlier RODs and for which an analysis of their risks to humans and non-target plants and animals was conducted for this PEIS. These active ingredients are: 2,4-D, bromacil, clopyralid, dicamba, diuron, glyphosate, hexazinone, picloram, tebuthiuron, and triclopyr. The six other active ingredients currently approved for use by the BLM—2,4-DP, atrazine, asulam, fosamine, mefluidide, and simazine—would not be used unless guidelines given for the Preferred Alternative were met.

In addition, the BLM would be allowed to use three additional active ingredients in all 17 states: diquat, diflufenzopyr (if it becomes registered for herbicidal use), and fluridone. In addition, the BLM would be able to use a formulation of diflufenzopyr and dicamba. These active ingredients and formulations could only be applied for uses, and at application rates, specified on the label directions.

Under Alternative E, the BLM would be able to use new active ingredients that are developed in the future if they follow protocols for use of new active ingredients identified under the Preferred Alternative and do not contain sulfonylurea and imidazolinone chemistry and other acetolactate synthase-inhibiting compounds.

Under this alternative, the BLM would treat approximately 466,000 acres annually using herbicides (Table 2-5). Spot herbicide treatments would be favored over broadcast treatments. Herbicides use would not be encouraged in areas populated by amphibians. To protect Native American and Alaska Native resources, the BLM would establish herbicide-free zones around culturally significant plant and wildlife resources.

This alternative would place greater emphasis on passive restoration, by prohibiting or restricting activities such as livestock grazing, OHV use, logging, or oil and gas development in areas where these activities have promoted a less desirable vegetation community, or increased erosion. Since these activities are allowed under FLPMA, however, restrictions on their use would only be considered to the extent they are consistent with BLM vegetation and land use management practices (e.g., excluding grazing animals from recently seeded areas).

Alternatives Considered but Not Further Analyzed

Several other alternatives were identified during public scoping and reviewed by the interdisciplinary team (ENSR 2002). In most cases, these alternatives would not fulfill the purpose and need for the project, are inconsistent with BLM or other federal, state, or local policies or regulations, or are not practical based on likely funding for vegetation treatments. The alternatives that were considered but not further analyzed are:

- **Treat up to 25 million acres annually**. This alternative was excluded from analysis because the BLM felt it was highly unlikely that the agency would have sufficient funding during the next 10 to 15 years to treat up to 25 million acres annually.
- **Treat fewer acres than are currently treated**. Under this alternative, fewer acres would be treated annually than would occur under the No Action Alternative (Alternative A). Given that current treatment levels have been insufficient to control unwanted vegetation and reduce the risk of wildfire to life and property on public lands, this alternative would not meet the project purpose and need.
- **Do not treat competing and unwanted vegetation**. Under this alternative, the BLM would continue ESR activities, HFR activities that did not involve the treatment of vegetation, and passive vegetation management, but would not actively treat competing and unwanted vegetation. This alternative was eliminated because it would not control the spread of unwanted vegetation, which could adversely impact land health on public lands and increase the risk of loss of life and property due to fires.
- **Treat only acres needed to protect human health and safety**. Under this alternative, the BLM would only treat those acres needed to protect human health and safety. Nearly all of these acres would be associated with hazardous fuels reduction near homes and other developments in the WUI. This alternative was eliminated because it would not maintain or improve land health on most public lands.
- **Do not conduct hazardous fuels treatments.** Like the preceding alternative, this alternative was excluded because it does not restore the health of fire-adapted ecosystems. The buildup of hazardous fuels that have led to catastrophic wildfires and significant impacts to air quality, water resources, human health, and other resources.
- **Revegetate with native vegetation**. Under this alternative, only native vegetation would be used to restore fire-impacted and other degraded public lands. This alternative was eliminated because it has been incorporated into the proposed action to the extent practical.
- **Exclude logging, grazing, OHV use, and energy/mineral development on public lands**. This alternative was eliminated because FLPMA requires that BLM manage public lands for multiple uses including those listed. Field offices, however, can limit these activities, consistent with its land use plan where it benefits vegetation management and land health and complies with the FLPMA.

The rest of this chapter includes actions that would be common to all alternatives.

Herbicide Treatment Standard Operating Procedures

This section identifies standard operating procedures (SOPs) that would be followed by the BLM under all alternatives to ensure that risks to human health and the environment from herbicide treatment actions were kept to a minimum.

Prevention, early detection, and rapid response are the most cost effective methods for weed control. Prevention, early detection, and rapid response strategies that reduce the need for vegetative treatments for noxious weeds should lead to a reduction in the number of acres treated using herbicides in the future by reducing or preventing their establishment. However, once weed populations become established, infestations can increase and expand in size.

Weeds colonize highly disturbed ground and invade plant communities that have been degraded, but are also capable of invading intact communities. The BLM is required to develop a noxious weed risk assessment when it is determined that an action may introduce or spread noxious weeds or when known habitat exists (USDI BLM 1992b). If the risk is moderate or high, the BLM may have to modify the project to reduce the likelihood of weeds infesting the site, and to identify control measures to be implemented if weeds do infest the site.

To prevent the spread of weeds, the BLM takes actions to minimize the amount of existing non-target vegetation that is disturbed or destroyed during project or vegetation treatment actions. Disturbed areas may be reseeded or planted with desirable vegetation when the native plant community cannot recover and occupy the site sufficiently. Prevention actions include the use of weed-free seed, hay, mulch, gravel, soil, and mineral materials on public lands where there is a state or county program in place. Plant materials that are brought onto public lands should be free of disease. It is recommended that grazing animals be fed only weed-free forage for a minimum of 96 hours prior to going onto public lands. Grooming of pets or other privately-owned animals to remove weed seeds prior to entering public lands is also recommended.

Conditions that enhance invasive species abundance should be addressed, such as excessive disturbance associated with road maintenance, poor grazing management, and high levels of recreational use. If livestock grazing is managed to maintain the vigor of native perennial plants, especially grasses, the chance of weeds invading rangeland is much less. By carefully managing recreational use and educating the public on the potential impacts of recreational activities on vegetation, the amount of damage to native vegetation and soil can be minimized at high use areas, such as campgrounds and OHV trails. Early detection in recreation areas is focused on roads and trails, where much of the weed spread occurs. In addition, power washing or using compressed air to clean vehicles and equipment before going onto public lands helps to reduce the spread of weeds.

BLM Manual 9011 outlines the policies and BLM Handbook H-9011-1 (*Chemical Pest Control*; USDI BLM 1988e) outlines the procedures for use of herbicides on public lands. As part of policy, the BLM is required to thoroughly evaluate the need for chemical treatments and their potential for impact on the environment. The BLM is required to use only USEPA-registered herbicides that have been properly evaluated under NEPA, and to carefully follow label directions and additional BLM requirements.

An operational plan is developed and updated for each herbicide project. The plan includes information on project specifications, key personnel responsibilities, and communication, safety, spill response, and emergency procedures. For application of herbicides not approved for aquatic use, the plan should also specify minimum buffer widths between treatment areas and water bodies. Recommended widths are provided in BLM Handbook H-9011-1, but actual buffers are site and herbicide active ingredient specific, and are determined based on a scientific analysis of environmental factors, such as climate, topography, vegetation, and weather; timing and method of application; and herbicide risks to humans and non-target species. Recommended buffer widths for each herbicide active ingredient under different application scenarios are listed later in this chapter under Mitigation. Table 2-6 summarizes important SOPs that should be used when applying herbicides to help protect resources of concern on public lands.

Special Precautions

Special Status Species

Federal policies and procedures for protecting federally-listed threatened and endangered plant and animal species, and species proposed for listing, were established by the ESA of 1973 and regulations issued pursuant to the Act. The purposes of the Act are to provide mechanisms for the conservation of threatened and endangered species and their habitats. Under the ESA, the Secretary of the Interior is required to determine which species are threatened or endangered and to issue recovery plans for those species.

Section 7 of the ESA specifically requires all federal agencies to use their authorities in furtherance of the ESA to carry out programs for the conservation of listed species, and to ensure that no agency action is likely to jeopardize the continued existence of a listed species or adversely modify critical habitat. Policy and guidance (BLM Manual 6840) also stipulates that species proposed for listing is managed at the same level of protection as listed species.

The BLM state directors may designate sensitive species in cooperation with their respective state. These sensitive species (special status) must receive, at a minimum, the same level of protection as federal candidate species. The BLM will also carry out management for the conservation of state-listed species, and state laws protecting these species shall apply to all BLM programs and actions to the extent that they are consistent with FLPMA and other federal laws.

The BLM consulted with the USFWS and NOAA Fisheries during development of the PEIS as required under Section 7 of the ESA. As part of this process, the BLM prepared a formal consultation package that included a description of the program; species listed as threatened or endangered, species proposed for listing, and critical habitats that could be affected by the program; and a BA that evaluated the likely impacts to listed species, species proposed for listing, and critical habitats from the proposed vegetation treatment program. Over 300 species were evaluated in the BA. The BA also provides broad guidance on a programmatic level for actions that would be taken by the BLM to avoid adversely impacting species or result in the destruction of critical habitat (USDI BLM 2005b).

Before any vegetation treatment or ground disturbance occurs, BLM policy requires a survey of the project site for species listed or proposed for listing, or special status species. This is done by a qualified biologist consulting state and local databases, and visiting the site at the appropriate season. If a proposed project may affect a proposed or listed species or its critical habitat, the BLM consults with the USFWS and/or NOAA Fisheries. A project with a "may affect, likely to adversely affect" determination requires formal consultation and receives a Biological Opinion from the USFWS and/or NOAA Fisheries. A project with a "may affect, not likely to adversely affect" determination requires informal consultation and receives a concurrence letter from USFWS and/or NOAA Fisheries.

Wilderness Areas

Wilderness areas, designated by Congress, are defined by the Wilderness Act of 1964 as places "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." The BLM manages 175 Wilderness Areas encompassing 7.2 million acres (USDI BLM 2005c).

Activities allowed in wilderness areas are identified in wilderness management plans prepared by the BLM. The BLM does not ordinarily treat vegetation in wilderness areas, but will control invasive and noxious weeds when they threaten lands outside wilderness area or are spreading within the wilderness and can be controlled without serious adverse impacts to wilderness values.

Management of vegetation must be directed toward retaining the natural character of the environment. Tree and shrub removal is usually not allowed except for fire, insect, or disease control. Reforestation is generally prohibited except to repair damage caused by humans in areas where natural reforestation is unlikely. Only native species and primitive methods, such as hand planting, are allowed for reforestation.

Tools and equipment may be used for vegetation management when they are the minimum amount necessary for the protection of the wilderness resource. Motorized tools may only be used in special or emergency cases involving the health and safety of wilderness visitors, or the protection of wilderness values.

Habitat manipulation using mechanical or chemical means may be allowed to protect threatened and endangered species and to correct unnatural conditions, such as weed infestations, resulting from human influence.

The BLM also manages a total of 591 Wilderness Study Areas (WSAs) encompassing 14.6 million acres. These are areas that have been determined to have wilderness characteristics worthy of consideration for wilderness designation. The BLM's primary goals in WSAs are to manage them so as to not impair their wilderness values and to maintain their suitability for preservation as wilderness until Congress makes a determination on their future.

In WSAs, the BLM must foster a natural distribution of native species of plants and animals by ensuring that ecosystems and processes continue to function naturally.

Cultural Resources

The effects of BLM actions on cultural resources are addressed through compliance with the National Historic Preservation Act, as implemented through a national Programmatic Agreement (*Programmatic Agreement among the Bureau of Land Management, the*

TABLE 2-6
Standard Operating Procedures for Applying Herbicides

Resource Element	Standard Operating Procedure
Guidance Documents	BLM Handbook H-9011-1 (*Chemical Pest Control*); and manuals 1112 (*Safety*), 9011 (*Chemical Pest Control*), 9012 (*Expenditure of Rangeland Insect Pest Control Funds*), 9015 (*Integrated Weed Management*), and 9220 (*Integrated Pest Management*)
General	• Prepare spill contingency plan in advance of treatment. • Conduct pretreatment survey before applying herbicides. • Select chemical that is least damaging to environment while providing the desired results. • Review, understand, and conform to the "Environmental Hazards" section on the herbicide label. This section warns of known pesticide risks to the environment and provides practical ways to avoid harm to organisms or to the environment. • Consider surrounding land use before assigning aerial spraying as a method and avoid aerial spraying near agricultural or densely populated areas. • Use the proper amount of chemical needed to achieve results and follow product label for use and storage. • Have licensed applicator apply herbicides. • Use only USEPA-approved herbicides and follow product label directions and "advisory" statements. • Keep copy of Material Safety Data Sheets (MSDSs) at work sites. • Keep records of each application, including the active ingredient, formulation, application rate, date, time, and location. • Avoid aerial spraying during periods of adverse weather conditions (snow or rain imminent, fog, or air turbulence). • Helicopter applications should be made at an airspeed of 40 to 50 miles per hour (mph), and at about 30 to 45 feet above ground.
Land Use	• Consider surrounding land uses before aerial spraying. • Comply with herbicide-free buffer zones to ensure that drift will not affect crops or nearby residents/landowners. • Post treated areas and specify reentry or rest times, if appropriate.
Air Quality See Manual 7000 (*Soil, Water, and Air Management*)	• Consider effects of wind, humidity, temperature inversions, and heavy rainfall on herbicide effectiveness and risks. • Use drift reduction agents, as appropriate, to reduce the drift hazard. • Select proper application equipment and apply herbicides in favorable weather conditions to minimize drift.
Soil See Manual 7000 (*Soil, Water, and Air Management*)	• Minimize treating areas where herbicide runoff is likely, such as steep slopes when heavy rainfall is expected. • Minimize use of herbicides with high soil mobility, such as in areas where soil type would contribute to soil mobility. • Do not apply granular herbicides on slopes of more than 15% where there is the possibility of runoff carrying the granules into non-target areas.

TABLE 2-6 (Cont.)
Standard Operating Procedures for Applying Pesticides

Resource Element	Standard Operating Procedure
Water Resources See Manual 7000 (*Soil, Water, and Air Management*)	• Consider climate, soil type, slope, and vegetation type in determining contamination risk. • Conduct mixing and loading operations in an area where an accidental spill would not contaminate an aquatic body. • Do not rinse spray tanks in or near water bodies. • Do not broadcast pellets where there is danger of contaminating water supplies. • Minimize treating areas with high risk for groundwater contamination. • Maintain buffers between treatment area and water bodies.
Streams and Wetlands	• Use appropriate herbicide-free buffer zone for herbicides not labeled for aquatic use based on risk assessment guidance with minimum widths of 100 feet for aerial, 25 feet for vehicle, and 10 feet for hand spray applications.
Vegetation See Handbook H-4410-1 (*National Range Handbook*), and manuals 5000 (*Forest Management*) and 9015 (*Integrated Weed Management*)	• Use drift reduction agents, as appropriate, to reduce the drift hazard to non-target species. • Refer to the herbicide label when planning revegetation to ensure that subsequent vegetation would not be injured following application of the herbicide. • Aerially applied treatments must be turned off at the completion of spray runs and during turns to start another spray run. • Consider site characteristics, environmental conditions, and application equipment in order to minimize damage to non-target vegetation.
Fish See manuals 6500 (*Wildlife and Fisheries Management*) and 6780 (*Habitat Management Plans*)	• Use appropriate buffer zones based on label and risk assessment guidance. • Minimize treatments near fish bearing water bodies during periods when fish are in life stages most sensitive to the herbicide(s) used. • Use appropriate application equipment/method near water bodies if the potential for off-site drift exists. • Use herbicides least toxic to fish, yet still effective. • Treat only that portion of the aquatic system necessary to achieve acceptable vegetation management. • Select appropriate application method to minimize the potential for injury to desirable vegetation and aquatic organisms. • Follow water use restrictions presented on the herbicide label.
Wildlife See manuals 6500 (*Wildlife and Fisheries Management*) and 6780 (*Habitat Management Plans*)	• Minimize treatments during nesting and other critical periods for birds and other wildlife. • Use herbicides of low toxicity to wildlife, where feasible. • Use timing restrictions, as specified on the herbicide label, to minimize impacts to wildlife.
Threatened and Endangered Species See Manual 6840 (*Special Status Species*)	• Survey for endangered, threatened, and sensitive species if project could impact these species. • Avoid treating vegetation during time-sensitive periods (e.g., nesting and migration) for species of concern in area to be treated.
Livestock See Handbook H-4120-1 (*Grazing Management*)	• Use herbicides of low toxicity to livestock, where feasible. • Avoid accidental direct spray and spill conditions to reduce the largest potential impacts. • As directed by the herbicide label, remove livestock from treatment sites prior to herbicide application, where feasible. • Use the typical application rate, rather than the maximum application rate where practical, to reduce risk to livestock for most herbicides. • Take into account the different types of application equipment and methods, where possible, to reduce the probability of contamination of non-target food and water sources. • Notify permittees of livestock feeding restrictions in treated areas if necessary. • Notify permittees of the project to improve coordination and avoid potential conflicts and safety concerns during implementation of the treatment.

TABLE 2-6 (Cont.)
Standard Operating Procedures for Applying Pesticides

Resource Element	Standard Operating Procedure
Wild Horses and Burros	• Minimize using herbicides in areas grazed by wild horses and burros. • Use herbicides of low toxicity to wild horses and burros, where feasible. • Avoid accidental direct spray and spill conditions to reduce the largest potential impacts. • Remove wild horses and burros from target sites before herbicide application, if feasible. • Use the typical application rate, rather than the maximum application rate where practical, to reduce risk to wild horses and burros for most herbicides. • Take into account the different types of application equipment and methods, where possible, to reduce the probability of contamination of non-target food and water sources.
Cultural Resources and Paleontological Resources See handbooks H-8120-1 (*Guidelines for Conducting Tribal Consultation*) and H-8270-1 (*General Procedural Guidance for Paleontological Resource Management*), and manuals 8100 (*Cultural Resource Management*), 8120 (*Tribal Consultation Under Cultural Resource Authorities*), and 8270 (*Paleontological Resource Management*). See also: *Programmatic Agreement among the Bureau of Land Management, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers Regarding the Manner in Which BLM Will Meet Its Responsibilities Under the National Historic Preservation Act.*	• Follow standard procedures for compliance with Section 106 of the National Historic Preservation Act as implemented through the *Programmatic Agreement among the Bureau of Land Management, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers Regarding the Manner in Which BLM Will Meet Its Responsibilities Under the National Historic Preservation Act* and state protocols or 36 CFR Part 800, including necessary consultations with State Historic Preservation Officers and interested tribes. • Follow BLM Handbook H-8270-1 (*General Procedural Guidance for Paleontological Resource Management*) to determine known Condition I and Condition 2 paleontological areas, or collect information through inventory to establish Condition 1 and Condition 2 areas, determine resource types at risk from the proposed treatment, and develop appropriate measures to minimize or mitigate adverse impacts. • Consult with tribes to locate any areas of vegetation that are of significance to the tribe and that might be affected by herbicide treatments. • Work with tribes to minimize impacts to these resources. • Follow guidance under Human Health and Safety in areas that may be visited by Native peoples after treatments.
Visual Resources See handbooks H-8410-1 (*Visual Resource Inventory*) and H-8431-1 (*Visual Resource Contrast Rating*), and manual 8400 (*Visual Resource Management*)	• Minimize use of broadcast foliar applications in sensitive watersheds to reduce the creation of large areas of browned vegetation. • Minimize herbicide drift. • Design activities to repeat the form, line, color, and texture of the natural landscape character conditions to meet established Visual Resource Management (VRM) objectives.
Wilderness and Other Special Areas See handbooks H-8550-1 (*Management of Wilderness Study Areas (WSAs)*), and H-8560-1 (*Management of Designated Wilderness Study Areas*), and Manual 8351 (*Wild and Scenic Rivers*)	• Revegetate sites with native species if there is no reasonable expectation of natural regeneration. • Use chemicals only when they are the minimum method necessary to control weeds that are spreading within the wilderness or threaten lands outside the wilderness. • Encourage backcountry pack and saddle stock users to feed their livestock only weed-free feed for several days before entering a wilderness area. • Provide educational materials at trailheads and other wilderness entry points to educate the public on the need to prevent the spread of weeds.

TABLE 2-6 (Cont.)
Standard Operating Procedures for Applying Pesticides

Resource Element	Standard Operating Procedure
Recreation See Handbook H-1601-1 (*Land Use Planning Handbook, Appendix C*)	• Adhere to entry restrictions identified on the herbicide label for public and worker access. • Post signs noting exclusion areas and the duration of exclusion, if necessary. • Use herbicides during periods of low human use, where feasible.
Rights-of-way	• Use, update, or develop site-specific vegetation management plans for ROW that cross public lands. • Contact the local BLM office before implementing vegetation management activities on public land. Notification should be made as far in advance of the planned date of on-the-ground implementation as is reasonably possible. • Consult with the appropriate BLM office regarding the presence of natural resources and features and appropriate buffers or other mitigation measures. • Coordinate vegetation management activities where joint or multiple use of a ROW exists. • Notify other public land users which are within or adjacent to the ROW proposed for treatment.
Human Health and Safety	• Establish buffer between treatment areas and human residences based on guidance given in the HHRA, with a minimum buffer of ¼ mile for aerial applications and 100 feet for ground applications unless a written waiver is granted. • Post treated areas with appropriate signs at common public access areas. • Observe restricted entry intervals specified by the herbicide label. • Provide public notification in newspapers or other media where potential exists for public exposure. • Have a copy of Material Safety Data Sheets at work site. • Notify local emergency personnel of proposed treatments. • Contain and clean up spills and request help as needed. • Secure containers during transport. • Follow label directions for use and storage. • Dispose of unwanted herbicides promptly and correctly.

Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers Regarding the Manner in Which BLM Will Meet Its Responsibilities Under the National Historic Preservation Act) and state-specific protocol agreements with SHPOs. The BLM's responsibilities under these authorities are addressed as early in the vegetation management project planning process as possible.

The BLM meets its responsibilities for consultation and government-to-government relationships with Native American tribes by consulting with appropriate tribal representatives prior to taking actions that affect tribal interests. The BLM's tribal consultation policies are detailed in BLM Manual 8120 (*Tribal Consultation Under Cultural Resource Authorities)* and Handbook H-8120-1 (*Guidelines for Conducting Tribal Consultation)*. The BLM consulted with Native American tribes and Alaska Native groups during development of this PEIS. Information gathered on important tribal resources and potential impacts to them from herbicide treatments is presented in the analysis of impacts from proposed treatments.

When conducting vegetation treatments, field office personnel consult with relevant parties (including tribes, native groups, and SHPOs), assess the potential of the proposed treatment to affect cultural and subsistence resources, and devise inventory and protection strategies suitable to the types of resources present and the potential impacts to them.

Herbicide treatments, for example, are unlikely to affect buried cultural resources, but might have a negative effect on traditional cultural properties comprised of plant foods or materials significant to local tribes and native groups. These treatments require inventory and protection strategies that reflect the different potential of each treatment to affect various types of cultural resources.

Impacts to significant cultural resources are avoided through project redesign or are mitigated through data recovery, recordation, monitoring, or other appropriate measures. When cultural resources are discovered during vegetation treatment, appropriate actions are taken to protect these resources.

Monitoring

Monitoring ensures that vegetation management is an adaptive process that continually builds upon past successes and learns from past mistakes. The regulations of 43 CFR 1610.4-9 require that land use plans establish intervals and standards for monitoring and evaluation of land management actions. During preparation of implementation plans, treatment objectives, standards, and guidelines are stated in measurable terms, where feasible, so that treatment outcomes can be measured and evaluated, and used to guide future treatment actions. This ensures that vegetation treatment processes are effective, adaptive, and based on prior experience.

BLM monitoring activities range from site evaluations for local projects, to the BLM Legacy Program, which is an outgrowth of the need to provide current BLM field managers and specialists with an opportunity to learn about past land management practices and land treatments, and to evaluate the results of those practices 25 or more years later. The Legacy Program is intended to bring together current land managers and specialists with those retired and active employees who conducted the land treatments in the past. The underlying philosophy of the program is that if BLM land managers do not learn from the past, they are bound to repeat the mistakes in the future.

The BLM recognizes that many sites treated in the past lack monitoring data. In many cases, project monitoring was not done, was done sporadically without consistent documentation, or was done but the records were lost or destroyed.

To correct past problems, and make monitoring data more useful, monitoring must be designed to determine if the treatment was effective (effectiveness monitoring), and to ensure that the treatment did not adversely impact other resources. Post-treatment monitoring generally occurs within 2 years after treatment and, where applicable, should include a water monitoring program to determine the effectiveness of buffer strips and impacts, if any, to water quality.

In addition, the results of monitoring should be made available to interested parties. A website with links to geospatial and other datasets will ensure that inventory data, and treatment methods and results, are shared easily. The BLM has a website, www.blm.gov, with links to BLM programs, such as the weed program, http://www.blm.gov/weeds, and other data sources, including geospatial data. Most state offices are tied into state data clearinghouses that contain useful information gathered by federal, state, and local agencies.

Coordination and Education

Several laws and Executive Orders set forth public involvement requirements, including involving the public in the environmental analysis, land use planning, and implementation decision-making processes to address local, regional, and national interests (USDI BLM 2000f).

The BLM is ultimately responsible for land use plan decisions, including vegetation management, on public lands. The BLM has found, however, that collaborative relationships with stakeholders, including individuals, communities, and governments, improves communication, develops a greater understanding of different perspectives, and helps to find solutions to issues and problems. Input from the public and government agencies has been critical during development of this PEIS.

The NEPA process ensures that the public is allowed input into vegetation management actions on public lands. For treatment projects requiring an EA or EIS, the BLM must notify the public of the proposed project and give the public the opportunity to comment on the site-specific analysis done for the project. Treatment actions may be modified in response to comments posed by the public. The public may also be invited to observe treatment activities and participate in project monitoring.

Public lands are often commingled with private lands, or lands under the jurisdiction of tribal, state, or local governments or other federal agencies. Multijurisdictional planning assists land use planning efforts when there is a mix of land ownership and government authorities, and there are opportunities to develop complementary decisions across jurisdictional boundaries.

Examples of these types of decisions include development of weed treatment programs involving the

BLM and nearby private landowners, or coordination with parties who hold land use authorizations including ROW, leases, permits, or easements. Many BLM weed coordinators hold classes for public land users to make them aware of the problem and to solicit their help in reporting new weed infestations.

It is critical that the BLM notify potentially affected parties of treatment activities that occur on public lands. This can be done through a letter, phone call, meeting, newsletter, newspaper article, or other medium to ensure that potentially affected parties can comment on the proposed action and take any steps needed to protect life and property from proposed actions.

Because vegetation treatments have a direct effect on the productivity and use of grazing allotments, coordination and consultation with the grazing permittee(s), and any other interested parties affected by a vegetation treatment, would be necessary.

Mitigation

Table 2-7 identifies the means the BLM proposes to mitigate adverse environmental impacts identified in Chapter 4 (Environmental Consequences). As defined by CEQ regulation 1508.20, mitigation includes: 1) avoiding the impact altogether by not taking a certain action or parts of an action; 2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; 3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and 5) compensating for the impact by replacing or providing substitute resources or environments.

Numerous mitigation measures were developed from information provided in ERAs. The measures listed below would apply to plants, animals, and other resources at the programmatic level in all 17 western states. However, local BLM field offices could use interactive spreadsheets and other information contained in the ERAs to develop more site-specific mitigation and management plans based on local conditions (e.g., soil type, rainfall, vegetation type, herbicide treatment method, and herbicide application rate). It is possible that mitigation measures would be less restrictive than those listed below if local site conditions were evaluated using the ERAs when developing project-level mitigation plans. In addition, the BLM may be able to use timing restrictions or similar practices to reduce the level of risk to an acceptable level. For example, it may be necessary to apply diuron at the typical herbicide application rate to ensure protection of a migratory bird species. However, it may be acceptable to use the maximum application rate during periods of the year when the bird has migrated from the treatment area. Local field managers would consult the ERAs and review species life history requirements before making these decisions to ensure that birds and other resources are adequately protected.

Summary of Impacts by Alternatives

Table 2-8 summarizes the likely effects of vegetation treatments using herbicides for each alternative. Information contained in this table is discussed in more detail in Chapter 4 (Environmental Consequences).

TABLE 2-7
Mitigation Measures

Resource	Mitigation Measures
Air Quality	None proposed.
Soil Resources	None proposed.
Water Resources and Quality	• Avoid accidental direct spray and spill conditions to reduce the largest potential impacts. Use the typical application rate, rather than the maximum application rate, to reduce risk for most herbicides, where practical. • Reduce the size of the application area, when possible. • Establish appropriate (herbicide specific) buffer zones to downstream waterbodies, habitats, or species/populations of interest (see Appendix C, Table C-16).
Wetland and Riparian Areas	• See mitigation for Water Resources and Quality and Vegetation.
Vegetation	• Minimize the use of terrestrial herbicides (especially bromacil, diuron, and sulfometuron methyl) in watersheds with downgradient ponds and streams if potential impacts to aquatic plants exist. • Establish appropriate (herbicide specific) buffer zones to downstream waterbodies, habitats, or species/populations of interest. Consult the ERAs for more specific information on appropriate buffer distances under different soil, moisture, vegetation, and application scenarios. • To protect TES plant species, implement all mitigation measures for plants presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment*. • Where feasible, implement the mitigation measures for plants presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* to minimize impacts to non-TES special status plants, unless treatments are specifically designed to improve habitats for these species. • Consider manual spot applications over broadcast spraying where populations of special status plant species occur. • At the local level, consider effects to special status plant species when designing herbicide treatment programs.
Fish and Other Aquatic Organisms	• Regulate the use of diquat in waterbodies that have native fish and aquatic resources. • Regulate the use of terrestrial herbicides in watersheds, which have characteristics suitable for potential surface runoff, with fish-bearing streams during periods when fish are in life stages most sensitive to the herbicide(s) use. • To protect TES fish and other aquatic organisms, implement all mitigation measures for aquatic animals presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment*. • Establish appropriate herbicide-specific buffer zones to waterbodies, habitats, or fish or other aquatic species of interest. • At the local level, consider effects to special status fish and other aquatic organisms when designing treatment programs.
Wildlife	• Minimize potential risks to terrestrial wildlife by applying dicamba, diuron, glyphosate, hexazinone, tebuthiuron, and triclopyr at the typical application where feasible. • Minimize the size of application areas, where practical, when applying 2,4-D, bromacil, diuron, and Overdrive® to limit impacts to wildlife, particularly through the contamination of food items. • Where practical, limit glyphosate and hexazinone to spot applications in rangeland and wildlife habitat areas to avoid contamination of wildlife food items.

TABLE 2-7
Mitigation Measures (Cont.)

Resource	Mitigation Measures
Wildlife (Cont.)	• When using bromacil and diuron, potential off-site contamination can be reduced through the use of appropriate buffer zones (see Vegetation section of Chapter 4). • To protect TES wildlife species, implement all mitigation measures for terrestrial animals presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment.* • Where feasible, implement the mitigation measures for terrestrial animals presented in the BA to minimize impacts to non-TES species, unless treatments are specifically designed to improve habitats for these species. Refer to mitigation for a similar size and type of species, of the same trophic guild as the non-TES species in question. • At the local level, consider effects to special status terrestrial wildlife species when designing treatment programs.
Livestock	• Minimize potential risks to livestock by applying diuron, glyphosate, hexazinone, tebuthiuron, and triclopyr at the typical application rate, where feasible. • Consider the size of the application area when making applications of 2,4-D, bromacil, dicamba, diuron, Overdrive®, picloram, and triclopyr in order to reduce potential impacts to livestock. • Adhere to grazing restriction and use of livestock that have grazed in herbicide treated areas as specified on the herbicide label. • Where feasible, limit glyphosate and hexazinone to spot applications in rangeland. • When using bromacil and diuron, potential off-site contamination can be reduced through the use of appropriate buffer zones (see Vegetation section of Chapter 4).
Wild Horses and Burros	• Minimize potential risks to wild horses and burros by applying diuron, glyphosate, hexazinone, tebuthiuron, and triclopyr at the typical application rate, where feasible. • Consider the size of the application area when making applications of 2,4-D, bromacil, dicamba, diuron, Overdrive®, picloram, and triclopyr in order to reduce potential impacts to livestock. • Adhere to grazing restriction and use of livestock that have grazed in herbicide treated areas as specified on the herbicide label. • Where feasible, limit glyphosate and hexazinone to spot applications in rangeland. • When using bromacil and diuron, potential off-site contamination can be reduced through the use of appropriate buffer zones (see Vegetation section of Chapter 4). • Do not apply 2,4-D, bromacil, or diuron at typical application rates, and these herbicides and Overdrive® and hexazinone at maximum application rates, in HMAs during the peak foaling season (March though June, and especially in May and June).
Paleontological and Cultural Resources	• Minimize potential risks in traditional use areas by applying 2,4-D, bromacil, diquat, diuron, fluridone, hexazinone, tebuthiuron, and triclopyr at the typical application rate where feasible. • Avoid applying bromacil or tebuthiuron aerially in known traditional use areas. • Limit diquat applications to areas away from high residential and traditional use areas to reduce risks to Native Americans and Alaska Natives.
Visual Resources	None proposed.
Wilderness and Other Special Areas	Mitigation measures that may apply to wilderness and other special area resources are associated with human and ecological health and recreation. Please refer to the Vegetation, Fish and Other Aquatic Resources, Wildlife Resources, Recreation, and Human Health and Safety sections of Chapter 4.
Recreation	Mitigation measures that may apply to recreational resources are associated with human and ecological health. Please refer to the Vegetation, Fish and Other Aquatic Resources, Wildlife Resources, and Human Health and Safety sections of Chapter 4.

TABLE 2-7
Mitigation Measures (Cont.)

Resource	Mitigation Measures
Social and Economic Values	• To the degree possible within the law, hire local contractors and workers to assist with herbicide application projects. • To the degree possible within the law, purchase materials and supplies, including chemicals, for herbicide treatment projects through local suppliers. • Provide public educational programs on the herbicides proposed for local use to minimize fears based on lack of information.
Human Health and Safety	• Use the typical application rate, where feasible, when applying 2,4-D, 2,4-DP, atrazine, bromacil, diquat, diuron, fluridone, fosamine, hexazinone, tebuthiuron, and triclopyr to reduce risk to occupational and public receptors. • Avoid applying atrazine, bromacil, diuron, or simazine aerially. • Limit application of chlorsulfuron via ground broadcast applications at the maximum application rate. • Limit diquat application to ATV, truck spraying, and boat applications to reduce risks to occupational receptors; limit diquat applications to areas away from high residential and subsistence use to reduce risks to public receptors. • Evaluate diuron applications on a site-by-site basis to avoid risks to humans. There appear to be few scenarios where diuron can be applied without risk to occupational receptors. • Do not apply hexazinone with an over-the-shoulder broadcast applicator.

TABLE 2-8
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
EFFECTS ON AIR QUALITY				
General Effects: None of the predicted annual emissions by pollutant or state would exceed PSD annual emissions significance thresholds. Treatments would result in approximately 77 tons per year (tpy) of total suspended particles (TSP), 24 tpy of carbon monoxide (CO), and 17 tpy of PM_{10} (particulate matter less than 10 microns in diameter). These emissions are lower than emissions all other herbicide treatment alternatives.	**General Effects:** None of the predicted annual emissions by pollutant or state would exceed PSD annual emissions significance thresholds. Particulate matter concentrations from treatments are expected to be substantially lower than NAAQS thresholds based on modeling. Treatments would result in approximately 206 tpy of TSP, 62 tpy of CO, and 45 tpy of PM_{10}. These emissions are twice those predicted for the No Action Alternative, with half of the emissions occurring in Idaho and Nevada.	**General Effects:** Herbicides would not be used for vegetation management. There would be no herbicide treatment-related emissions associated with this alternative.	**General Effects:** None of the predicted annual emissions by pollutant or state would exceed PSD annual emissions significance thresholds. PM concentrations are substantially lower than NAAQS thresholds at sample locations. Treatments would result in approximately 257 tpy of TSP, 83 tpy of CO, and 55 tpy of PM_{10}, greater than the amount of emissions generated under the Preferred Alternative, even though 40% fewer acres would be treated. The elevated amounts of emissions are primarily related to the reliance on ground equipment for treatment applications. However, herbicide drift would likely be less than under the other herbicide treatment alternatives.	**General Effects:** None of the predicted annual emissions by pollutant or state would exceed PSD annual emissions significance thresholds. PM concentrations are substantially lower than NAAQS thresholds at sample locations. Treatments would result in approximately 106 tpy of TSP, 32 tpy of CO, and 23 tpy of PM_{10}, about twice those of the No Action Alternative and half those of the Preferred Alternative.
Cumulative Effects: The cumulative effects of all agricultural, commercial, industrial, and other activities that have emitted air pollutants in the western U.S. and Alaska have contributed to a deterioration in air quality. Despite increases in these activities and in human population, total emissions of principal air pollutants peaked in the 1970s and early 1980s and have generally declined during the past 2 decades. BLM treatment activities have contributed < 1% of criteria pollutants nationwide in recent years. Emissions associated with fire use and other treatment methods under the action alternatives would increase from current levels, but would still comprise < 1% of total pollutants generated nationwide. Most emissions would be associated with the use of fire. However, emissions associated with wildfire are generally greater than those associated with prescribed fire on a per unit area basis. Smoke emissions would be reduced by permitting fires only during meteorological periods favorable to dispersion and avoiding population centers. BLM efforts to use vegetation treatments, including fire use, to restore historical fire regimes, native vegetation, and natural ecosystem processes should reduce the frequency and intensity of wildfire, resulting in less accumulation of pollutants than would occur under the No Action Alternative. Although 40% fewer acres would be treated using herbicides (the number of acres treated using other treatment methods would be similar between the two alternatives), criteria pollutant emissions would be greater under Alternative D than the Preferred Alternative because herbicide treatments would be ground-based, while much of the acreage treated under the Preferred Alternative would be applied using aircraft. Exceedances of NAAQS would not occur under any alternatives. Improvements in pollution control technology should further reduce pollutants associated with vegetation treatments in the future.				
EFFECTS ON SOIL RESOURCES				
Under the No Action Alternative, approximately 305,000 acres would be treated annually. None of the herbicides likely to be used would result in severe effects to soil. Because fewer acres would	Under the Preferred Alternative, approximately 932,000 acres would be treated annually. None of the herbicides likely to be used would result in severe effects to soil. New herbicides proposed for	Under Alternative C, herbicides would not be used for vegetation management; thus there would be no effects to soil from herbicides. Because herbicides would not be used to treat vegetation, invasive	Under Alternative D, approximately 530,000 acres would be treated annually. The risk of inadvertent applications to soils off of public lands would be less under this alternative than	Under Alternative E, approximately 466,000 acres would be treated annually. ALS-inhibiting herbicides would not be used under this alternative. However, ALS-inhibiting

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
be treated under this alternative than under the other herbicide treatment alternatives, benefits to soil from treatments (e.g., improved soil productivity, reduced soil erosion) would be less under this alternative than under the other treatment alternatives.	use would have minor effects on soil, but should help reduce populations of invasive species. Because more acres would be treated under this alternative than under the other alternatives, benefits to soil from treatments (e.g., improved soil productivity, reduced soil erosion) would be greatest under this alternative. Herbicides could also be used to benefit soils in Alaska, Nebraska, and Texas if treatments occurred there.	plant populations could increase and adversely affect soil resources in areas where herbicide treatments are the only practical method of treatment. Other treatment methods (manual, mechanical, biological, and use of prescribed fire) could also disturb and harm soil and could be more detrimental to soil in a treatment area than the use of herbicides.	under the other treatment alternatives. In areas where ground-based treatments were ineffective or too costly to implement, vegetation control might not occur, potentially resulting in adverse effects to soil. Because fewer acres would be treated under this alternative than under the Preferred Alternative, benefits to soil from treatments (e.g., improved soil productivity, reduced soil erosion) would be less. New herbicides proposed for use would have minor effects on soil, but should help reduce populations of invasive species. It is likely that the BLM would use less imazapic under this alternative than under the Preferred Alternative. Herbicides could also be used to benefit soils in Alaska, Nebraska, and Texas if treatments occurred there.	herbicides have not been found to be more toxic to soil organisms or to demonstrate other soil effects notably different from the other herbicides available to, or proposed for use by, the BLM. Thus, there could be greater impacts to soil under this alternative if the BLM uses non-ALS-inhibiting herbicides. This alternative would discourage activities that are known to harm soils (e.g., OHV use, livestock grazing). Because fewer acres would be treated under this alternative than under the Preferred Alternative, benefits to soil from treatments (e.g., improved soil productivity, reduced soil erosion) would be less. In addition, the BLM would not be able to use imazapic, which has been proposed for treatment of downy brome. Catastrophic fires and damage to soil in the Great Basin and elsewhere have been attributed to the growth and spread of downy brome. Herbicides could also be used to benefit soils in Alaska, Nebraska, and Texas if treatments occurred there.
Cumulative Effects: Human activities associated with commodity extraction , agriculture, and urbanization, and more recently with large-scale, catastrophic wildfire have resulted in soil erosion and loss of soil productivity on public lands and throughout the West. Soils in Alaska have been impacted by mineral extraction, logging, and oil and gas development. Treatments would lead to loss of vegetation and soil, but long-term improvement in ecosystems should restore soil and improve soil productivity. Several recently implemented conservation programs by the BLM will also improve soil on rangelands and grasslands. Rangeland health on public lands has shown improvement over the past 2 decades, and nationwide, the rate of soil loss has slowed. Short term soil loss would be greatest under the Preferred Alternative, but long-term improvement in soil function would be greatest under this alternative. Soil loss would be irretrievable, but soil productivity on degraded lands could be retrieved over decades or centuries.				
EFFECTS ON WATER RESOURCES AND QUALITY				
Impacts to surface and groundwater quality would be	Benefits and risks to water quality and quantity would be greatest	There would be no effects from herbicides on water quality. In	The BLM would be unable to treat large areas with herbicides.	Under this alternative, ALS-inhibiting herbicides would not

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
similar to the ongoing program. Herbicides most commonly used are known groundwater contaminants (2,4-D, glyphosate, picloram, and tebuthiuron), and several other herbicides that may be used (2,4-DP, atrazine, and simazine) are also known groundwater contaminants. Impacts to water quality and quality, and benefits to watersheds from herbicide treatments would be lowest under this alternative.	under this alternative. Of new herbicides proposed for use, diquat and fluridone are effective in controlling aquatic plants to improve water quality in lakes and streams, but diquat is a known groundwater contaminant. Imazapic is not known to contaminate groundwater and in upland treatments could serve as a replacement for upland treatments that are known groundwater contaminants. Removal of unwanted vegetation should improve hydrologic functions in treated watersheds. The BLM would also be able to use herbicides to improve watershed function and water resources and quality in Alaska, Nebraska, and Texas, although no herbicide treatments are currently proposed for Alaska and Nebraska.	areas with weeds and other infestations, hydrologic functions could deteriorate in areas where herbicide treatments are the only effective treatment method.	Thus, benefits to watersheds from large-scale herbicide treatments would not occur. Fire use and mechanical treatments could replace herbicide treatments in some areas, but could be less effective and cause greater soil disturbance, leading to reduced water quality. Risk of herbicide drift, in terms of reducing off-site contamination of water bodies, would be lower under this alternative than under the other treatment alternatives. The BLM would be able to use herbicides to improve watershed function and water resources and quality in Alaska, Nebraska, and Texas, although no herbicide treatments are currently proposed for Alaska and Nebraska.	impact surface water and groundwater quality. Passive treatments promoted under this alternative could benefit watersheds long-term, but would have few short-term benefits. Restrictions on herbicide treatments in riparian areas would limit the risk of adverse impact from herbicides on water resources in these areas, but would also limit long-term gains from treatment of unwanted vegetation. The BLM would be able to use herbicides to improve watershed function and water resources and quality in Alaska, Nebraska, and Texas, although no herbicide treatments are currently proposed for Alaska and Nebraska.
Cumulative Effects: As a result of human activities, 21% of watersheds nationwide have serious water quality problems. Commodity extraction, livestock grazing, fire suppression, and spread of weeds have contributed to water quality problems on public lands, primarily from high turbidity and sediment levels and high water temperatures. Approximately 25% of wetlands and 52% of riparian areas on public lands are not functioning properly, although the percentage of poor-functioning areas has declined during the past decade. Future BLM efforts will focus on watersheds where water quality does not meet state or tribal standards. Management of weeds and other invasive vegetation and restoration of natural fire regimes would cause erosion and sedimentation over the short term, but treatments should improve watershed health over the long term. In Alaska, most aquatic areas are of high quality, although there are water quality concerns associated with mining and oil and gas development. Short-term impacts and long-term improvements would be greatest under the Preferred Alternative. There would be more emphasis on passive management to improve ecosystem health under Alternative E, but this management would have to be considered within the multiple use requirements of FLPMA. An accidental spill of an herbicide or a major fire would cause damage to water bodies that could be irretrievable. Over the long term, effects of treatments on water resources and quality could be reversed under all alternatives.				
EFFECTS ON WETLAND AND RIPARIAN AREAS				
Potential benefits and risks of using herbicides would be lowest under this alternative. Approximately 2,300 acres of wetland and riparian areas would be treated. The BLM would not be able to use 4 herbicides proposed for use that would be	Potential benefits and risks of using herbicides would be greatest under this alternative. Approximately 10,000 acres of wetland and riparian areas would be treated. The BLM would be able to use 4 herbicides proposed for use that would be more	Possible ecosystem benefits of not using herbicides include the elimination of risks associated with accidental spills, drift, and persistence of herbicides on non-target biota. However, the risk of noxious weeds and invasive vegetation spreading are greatest	Risk of herbicide drift, in terms of reducing off-site contamination of wetland and riparian areas, would be lower under this alternative than under the other treatment alternatives (although differences would be small because few acres [< 2%] would be treated by air	Under this alternative, ALS-inhibiting herbicides would not impact surface water and groundwater quality. Passive treatments and limits on the use of livestock and OHV activity (within the limitations of the FLPMA) could benefit riparian

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
more effective in treating vegetation in or near wetland and riparian areas and that have similar or lower ecological risks than herbicides currently available for use by the BLM.	effective in treating vegetation in or near wetland and riparian areas and that have similar or lower ecological risks than herbicides available for use by the BLM. The BLM would also be able to use new herbicides in the future that may be even more effective and safer than currently-available herbicides. The BLM would be able to treat unwanted wetland and riparian vegetation in Alaska, Nebraska, and Texas.	under this alternative, especially for plant species that cannot be effectively controlled using other treatment methods. It could be more difficult for the BLM to effectively treat unwanted vegetation in remote riparian and wetland areas using non-herbicide treatment methods.	under alternatives A, B, and E). However, control of unwanted upland vegetation over large and/or remote areas would be more difficult, reducing benefits to watershed that could improve downslope wetland and riparian areas. The BLM would be able to treat unwanted wetland and riparian vegetation in Alaska, Nebraska, and Texas.	and wetland areas. Restrictions on use of herbicides in riparian conservation areas could benefit these areas, unless noxious weeds or other invasive vegetation were present that would not effectively be controlled using other treatment methods. The BLM would be able to treat unwanted wetland and riparian vegetation in Alaska, Nebraska, and Texas.
Cumulative Effects: An estimated 53% of wetlands have been lost in the U.S., and much of the remaining habitat has become degraded from agriculture, commodity extraction, urbanization, and other human activities. The spread of weeds and fire suppression have also caused some wetland and riparian areas on public lands to fail to function properly. To correct this situation, vegetation treatments would be focused on watershed in greatest need, and approximately 30,000 acres of wetland and riparian habitat would be treated annually under the Preferred Alternative. Collaborative efforts by the BLM, Forest Service, other federal, state, tribal, and local land management agencies, and private conservation groups will slow of stop the decline in wetland acreage. Restoring natural fire regimes and native vegetation, and controlling weeds and other invasive vegetation, would improve wetland and riparian habitat and function, with greatest benefits likely to occur under the Preferred Alternative. Use of new herbicides proposed for use by the BLM would further reduce risks to wetland and riparian areas from the use of herbicides. Alternative C would ensure that wetland and riparian areas were not impacted by herbicides, but aquatic weed control could be difficult under this alternative as herbicides are the most effective treatment methods for controlling some aquatic plants. It is unlikely that there would be an irreversible or irretrievable commitment of resources under all alternatives.				
EFFECTS ON VEGETATION				
The nature of impacts to vegetation would be similar to impacts that have occurred in the past, as the BLM would continue to treat about 305,000 acres annually. Negative impacts to vegetation (i.e., harm to non-target vegetation) would be less under this alternative than under the other herbicide treatment alternatives, as would long-term positive benefits on vegetation and improvement in ecosystems. Since the BLM would not be able to use proposed herbicides, risks to non-target plants could be greatest under this alternative. Treatments would not be allowed	The most extensive impacts (both negative and positive) to vegetation would occur. The BLM would be able to use 4 proposed herbicides that pose less risk to non-target plants than herbicides currently used. The BLM could also be able to use new herbicides in the future, which could reduce risks to non-target plants and provide greater ecosystem benefits. Risks to TES species would be greatest under this alternative. Use of proposed herbicides and new herbicides in the future should reduce the risk to TES species from treatments. Ecosystem benefits to TES	Non-target plants would not be affected by herbicides, effects to vegetation would result from other treatment methods. Positive ecosystem benefits from vegetation management would be least under this alternative, as there are certain invasive and weedy species for which herbicide use is the only effective method of treatment or for which other methods are impractical. Under this alternative, invasive plant populations would likely continue to spread, possible at increased rates. There would be no risks to TES species from use of herbicides under this	This alternative would substantially reduce the risk of off-site drift to non-target vegetation, and impacts to non-target vegetation could be least under this alternative. Similar to the Preferred Alternative, there would be benefits associated with increased availability of new and future herbicides. However, the BLM might not be able to treat large and remote areas using ground treatment methods, increasing the likelihood that noxious weeds and other invasive species would spread in these areas. Fire and mechanical treatments would be substituted in	Per treatment impacts to non-target vegetation from herbicide use could be least under this alternative because ALS-inhibiting herbicides would not be used. Several studies have shown that drift of ALS-inhibiting herbicides can have adverse effects on crops found near treatment areas. Focus on passive treatments and avoidance of herbicide use in riparian conservation and important cultural areas could provide benefits to these areas, except where aggressive weeds would only be controlled by ALS-inhibiting herbicides. Treatments

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
in Alaska, Nebraska, and Texas. Risks to TES species would be less under this alternative than under the other treatment alternatives because fewer acres would be treated.	species from vegetation treatments would be greatest under this alternative. The BLM would be able to treat vegetation in Alaska, Nebraska, and Texas using herbicides, although no treatments are currently planned for Alaska or Nebraska.	alternative, although ecosystem benefits to TES species from herbicide treatments would be least under this alternative.	some of these areas, but might not be as effective in areas with insufficient fuel to carry fires, or where sprouting species increased after mechanical treatments. Treatments would also be allowed in Alaska, Nebraska, and Texas, although use of herbicides in Alaska is unlikely. Based on acres treated, TES species would be less likely to be exposed to herbicides than under the Preferred Alternative. TES species would not be exposed to herbicides from off-site drift. However, ecosystem benefits to TES species from aerial treatments, especially in remote areas and large areas with invasive vegetation would be less than under the Preferred Alternative. The BLM would be able to treat vegetation in Alaska, Nebraska, and Texas using herbicides, although no treatments are currently planned for Alaska or Nebraska.	would be allowed in Alaska, Nebraska, and Texas, although use of herbicides in Alaska is unlikely. Increased emphasis on passive restoration could benefit some TES species. Risks to TES species may be greater from using non-ALS-inhibiting herbicides than from using ALS-inhibiting herbicides. The BLM would be able to treat vegetation in Alaska, Nebraska, and Texas using herbicides, although no treatments are currently planned for Alaska or Nebraska.
Cumulative Effects: Human-caused effects to vegetation began when man first arrived in North America, nearly 12,000 years ago, but intensified in the western U.S. during the past 150 years as a result of commodity extraction, overgrazing, and urbanization. Fire suppression led to altered fire regimes and ecosystem degradation that has resulted in high severity fires and the spread of noxious weeds and other invasive vegetation during the past few decades. Many forest areas have become dominated by mid-seral shade-tolerant species, woodlands have invaded grasslands, and native grasslands have been lost to annual weeds. Only 34% of public land was considered to be in good to excellent condition in 1986. Treatments to reduce hazardous fuel levels, control the spread of weeds, and restore native vegetation should improve ecosystem health over much of the West. Treatments would be focused in degraded watersheds and in the Temperate Desert Ecoregion to benefit sagebrush and other evergreen shrubland species. Based on modeling, treatments should slow land degradation and increase the number of acres of vegetation that are resilient to risks from fires, insects, and disease. All treatments would benefit vegetation, but the Preferred Alternative would convey the greatest benefits as more acres would be treated under that alternative than the other alternatives. Treatments would kill target and non-target species, and would return some areas to an early successional stage. Native plant production that was lost from treatments could not be retrieved, but treatments could slow or reverse this loss and lead to improved ecosystem health.				
EFFECTS ON FISH AND OTHER AQUATIC ORGANISMS				
Potential benefits and risks of using herbicides would be lower than under the other herbicide	Potential benefits and risks of using herbicides would be greatest. Approximately 10,000	Possible ecosystem benefits include the elimination of risks associated with accidental spills,	Risk of herbicide drift, in terms of reducing off-site contamination of habitat for aquatic organisms,	Disallowing use of ALS-inhibiting herbicides would have limited benefits fish and other

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
treatment alternatives. Approximately 2,300 acres of habitat for aquatic organisms could be treated. The BLM would not be able to use 4 herbicides proposed for use that are more effective in treating vegetation in or near wetland and riparian areas and that have ecological risks to aquatic organisms similar to or lower than those associated with herbicides currently available for use by the BLM.	acres of habitat for aquatic organisms could be treated. The BLM would be able to use 4 herbicides proposed for use that are more effective in treating vegetation in or near wetland and riparian areas and that have ecological risks to aquatic organisms similar to or lower than those associated with herbicides currently available for use by the BLM. The BLM would be able to use new herbicides in the future that may be even more effective and safer than currently-available herbicides. The BLM would be able to treat unwanted wetland and riparian vegetation in Alaska, Nebraska, and Texas to the benefit of aquatic organisms found on public lands in these states.	drift, and persistence of herbicides. However, the risk of noxious weeds and invasive vegetation spreading in riparian and wetland areas would be greatest, especially for plant species that cannot be effectively controlled using other treatment methods. It also could be more difficult for the BLM to effectively treat unwanted vegetation in remote riparian and wetland areas.	would be lower under this alternative than under the other treatment alternatives (although differences would be small because few acres [< 2%] would be treated by air under alternatives A, B, and E). However, control of unwanted upland vegetation over large and/or remote areas would be difficult, limiting benefits to watersheds that could improve downslope wetland and riparian areas. Risk of herbicide drift from aerial applications affecting riparian and wetland vegetation and aquatic organisms would be lowest under this alternative. The BLM would be able to treat unwanted wetland and riparian vegetation in Alaska, Nebraska, and Texas to the benefit of aquatic organisms found on public lands in these states.	aquatic organisms, as ALS-inhibiting herbicides pose few risks to aquatic organisms. Passive treatments and limits on the use of livestock and OHV activity (within the limitations of the FLPMA) could benefit riparian and wetland areas used by aquatic organisms. Restrictions on use of herbicides in riparian conservation areas could benefit aquatic organisms found in these areas, unless noxious weeds or other invasive vegetation could not be effectively controlled using other treatment methods. The BLM would be able to treat unwanted wetland and riparian vegetation in Alaska, Nebraska, and Texas, to the benefit of fish and aquatic organisms found on public lands in these states..
Cumulative Effects: Human-related activities, including urbanization, building of dams, and conversion of wetlands to other land types, fire exclusion, agriculture, and construction of roads have had a profound impact on populations and habitats of fish and other aquatic organism in the western U.S. Fire suppression has led to degraded riparian habitats, while the spread of weeds and other invasive vegetation have clogged waterways, and degraded upland and riparian habitats that has led to erosion and degradation of water quality in habitats used by these organisms. Efforts to restore natural fire regimes and control the spread of invasive vegetation should benefit aquatic habitat. Treatments would be focused in the most degraded watershed subbasins. However, benefits may be greater for resident fish than fish that migrate off of public lands (e.g., anadromous fish), as the BLM would not have control over factors that could harm migratory fish off of public lands. Adverse and beneficial effects of using herbicides would be greatest under the Preferred Alternatives; effects of other treatment methods would be similar among all action alternatives. Herbicides would not be used under Alternative C; thus, the BLM's ability to control aquatic weeds would be limited. Treatments could adversely affect the health and survivorship of aquatic organisms, and indirectly impact these organisms through impacts to habitat. New herbicides proposed for use should improve treatment success while having minimal impacts to aquatic organisms. Fish harmed or killed, and habitat productivity lost, from treatment would be irreversible. However, treatments should slow or reverse the loss of habitat function.				
EFFECTS ON WILDLIFE				
Beneficial and adverse impacts to wildlife would be less under this alternative than under the other herbicide treatment alternatives. The nature of wildlife impacts would be similar to those during	Beneficial and adverse impacts to wildlife would be greatest under this alternative. Approximately 2 times more vegetation would be treated specifically to benefit wildlife than under the No Action	Wildlife would not be affected by herbicide use. Benefits to wildlife habitat could be lowest under this alternative, as there are certain invasive species for which herbicide use is the only effective	There would be fewer impacts to wildlife due to off-site drift than under the other herbicide treatment alternatives. Wildlife may be unable to avoid contact with herbicides, especially in	Elimination of the use of ALS-inhibiting herbicides would provide few benefits, if any, to wildlife, including TES species, and could result in more harm to wildlife if more toxic herbicides

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
the past 10 years. The BLM would not be able to use 4 new herbicides that pose fewer risks to wildlife than many currently-available herbicides. The BLM would be unable to treat unwanted vegetation in Alaska, Nebraska, and Texas, to the benefit of wildlife.	Alternative. New herbicides proposed for use are less toxic to wildlife than many currently available herbicides, although diquat and fluridone pose some risks to amphibians. Future herbicides should also be less toxic, allowing managers to reduce the overall risk to wildlife from herbicide treatments. Over 70% of all treatments would occur in the Temperate Desert Ecoregion, a much higher percentage than under the No Action Alternative, to benefit sage-grouse and other species using evergreen shrublands. The BLM would be able to treat wildlife habitat in Alaska, Nebraska, and Texas.	method of treatment, especially in remote areas, areas with limited fuel to carry a fire, and in shrublands where mechanical treatments are not effective in controlling shrubs.	areas typically treated using aircraft. However, long-term negative impacts on wildlife habitat and ecosystems could be greatest under this alternative, especially in remote areas that could not be effectively treated using fire (due to lack of fuels) or other treatment methods (primarily due to cost or lack of effectiveness). The BLM would be able to treat wildlife habitat in Alaska, Nebraska, and Texas.	that are currently available to the BLM were used in their place. Other management practices proposed under this alternative, including limitations on the use of broadcast applications in some riparian areas, especially those used by amphibians, could reduce short-term impacts to wildlife. The BLM would be able to treat wildlife habitat in Alaska, Nebraska, and Texas.
Cumulative Effects: Human activities have led to the loss of wildlife and impacts to their habitats. About 21% of lands in the western U.S. have been converted to intensive land uses, while nearly all of the remaining land has been converted to other uses, such as forestry, that has often reduced its value to wildlife. Livestock grazing has degraded public land, and livestock and wild horses and burros compete with native herbivores for food. Timber management has led to tree stands dominated by early- to mid-seral, shade tolerant species to the detriment of wildlife that need old-growth forests. Fire suppression has modified forest habitats and favored the encroachment of woodlands into grassland habitats, while intensive, short-cycle fires have promoted weed establishment and spread. Human activities have fragmented the landscape and hindered the movement and habitat use of wildlife, and have placed species with narrow habitat requirements and limited mobility at great risk. Proposed vegetation treatments would slow or reverse many of these adverse effects to wildlife habitat. Habitat loss would continue, especially off public lands. Modification of habitats due to fire suppression and spread of weeds and other invasive vegetation would be slowed on public lands. Some treatments would be designed to restore large areas of land and reduce habitat fragmentation, while most treatments would strive to create a mosaic of habitats to benefit a diversity of wildlife species. Greatest adverse impacts and benefits from treatments would occur under the Preferred Alternative. Risks to wildlife would not occur under Alternative C, and would be less under the other treatment alternatives than under the Preferred Alternative. However, herbicides may be needed to control vegetation that is not readily controlled using other treatment methods; use of proposed and new herbicides in the future would reduce health risks to wildlife from current levels. All treatments could kill or harm wildlife and adversely impact their habitats, but short-term impacts would be offset by long-term gains in number of acres revegetated using native vegetation and in improvement to ecosystem health. Loss of wildlife and habitat function would be irretrievable, but treatments should slow or reverse the downward trend in wildlife habitat quality on public lands.				
EFFECTS ON LIVESTOCK				
Beneficial and adverse impacts to livestock would be less than under the other herbicide treatment alternatives. The nature of livestock impacts would be similar to those during the past 10 years. The BLM would not be	Beneficial and adverse impacts to livestock would be greatest under this alternative. Approximately 3 times more vegetation would be treated to specifically benefit livestock than under the No Action Alternative. Three of the	Livestock would not be affected by herbicide use. Positive livestock habitat benefits could be lowest under this alternative, as there are certain invasive species for which herbicide use is the only effective method of	There would be fewer impacts to livestock due to off-site drift than under the other herbicide treatment alternatives. Long-term negative impacts on livestock forage could be greater under this alternative than under other	Elimination of the use of ALS-inhibiting herbicides would provide few benefits, if any, to livestock, and could result in more harm to livestock if more toxic herbicides that are currently available to the BLM were used

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
able to use 4 new herbicides that pose fewer risks to livestock than many currently-available herbicides. The BLM would be unable to treat unwanted vegetation in Nebraska, Texas, and Alaska.	four new herbicides proposed for use are less toxic to livestock than currently available herbicides. The BLM's ability to use new herbicides in the future should further reduce the risks to livestock from the use of herbicides. The BLM would be able to use herbicides in Texas, Nebraska, and Alaska, to the benefit of any livestock that are found on public lands in those areas.	treatment, especially in remote areas, areas with limited fuel to carry a fire, and in shrublands where mechanical treatments are not effective in controlling shrubs. Herbicides, which are effective in the treatment of noxious weeds and other invasive plants that are toxic to livestock, would be unavailable.	treatment alternatives, especially in remote areas that could not be effectively treated using fire (due to lack of fuels) or other treatment methods (due to cost or lack of effectiveness). The BLM would be able to use herbicides in Texas, Nebraska, and Alaska, to the benefit of any livestock that are found on public lands in those areas.	in their place. Other management practices proposed under this alternative, including limitations on the use of broadcast applications in some riparian areas, could reduce short-term impacts to livestock. The BLM would be able to treat rangeland in Alaska, Nebraska, and Texas.
Cumulative Effects: Commodity extraction, agriculture, and urbanization are some of many human-related factors that have adversely impacted lands used by livestock. Livestock have also contributed to the loss of rangeland health in areas where they have overgrazed. Altered fire regimes have led to large and severe fires, facilitated the spread of noxious weeds and other invasive vegetation, and have removed forage and degraded rangelands used by livestock in the West. Treatments would restore native vegetation favored by livestock and make rangelands more resilient to disturbance. Efforts to better match livestock numbers to rangeland conditions should also help to improve conditions for livestock. Adverse impacts and improvements to rangeland would be greatest under the Preferred Alternative. Risk of herbicide drift impacting livestock on and off public lands would be least under alternatives D and E. New herbicides proposed for use by the BLM, in particular imazapic, would improve rangelands while having minimal impacts to livestock. Treatments could kill or harm livestock and damage vegetation used by livestock for forage and cover; these impacts would be irretrievable. Long-term, treatments would benefit livestock and slow or reverse rangeland degradation.				
EFFECTS ON WILD HORSES AND BURROS				
Beneficial and adverse impacts to wild horses and burros would be less than under the other herbicide treatment alternatives. The nature of wild horse and burro impacts would be similar to those during the past 10 years. Only 26% of treatments would occur in states where most (75%) wild horses and burros occur. Also, treatments in these states would mostly occur in evergreen shrublands, habitats that are not as important to wild horses and burros as grasslands, limiting risks to these animals. The BLM would not be able to use 4 new herbicides that pose fewer risks to wild horses and burros than many currently-	Beneficial and adverse impacts to wild horses and burros would be greatest under this alternative. Approximately 3 times more vegetation would be treated to specifically benefit wild horses and burros than under the No Action Alternative. Forty percent of treatments would occur in states where most (75%) wild horses and burros occur. However, as with the No Action Alternative, treatments in these states would mostly occur in evergreen shrublands, habitats that are not as important to wild horses and burros as grasslands, limiting risks to these animals. Three of the four new herbicides	Wild horses and burros would not be affected by herbicide use. Benefits to wild horses and burros rangeland could be lowest under this alternative, as there are certain invasive species for which herbicide use is the only effective method of treatment, especially in remote areas, areas with limited fuel to carry a fire, and in shrublands where mechanical treatments are not effective in controlling shrubs. Herbicides, which are effective in the treatment of noxious weeds and other invasive plants that are toxic to wild horses and burros, would be unavailable.	There would be fewer impacts to wild horses and burros due to drift than under the other herbicide treatment alternatives. Long-term negative impacts on wild horses and burros forage could be greater under this alternative, especially in remote areas that could not be effectively treated using fire (due to lack of fuels) or other treatment methods (primarily due to cost or lack of effectiveness).	Elimination of the use of ALS-inhibiting herbicides would provide few benefits, if any, to wild horses and burros, and could result in more harm to wild horses and burros if more toxic herbicides that are currently available to the BLM were used in their place. Other management practices proposed under this alternative, including limitations on the use of broadcast applications in some riparian areas, could reduce short-term impacts to wild horses and burros.

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
available herbicides.	proposed for use are less toxic to wild horses and burros than currently available herbicides. The BLM's ability to use new herbicides in the future should further reduce the risks to wild horses and burros from the use of herbicides.			
Cumulative Impacts: Wild horses and burros are protected under the Wild Free-roaming Horses and Burros Act of 1971. By the 1800s, more than 2 million animals were found in the western U.S., but by the 1950s, numbers were less than 20,000. As with livestock, human-caused factors have degraded rangelands used by wild horses and burros. These animals have also contributed to rangeland degradation. About 37,000 animals are found in the West, but the number of wild horses and burros the habitat can support is probably closer to 25,000. Efforts to better match wild horse and burro numbers to rangeland conditions should help to improve conditions for these animals. Treatments would restore native vegetation favored by wild horses and burros and make rangelands more resilient to disturbance. Adverse impacts and improvements to rangeland would be greatest under the Preferred Alternative. Risk of herbicide drift impacting wild horses and burros would be least under alternatives D and E. New herbicides proposed for use by the BLM, in particular imazapic, would improve rangelands while having minimal impacts to these animals. Treatments could kill or harm livestock and damage vegetation used by livestock for forage and cover; these impacts would be irretrievable. Over the long-term, treatments would benefit wild horses and burros and slow or reverse rangeland degradation.				
EFFECTS ON PALEONTOLOGICAL AND CULTURAL RESOURCES				
The risks to paleontological and cultural resources and health of Native Americans and other human receptors would be lower than under the other herbicide treatment alternatives. Fewer acres would be treated to control weeds and poisonous plants that could adversely affect humans., and that could displace native vegetation desirable to Native people's lifeway uses. This alternative would be least affective among herbicide treatment alternatives in reducing hazardous fuels, perhaps leading to greater incidence of wildfire and loss of paleontological and cultural resources, and Native people's life and property.	The risks to paleontological and cultural resources and health of Native Americans and other human receptors would be greatest under this alternative. However, benefits from reduction in noxious weeds and other invasive vegetation that is poisonous or displace vegetation used by Native Americans and Alaska Natives would also be greatest under this alternative. Herbicides could be used where paleontological and cultural resources were at risk from other treatment methods. Three of the four herbicides proposed for use are relatively harmless to Native peoples and other human receptors. The BLM would be able to treat vegetation in Alaska, Nebraska, and Texas, which may benefit vegetation that provided lifeway values.	There would be no risks to paleontological and cultural resources and human health from herbicide applications. Native people's health might suffer if noxious weeds and poisonous plants that harm humans are not controlled in traditional lifeway and other use areas.	Human health risks from herbicide drift would likely be lower than under the other treatment alternatives. However, benefits to vegetation used by Native peoples for traditional lifeway uses and to habitats used by fish and game harvested by Native Americans would be less than under the other herbicide treatment alternatives, as treatments would be less likely to occur in remote areas and areas where there is insufficient fuel to carry a fire or it is too costly to treat vegetation using other treatment methods. The BLM would be able to treat vegetation in Alaska, Nebraska, and Texas, which may benefit vegetation used for Native lifeway uses n these states.	The BLM would not be able to use ALS-inhibiting herbicides that have low risk to humans. The BLM would make additional effort to collaborate with Native American tribes and Alaska Native groups to protect and enhance culturally significant plants and other sites of cultural importance. Because fewer acres would be treated under this alternative, improvements in vegetation quality and reductions in populations of plant species that are harmful or poisonous to humans would not be as great as under the Preferred Alternative.

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
Cumulative Effects: Most paleontological material is buried and thus has been minimally disturbed, except where these resources are near the surface. Vegetation treatment activities would have little impact on paleontological resources, and can even protect these resources by reducing erosion. Cultural resources were destroyed or taken by settlers and collectors; these losses slowed after passage of the National Historic Preservation Act and Archaeological Resources Protection Act. Treatments would have little effect on cultural resources, although vegetation and other traditional lifeway resources would be impacted. Risks to paleontological and cultural resources would be least under the No Action Alternative. Benefits to vegetation for traditional lifeway uses would be greatest under the Preferred Alternative. Treatments could result in unavoidable adverse effects, but the risks would be minor. Treatments would likely result in short-term loss of vegetation used for food, baskets, and other traditional lifeway uses. Over the long term, restoration of natural fire regimes and native vegetation, and control of weeds, should improve vegetation used for traditional lifeway activities. Loss of paleontological and cultural resources would be irretrievable. Vegetation used for traditional lifeway uses would be lost from treatments and human-caused activities, but over the long-term, treatments should slow or reverse this loss on public lands.				
EFFECTS ON VISUAL RESOURCES				
Adverse visual impacts associated with herbicide treatments would be similar to current impacts, and lower than under the other alternative than other herbicide treatment alternatives. Improvements in the visual characteristics of landscapes would also be lower under this alternative than the other treatment alternatives.	Adverse visual impacts associated with herbicide treatments would be greatest under this alternative. Over the long term, this alternative should have the greatest positive impact on visual resources as natural vegetation communities and landscapes are restored. The BLM would be able to improve visual resources on lands in Alaska, Nebraska, and Texas.	Visual resources would not be impacted by herbicide treatments. However, there could be less improvement in the visual quality of the landscape over time if herbicides could not be used to treat invasive plants, or large areas were burned instead to remove unwanted vegetation.	Impacts to the visual resources would be less than under the Preferred Alternative, but greater than under the No Action Alternative. Areas that could not be effectively treated except by aerial applications of herbicides would not be treated. The BLM would be able to improve visual resources on lands in Alaska, Nebraska, and Texas.	Impacts to visual resources would be similar to those under Alternative D. as broadcast treatments would be discouraged. ALS-inhibiting herbicides would not be used to control downy brome and other invasive vegetation to benefit visual resources. The BLM would be able to improve visual resources on lands in Alaska, Nebraska, and Texas.
Cumulative Effects: Past human activities have modified the visual characteristics of public lands. In addition, large, severe wildfires, and the spread of weeds and other noxious and invasive vegetation have altered the landscape and made much of the West less visually appealing. Proposed vegetation treatments would impact visual quality over the short term by killing vegetation and burning rangeland and forests, causing large areas to appear brown or black. Over the long term, the health and visual appearance of public lands should improve as degraded lands were revegetated with native vegetation and natural fire regimes were restored. Adverse impacts and benefits would be greatest under the Preferred Alternative. The risk of herbicide drift impacting the visual characteristics of non-public lands would be least under alternatives D and E. Treatments would have short-term impacts on visual characteristics in the treatment area, but visual qualities of the area should improve over the long-term. Visually appealing vegetation could be irretrievably lost if harmed or killed, but impacts to the visual characteristics of the area could be reversed if native, more visually appealing vegetation was restored.				
EFFECTS ON WILDERNESS AND OTHER SPECIAL AREAS				
Fewer acres would be treated under this alternative than under the other herbicide treatment alternatives. Adverse impacts to wilderness and other special areas would be less, but benefits to ecosystem health would also be less under this alternative than under other herbicide treatment alternatives.	Adverse impacts, including temporary closures of wilderness areas, would be greatest under this alternative. Visitors could be displaced to other wilderness and recreation areas. Positive ecosystem benefits would also be greatest under this alternative and the BLM would be most likely to control noxious weeds and other invasive species in wilderness and	There would be no risks to wilderness and other special area users from accidental exposure to herbicides. However, weeds could spread more rapidly and infest more acres in wilderness and other special areas if herbicides could not be used.	Although aerial treatments in wilderness and other special areas would be uncommon under the other treatment alternatives, this alternative would ensure that the amount of area temporarily closed to wilderness and other special area visitors was kept small. However, aerial treatments could be completed more quickly and with less disturbance to solitude	An emphasis on ecosystem based management and on controlling weed populations outside of wilderness and other special areas before treating larger infestations in these areas could help to protect wilderness values. However, if weed infestations become established in wilderness and other special areas before they were controlled outside the

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
	other special areas under this alternative. Risk to wilderness and other special area users from the new herbicides would be less than risks associated with most currently-available herbicides.		and other wilderness values than other treatment methods, including mechanical treatments and fire use.	area, they could spread rapidly and degrade the wilderness experience. The five herbicides that would not be allowed for use under this alternative are among the lowest risk herbicides that would be available to the BLM
Cumulative Effects: Wilderness and other special areas represent about 4% of lands in the U.S. and represent some of the last remaining wild conditions and natural landscapes in the country. Because of their small size (the average size of wilderness areas on public lands is 42,000 acres), most wilderness areas are ecological "islands." Thus, a large, severe fire or weed infestation can substantially alter the characteristics of wilderness. Treatments to restore natural fire regimes and ecosystem health should benefit wilderness and other special areas. Although few treatments are proposed for these special areas, treatments near special areas would reduce the risk of weeds and catastrophic fire impacting special areas. Short-term impacts and long-term benefits from treatments would be greatest under the Preferred Alternative. Mechanical treatments would be limited under all alternatives. Under Alternative E, treatment of weeds in special areas could not occur until weed threats near special areas were halted, potentially increasing the risk of weed spread within wilderness and other special areas. Treatments could adversely impact the "unspoiled" nature of wilderness over the short term, but effects would begin to disappear within 1-2 growing seasons, and special area ecosystems would benefit over the long term. There could be some irretrievable loss of wilderness values during the period that areas are treated and appear "unnatural." However, loss of values would cease once treated areas were restored.				
EFFECTS ON RECREATION				
Fewer acres would be treated than under the other treatment alternatives. Thus, adverse effects to recreation, including temporary site closures, decline in scenic appeal of recreation sites, and potential human and wildlife health effects, would be less than under the other treatment alternatives. However, benefits to recreation from treatments, including control of thorny and poisonous plants, restoration of degrades areas to a more natural condition, and reduced risk of catastrophic fires, would also be less. The BLM would not be able to use herbicides to treat recreation sites in Alaska, Nebraska, and Texas.	Effects to recreation would be greatest under this alternative. It is likely that there would be more temporary site closures and loss of recreation opportunities, including plant collecting, sightseeing, hiking, horseback riding, and fishing and hunting, than under the other treatment alternatives. Risks to humans, fish, and wildlife from currently-available herbicides would greatest based on the number of acres treated. However, new herbicides with lower risks to humans, fish, and wildlife than most currently-available herbicides could reduce overall risk from use of herbicides on recreation areas. The BLM would be able to use herbicides in Alaska, Nebraska, and Texas to benefit recreation sites, although the BLM presently does not have	There would be no risks to wilderness and other special area users from accidental exposure to herbicides. However, there are certain plants that could be injurious to humans, which are most easily controlled by herbicides (e.g., sprouting plants such as poison oak). An increase in populations of these weeds could discourage recreational use of infested areas.	Similar to the other treatment alternatives, it is unlikely that aerial spraying would be used in high public use recreation areas. However, aerial spraying would also be limited in more remote areas. Thus, the number of acres temporarily closed due to herbicide treatments would be less than under the other treatment alternatives.	An emphasis on passive restoration, ecosystem-based management techniques, greater reliance on spot versus broadcast treatments, and limits on use of herbicides in riparian areas would result in fewer effects to recreation areas and users as compared to other treatment alternatives. Because fewer acres would be treated, especially in areas where broadcast treatments would typically occur, restoration of natural vegetation might not occur, or might be more difficult or costly in these areas. The BLM would not be able to use ALS-inhibiting herbicides under this alternative. These herbicides tend to have lower risk to humans, fish, and wildlife than other herbicides that are currently-available or proposed for use

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
	plans to use herbicides in Alaska.			
Cumulative Effects: Recreation resources were of minor importance to the BLM until the 1950s. Natural resource commodity extraction, effects of fire suppression, and spread of weeds have adversely impacted recreational opportunities on public lands. Vegetation treatments would add to this cumulative loss by reducing recreation opportunities in treatment areas over the short term. Over the long term, vegetation management should increase recreational opportunities, including those involving wildlife viewing, hunting, hiking, and water sports. The greatest adverse impacts and benefits would occur under the Preferred Alternative. Loss of recreational opportunities would not be avoided during some treatments, especially in areas that required closure to protect the health and safety of visitors. Long-term improvement in ecosystem health should increase the number and quality of recreational opportunities and reduce the likelihood of large, severe fires and weed infestations making large tracts of public land unsuitable for recreation. Closure of facilities and restrictions on access as a result of treatments would result in irretrievable loss of recreational opportunities. The risk of future losses would be lessened over the long term as ecosystem health improved on public lands.				
EFFECTS ON SOCIAL AND ECONOMIC VALUES				
Social and economic benefits and impacts from herbicide treatments would be similar to what has occurred during the past several years. Approximately $30 million would be spent on herbicide treatments, or about $100 per acre. There would be little noticeable overall change in population, employment, and income on a regional scale, although small communities near larger treatment areas could benefit. Overall risks to minority populations and children would be less under this alternative than under the other treatment alternatives because fewer acres would be treated. However, risks per acre could be greater because the BLM would not be able to use new herbicides in the future that may have less health risk than currently-available herbicides, including the four herbicides evaluated in this PEIS. Long-term wildland fire cost savings and benefits from restoration of natural vegetation and ecosystems would be least under this alternative.	Social and economic benefits and impacts from herbicide treatments would be greatest under this alternative. Approximately $89 million would be spent on herbicide treatments, or about $95 per acre. There would be little noticeable overall change in population, employment, and income on a regional scale, although small communities near larger treatment areas could benefit, and increases in population, employment, and income, although short-term and localized, would be greatest under this alternative. Overall risks to minority populations and children would be greatest under this alternative. However, risks per acre could be less than under the other treatment alternatives because the BLM would be able to use new herbicides in the future that may have less health risk than currently-available herbicides, including the four herbicides evaluated in this PEIS. Long-term wildland fire cost savings and benefits from restoration of natural vegetation and ecosystems	There would be no social and economic benefits from herbicide treatments under this alternative. There would be no change in population, employment, and income on a regional scale from herbicide treatments, but increases in these factors could result from use of other treatment methods. There would be no risks to minority populations and children from herbicides. Long-term wildland fire cost savings and benefits from restoration of natural vegetation and ecosystems would be less under this alternative than the other treatment alternatives, especially in areas where other treatment methods would be less effective than herbicide treatment methods.	Economic benefits and impacts from herbicide treatments would be less than for the Preferred Alternative, but greater than for the other treatment alternatives. Approximately $77 million would be spent on herbicide treatments, or about $145 per acre. There would be little noticeable overall change in population, employment, and income on a regional scale, although small communities could benefit. Overall risks to minority populations and children would be similar to the No Action Alternative and less than the other treatment alternatives because 1) fewer acres would be treated than under the Preferred Alternative; 2) the BLM would be able to use newer herbicides with less health risks than currently-available herbicides, an improvement over the No Action Alternative and Alternative E; and 3) the risk of herbicide drift impacting humans would be less under this alternative than the other treatment alternatives. Long-term wildland fire cost savings and	Approximately $60 million would be spent on herbicide treatments, or about $128 per acre. There would be little noticeable overall change in population, employment, and income on a regional scale, although small communities near larger treatment areas could benefit. Overall risks to minority populations and children would be similar to the other herbicide-treatment alternatives. This alternative would clearly establish protection for Native Americans and Alaska Natives, but would also discourage use of ALS-inhibiting herbicides which tend to have less health risk than non-ALS-inhibiting herbicides. Long-term wildland fire cost savings and benefits from restoration of natural vegetation and ecosystems would be less than under the Preferred Alternative, similar to that of Alternative D, and greater than that of the No Action Alternative. An objective of this alternative is to restore native ecosystems and use passive treatments, where feasible.

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
	would be greatest under this alternative.		benefits from restoration of natural vegetation and ecosystems would be less than under the Preferred Alternative, and similar to that under the other treatment alternatives.	However, the BLM would have limited ability to conduct broadcast treatments, limiting the size of areas that could be effectively treated, especially if fire use would be ineffective to treat these areas. The BLM would also not be able to use imazapic and other ALS-inhibiting herbicides that have shown effectiveness in controlling downy brome and other noxious weeds and invasive species.
Cumulative Effects: Population growth rates in the West have exceeded those of the rest of the U.S. for several decades, with growth greatest in communities associated with the WUI. Agricultural, forestry, mining, fishing, and service jobs are important and closely tied with actions on public lands. Revenues derived from public lands have fluctuated with national and global needs and public policies, but in general, revenues provided to the BLM from mining and oil and gas development have increased, while timber harvesting and grazing revenues have declined. Expenditures by the BLM to state and local governments have doubled in the past 10 years, with the largest increases in states with active mining and oil and gas operations. Future high growth rates are expected, including those of minority populations that could potentially suffer greater impacts from treatments than in the past. Employment and income will continue to be tied to the global economy, with mining and oil and gas exploration and development increasing, and timber harvesting and grazing declining. However, timber-related jobs could increase in the short term as timber is removed to reduce hazardous fuels on BLM- and Forest Service-administered lands. Revenues to the federal government will reflect these trends. Costs to the federal government for fire suppression and restoration of historical fire regimes and ecosystem health would exceed $1.6 billion annually and would likely increase over time. Costs for vegetation treatments on public lands are estimated at $1.1 billion annually. Treatments could have adverse effects on local industries and communities, but long-term gains in ecosystem health should benefit communities and many resource-based industries. Treatments would require a substantial financial commitment by the federal government and would not be retrievable once spent.				
EFFECTS ON HUMAN HEALTH AND SAFETY				
Risk to occupational and public receptors would be lower than under other herbicide treatment alternatives. The risk to humans per application could be greater than under the other treatment alternatives, however, because the BLM would not be able to use new herbicides proposed for this PEIS, nor herbicides developed in the future, that likely would have less risks to humans than currently-available herbicides. In addition, the BLM would be able to use six herbicides that would not be allowed under the other	This alternative would likely result in the most overall risk to human health of all alternatives because of the large number of acres treated. The BLM would be able to use new herbicides that have lower health risks than currently-available herbicides. This alternative would also be most effective in treating noxious weeds and poisonous plants that adversely affect humans.	Alternative C would not result in human health risk from herbicide applications. However, human health could be adversely affected if noxious weeds and poisonous plants that are harmful to humans increased in occurrence under this alternative.	Human health risks per application area could be lower than for other herbicide treatment alternatives because herbicides would not drift as far. Overall risks would be lower than under the Preferred Alternative because fewer acres would be treated. Health of users of more remote public lands might be adversely affected if noxious weeds and poisonous plants that are harmful to humans increased in occurrence in these areas under this alternative due to the inability of the BLM to treat them using	The BLM would not be able to use ALS-inhibiting herbicides that have low risk to humans. However, this alternative favors spot over broadcast treatments, encourages additional protection of cultural resource and other areas used by Native Americans and Alaska Natives, and would treat fewer acres, thus presenting fewer risks to humans as compared to the Preferred Alternative. Health of users of more remote public lands might be adversely affected if noxious weeds and poisonous plants that

TABLE 2-8 (Cont.)
Summary and Comparison of Effects on Resources by Alternatives

No Action Alternative	Preferred Alternative	Alternative C	Alternative D	Alternative E
herbicide treatment alternatives—2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine—herbicides that have greater risk to humans than other currently-available or proposed herbicides.			aircraft.	are harmful to humans increased in occurrence in these areas due to the inability of the BLM to treat them using aircraft and other broadcast-treatment methods.
Cumulative Impacts: Risks to health from occupational injury or death, from cancer, and from exposure to pollutants has generally declined during the past few decades. However, risk from wildfire in recent years has held steady or increased as more people have moved into the WUI and the number and severity of wildfires has increased. Proposed vegetation treatments pose risks to worker and public health. Injuries and death could result from use of equipment, fire, and herbicides to treat vegetation, but the risk is very small to negligible. Treatments would minimize human exposure to smoke by scheduling prescribed burns when meteorological conditions are favorable for smoke dispersion. Risk from wildfire would hold steady or be reduced over time as levels of hazardous fuels and risk of wildfire in WUI areas were reduced. Risk of exposure to herbicides would increase under alternatives B, D, and E, although the BLM proposes to use new herbicides that pose less human health risk than most currently-available herbicides. Alternative E places greater emphasis on hazardous fuels treatments in the WUI and development of defensible spaces near structures, which would reduce risk to human life from wildfire. There would be risks to human health from vegetation treatments, but long-term improvement in ecosystem health and use of less toxic herbicides have the potential to reduce these risks.				

CHAPTER 3

AFFECTED ENVIRONMENT

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CHAPTER 3

AFFECTED ENVIRONMENT

Introduction and Study Area

This chapter describes the natural and socioeconomic environment of public lands in the western U.S., including Alaska that would be affected by the alternatives under consideration. It focuses on significant resources that were identified in Chapter 1, and is useful in understanding the environmental, cultural, and social consequences of the proposed program and alternatives.

Land Use and Ecoregions

Land Use

The BLM manages nearly 262 million acres in the western U.S. and Alaska. Public lands represent from less than 0.1% of total land area in a given state to over 67% of lands in Nevada (Table 3-1).

Approximately 165 million acres of public lands are upland rangeland, of which approximately 160 million acres are open to livestock grazing. Other public uses on rangeland include recreation, oil, gas, and mineral development.

Another 55 million acres are forestland and woodland. Forestlands and woodlands are a source of timber and other forest products, and are used for livestock grazing, recreational, and cultural purposes.

Wetland and riparian areas total about 23 million acres and are primarily used for recreation and grazing. The remaining 19 million acres consist of barren mountains, mountaintops, glaciers, sand dunes, and playas. These areas are primarily used for recreation.

Ecoregions

Because this PEIS addresses a broad geographic region with a diverse range of biophysical characteristics, it is useful to subdivide this region into smaller, homogeneous areas for analysis. Where possible, information on resources has been organized by ecoregions rather than by state boundaries. Ecoregions are geographic areas that are delineated and defined by similar climatic conditions, geomorphology, and soils (Bailey 1997, 2002). Since these factors are relatively constant over time and strongly influence the ecology of vegetative communities, ecoregions may have similar potentials and responses to disturbance (Clarke and Bryce 1997; Jensen et al. 1997). Ecoregions, therefore, provide a useful framework for organizing, interpreting, and predicting changes to vegetation following management treatments.

TABLE 3-1
Acres of Public Lands in Each State and Percent of the State Administered by the BLM

State	Acres of BLM Land	Percent of State Lands Administered by the BLM
Alaska	85,553,261	23.5
Arizona	12,229,583	16.8
California	15,208,002	15.1
Colorado	8,362,619	12.6
Idaho	11,995,125	22.5
Montana	7,959,097	8.5
Nebraska	6,354	<0.1
North Dakota	58,837	0.1
Nevada	47,847,657	67.6
New Mexico	13,371,737	17.2
Oklahoma	2,136	<0.1
Oregon	16,135,459	26.0
South Dakota	274,450	0.6
Texas	11,833	<0.1
Utah	22,869,246	42.1
Washington	403,316	0.9
Wyoming	18,362,513	29.3
Total	261,848,120	23.5
Source: USDI BLM (2005d).		

The public lands addressed in this PEIS lie within eight major physiographic regions, or ecoregion divisions: Tundra, Subarctic, Marine, Mediterranean, Subtropical Steppe, Subtropical Desert, Temperate Steppe, and Temperate Desert, including Mountain Provinces (Map 3-1).

Climate

Climate is the statistical distribution of atmospheric conditions, as determined by the weather patterns that result from long-term fluctuations in global atmospheric and hydrologic cycles. Climatic patterns describe the annual distribution of energy and moisture, thus affecting the amount and seasonal distribution of temperature, precipitation, and winds. These factors influence the composition and distribution of rangeland vegetation, as well as the formation and erosion of rangeland soils, and hydrological conditions. These factors also influence the distribution of wind-born air pollutants, such as smoke from wildfires and prescribed fires.

The western U.S. experiences several broad climatic groups: polar, boreal, temperate, Mediterranean highland, and dry. Polar and boreal climates dominate in Alaska, while a humid temperate climate is characteristic of the coastal areas of Washington, Oregon, and northern California. The southern California coast has a Mediterranean climate, while mountainous areas have a highland climate. The rest of the western states east of the Cascade, Sierra Nevada, and Rocky mountains are characterized by a dry climate. On a regional scale, temperature and precipitation vary with latitude, elevation, distance from the oceans, and the position of mountain ranges with respect to prevailing winds. The eight ecoregions found in the treatment area are based on the seasonality of precipitation, and on the degree of dryness or cold, and depend largely on latitude and continental position.

Tundra Ecoregion Division

The climate of the westernmost and northernmost portion of Alaska (including the Alaska Peninsula and Aleutian Islands), is typified by cold arctic air masses. The tundra climate has a very short, cool summer and a long, severe winter, with the warmest average monthly temperature between 50 °F and 32 °F (freezing). Between 55 and 188 days per year typically have a daily mean temperature above freezing. Annual precipitation is often less than 8 inches, but the climate is humid because of the low potential evaporation.

Subarctic Ecoregion Division

The moist, boreal climate type demonstrates a large seasonal temperature range. Winters dominate, with cool, short summers. Because average monthly temperatures are below freezing for up to 7 consecutive months, soil moisture freezes solidly to depths up to 14 feet. Only a single month has an average temperature above 50 °F. The limited precipitation (10 to 20 inches annually) falls mainly during the short summer months, although thunderstorms are uncommon.

Subtropical Steppe Ecoregion Division

The western subtropical steppe borders deserts on both the north and south, with the temperate steppe to the north and east. This division has a hot semiarid climate where potential evaporation exceeds precipitation, and where all months have average temperatures above freezing. Bright sunny days with cool clear nights are typical. Precipitation ranges from 10 to 20 inches per year, with a summertime peak due to thunderstorm activity.

Subtropical Desert Ecoregion Division

South and west of the Arizona-New Mexico Mountains is the subtropical desert climate. This region is not only very dry, but also has extreme maximum summer temperatures. In addition, both daytime solar and nocturnal radiation are high, leading to extreme daily temperature variations. Annual precipitation is less than 8 inches.

Temperate Steppe Ecoregion Division

Temperate steppes are areas with a semiarid continental climatic regime, where evaporation usually exceeds precipitation. Seven or less months have an average temperature above 50 °F. Winters are cold and dry, summers warm to hot, with at least 1 month's average temperature below freezing.

Temperate Desert Ecoregion Division

Temperate deserts are generally dry with wide temperature differences between summer and winter. In the intermountain region between the Pacific coast and Rocky Mountains, the temperate desert has a very pronounced drought season and a short humid season. Most precipitation falls in winter, despite a small peak in late spring. Eight or more months have an average temperature above 50 °F. Winter is relatively short, but with at least 1 month's average temperature below freezing.

Mediterranean Ecoregion Division

Most of California west of the Sierra Nevada Mountains and Mojave Desert is typified by alternate wet winters and dry summers, within a strong transition zone between the dry desert and the wet coast. Mild temperatures dominate, with the coldest average monthly temperature between 65 °F and 27 °F. Most precipitation occurs in winter, with the wettest month receiving nearly 3 times the precipitation of the driest summer month.

Marine Ecoregion Division

The temperate oceanic climate extends from southeast Alaska down the Pacific Coast to southwestern Oregon. This climate receives abundant rainfall from maritime air masses, with average temperatures moderated by the ocean. Although the warmest average monthly temperature is below 72 °F; for at least 4 months the average temperature is above 50 °F; the coldest month averages just above 32 °F. Annual precipitation is high (40 to 80 inches per year), but significantly lower in summer. The relatively low temperatures reduce evaporation, producing a very damp, humid climate with much cloud cover. Mild winters and cool summers are typical.

Mountain Provinces

The mountainous portions of all of these ecosystem divisions exhibit a highland climate, where site-specific conditions vary greatly, depending on altitude and exposure. Windward slopes typically have greater precipitation (and leeward slopes less precipitation) than the ecoregion division as a whole. Southern exposures also tend to be warmer than slopes with northern exposures. Finally, the occurrence of mountain winds (up slope during the day, down slope at night) and diurnal temperature inversions is greatest.

Air Quality

Because air pollution can directly cause health risks to humans, and cause significant welfare impacts, improvement of the air quality in the U.S. is an important regulatory goal. The Clean Air Act (originally passed in 1955 and amended several times since), establishes a mandate to reduce emissions of specific pollutants via uniform federal standards. Under the Act, the USEPA is responsible for setting standards and assuring local agencies comply with the Act through its approval of state implementation plans (SIPs).

The standards include the primary and secondary NAAQS. The USEPA has developed NAAQS for six pollutants, referred to as criteria pollutants, to protect public health and welfare. The criteria pollutants are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), lead (Pb), and particulate matter (PM_{10} and $PM_{2.5}$).

Particulate matter (PM) is a generic term for a broad class of chemically and physically diverse substances that exist as discrete particles over a wide range of sizes. For regulatory purposes, PM is sub-classified by the particle's aerodynamic diameter. PM_{10} includes all PM with an aerodynamic diameter of 10 microns or less and is referred to as inhalable PM. $PM_{2.5}$ includes all PM with an aerodynamic diameter of 2.5 microns or less, called fine PM, and is by definition a subset of PM_{10}. Studies have shown more serious health effects associated with $PM_{2.5}$, and therefore the USEPA promulgated more stringent standards for this class of PM.

The NAAQS are listed in Table 3-2. The primary NAAQS protect the health of sensitive individuals. The secondary NAAQS protect the general welfare of the public. Different averaging periods are established for the criteria pollutants based on their potential health and welfare effects. The NAAQS are enforced by states, which in some cases have adopted additional or more stringent standards.

All areas of the nation have been classified as to their status with regard to attaining the NAAQS. An area is designated by the USEPA as either being in attainment for a criteria pollutant if ambient concentrations of that pollutant are below the NAAQS, or being in nonattainment if criteria pollutant concentrations violate the NAAQS. Once nonattainment areas comply with the NAAQS, they are designated as maintenance areas. Areas that are classified as nonattainment must implement a plan to reduce ambient concentrations below the NAAQS. Areas where insufficient data are available to determine attainment status are designated as unclassified, and are treated as attainment areas for regulatory purposes.

The Clean Air Act also provides for the prevention of significant deterioration (PSD) of air quality, especially in those areas of the country where the air quality is much better than standards. In Class I areas, only a

TABLE 3-2
National Ambient Air Quality Impact Significance Criteria (μg/m³)

Pollutant	Averaging Period[1]	NAAQS		PSD Increments[2]	
		Primary	Secondary	Class I	Class II
NO_2	Annual	100	100	2.5	25
CO	1-hour	40,000	NA	NA	NA
	8-hour	10,000	NA	NA	NA
PM_{10}	24-hour	150	150	8	30
	Annual	50	50	4	17
$PM_{2.5}$	24-hour	65	65	NA	NA
	Annual	15	15	NA	NA
SO_2	3-hour	NA	1,300	25	512
	24-hour	365	NA	5	91
	Annual	80	NA	2	20
Lead	Quarter	1.5	1.5	NA	NA
O_3	1-hour[3]	235	235	NA	NA
	8-hour[3]	157	157	NA	NA

NA = Not Applicable

[1] Annual standards are never to be exceeded. Short-term standards (those other than annual or quarterly) are not to be exceeded more than once per year, except for O_3, PM_{10}, and $PM_{2.5}$ standards. For O_3, the expected number of days with ozone levels above the standard is not to be exceeded more than once per calendar year. For PM_{10}, the standard is attained when the 99th percentile concentration for the year is less than the standard. For $PM_{2.5}$, the standard is attained when the 98th percentile concentration for the year is less than the standard.

[2] Prevention of Significant Deterioration (PSD) increments are the maximum amounts of pollutants allowed above a specified baseline concentration. Class I areas are predominantly large national parks and wilderness areas as of August 7, 1977.

[3] The 1-hour NAAQS will no longer apply to an area 1 year after the effective date of the designation of that area for the 8-hour ozone NAAQS. The effective designation date for most areas is June 15, 2004.

NA = Not applicable.

very small amount or increment of air quality deterioration is permissible. Class I areas include specified national parks, wilderness areas, and certain Indian reservations (Map 3-2). Mandatory Class I areas, which include large national parks and wilderness areas that were in existence on August 7, 1977, are a subset of Class I areas that may not be redesignated, and are subject to visibility protection regulations. All areas that have not been designated Class I are considered Class II areas. The PSD permit provisions of the Clean Air Act only apply to stationary sources of air pollution and do not include prescribed fire, which is defined as a temporary source. Some states, however, have regulations to restrict intrusions of smoke from prescribed burning that might adversely impact visibility within mandatory federal Class I and other smoke-sensitive areas.

Detailed knowledge of the existing air quality for the area covered by this PEIS is limited to available monitoring sites for criteria pollutants. In the undeveloped regions of public lands, ambient pollutant levels are expected to be low, and probably negligible in remote areas. In general, locations experiencing high ambient pollutant levels in the treatment area will be areas with commercial and industrial land use (areas with mills, power plants, etc.) and local population centers (areas with automobile exhaust, residential heating, etc).

Table 3-3 lists those counties with public lands that are designated as nonattainment or maintenance areas for each criteria pollutant. PM_{10}, O_3, and NO_2 concentrations are expected to be higher near industrial areas and cities where there are significant combustion sources and vehicles. High SO_2 concentrations occur primarily near coal-fired power plants, smelters, and refineries.

Visibility Protection in Mandatory Federal Class I Areas

Under the Clean Air Act, Congress created the Grand Canyon Visibility and Transport Commission (GCVTC). The GCVTC was comprised of eight western states, six tribal agencies, and four federal land management agencies, and was charged with assessing the current scientific information on

TABLE 3-3
Counties within the Treatment Area that are Designated Nonattainment or Maintenance Areas for Various Pollutants

Pollutant	State	Nonattainment	Maintenance
PM_{10}	Alaska	None	None
	Arizona	Cochise*, Gila*, Maricopa*, Pima*, Pinal*, Santa Cruz*, Yuma*	Gila*, Mohave*
	California	Fresno*, Imperial*, Inyo*, Kern*, Kings*, Madera*, Mono*, Riverside*, San Bernardino, Stanislaus*, Tulare*	Kern*, Mono*
	Colorado	Prowers*	Adams*, Arapahoe*, Archuleta*, Boulder*, Broomfield, Denver, Douglas, Freemont*, Jefferson, Pitkin*, Routt*, San Miguel*
	Idaho	Bannock*, Bonner, Power*, Shoshone*	Ada*
	Montana	Missoula*, Rosebud*, Silver Bow*	None
	Nevada	Clark*, Washoe*	None
	New Mexico	Dona Ana*	None
	Oregon	Jackson*, Lake*, Lane*	Josephine*, Klamath*
	Utah	Salt Lake, Utah	None
	Washington	Yakima*	None
	Wyoming	Sheridan*	None
SO_2	Arizona	Cochise*, Gila*, Pinal*	Greenlee*, Pima*
	Montana	Lewis and Clark*, Yellowstone*	None
	Nevada	None	White Pine*
	New Mexico	None	Grant*
	Utah	Salt Lake*, Tooele*	None
NO_2	None		None
CO	Alaska	None	Fairbanks North Star*
	Arizona	Maricopa*	Pima*
	California	Los Angeles*, Riverside*, San Bernardino*	Butte*, El Dorado*, Fresno*, Kern*, Napa*, Placer*, San Diego*, Solano*, Sonoma*, Stanislaus*, Yolo*
	Colorado	None	Boulder*, El Paso*, Jefferson*, Larimer*, Teller*
	Idaho	None	Ada*
	Montana	Missoula*	Cascade*, Yellowstone*
	Nevada	None	Carson City*, Douglas*, Washoe*
	New Mexico	None	Bernalillo
	Oregon	Marion*, Polk*	Clackamas*, Jackson*, Josephine*, Klamath*, Lane*, Washington*
	Utah	Utah*	Salt Lake
	Washington	Spokane*	Yakima*
Ozone	Arizona	Maricopa*	
	California	Butte, El Dorado*, Fresno*, Imperial, Kern*, Kings, Napa*, Placer*, Riverside*, San Bernardino*, San Diego*, Solano*, Sonoma*, Stanislaus, Tulare, Yolo	Kern*, Monterey, San Benito, San Diego
	Colorado	None	Boulder*, Jefferson
	Nevada	Washoe	Clark*, King*, Pierce*, Snohomish*, Yakima*
	New Mexico	Dona Ana*	None
	Oregon	Marion*, Polk*	Clackamas*, Washington*
	Utah	None	Salt Lake
Lead	Montana	Lewis and Clark*	None

* Only a portion of the county is in nonattainment or maintenance for the pollutant.
Notes: States that are not listed for a particular pollutant do not have counties within the program area that are also within nonattainment or maintenance areas for that pollutant.
Source: USEPA Green Book available at http://www.epa.gov/oar/oaqps/greenbk/.

visibility impacts and making recommendations for addressing regional haze in the western U.S (GCVTC 1996). The GCVTC signed and submitted more than 70 recommendations to the USEPA that indicated that visibility impairment was caused by a wide variety of sources and pollutants, and that a comprehensive strategy was needed to remedy regional haze (Western Governors' Association 1996). Based on the findings and recommendations from the GCVTC, the USEPA established regional haze regulations, and encouraged states to coordinate their implementation efforts through regional planning organizations.

The Western Regional Air Partnership (WRAP) was established in 1997 as a successor to the GCVTC. The WRAP is a voluntary organization comprised of 13 western governors (Alaska, Arizona, California, Colorado, Idaho, Montana, North Dakota, New Mexico, Oregon, South Dakota, Utah, Washington, and Wyoming), 11 tribal leaders, and 2 federal departments (USDA and USDI).

In the 1990 amendments to the Clean Air Act, the U.S. Congress directed the USEPA to develop regional haze regulations to achieve the national visibility goal for "the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I federal areas, which impairment results from manmade air pollution."

The USEPA promulgated the Regional Haze Rule in 1999 to improve visibility in 156 mandatory federal Class I national parks and wilderness areas where visibility is an important value (USEPA 1999a). Improvement in visibility must be made every 10 years for the 20% most impaired (haziest) days and there must be no degradation for the 20% best (clearest) days, until the national visibility goal is reached in 2064. State Implementation Plans and Tribal Implementation Plans (TIPs) outline how reasonable progress towards this goal would be achieved and demonstrated. Section 308 of the Regional Haze Rule provides nationally applicable provisions of the rule in the development of SIPs and TIPs, which would address regional haze.

Herbicide Drift

Aerial and ground application of herbicides may transport herbicides through drift, allowing air-borne herbicides to move beyond the intended target. The primary factors that influence drift are droplet size, wind speed, humidity, formulation of the herbicide, height of emission, equipment and application techniques, and the size of the area treated with the herbicide. The factor that has the greatest influence on the downwind movement is droplet size. Procedures that can be employed to reduce drift include: 1) using lower spray nozzle height, 2) using the lower end of the pressure range, 3) increasing the spray nozzle size, 4) using drift-reducing nozzles, 5) using drift control additives, and 6) using sprayer shields (Hofman and Solseng 2001). Additionally, several university extension service agencies provide assistance regarding SOPs to minimize herbicide spray drift (Dexter 1993, Hofman and Solseng 2001).

Topography, Geology, Minerals, Oil, and Gas

The diversity in the landscape of the treatment areas reflects differences in geologic processes and the effects of climate, which have been shaping the land over a long period of time.

In 2003, on-shore public lands produced about 40% of the nation's coal, about 11% of its natural gas, and about 5% of its oil (USDI BLM 2005c). In 2004, the BLM administered over 54,000 oil and gas leases, of which approximately 21,000 leases were producing. Federal geothermal resources produced over 630 megawatt-hours of electric power. Information pertaining to mineral, oil, and gas resources, presented below, was gathered from the Mineral Resources Program, a section of the U.S. Geological Survey (USGS).

Tundra Ecoregion

The Tundra Ecoregion is rich in minerals, oil, and gas. Metallic minerals including silver, Pb, and zinc are found throughout the North Slope region of Alaska. To the south, along the western coast of Alaska, are significant concentrations of gold. The Northern Alaska physiographic province accounts for almost half of the oil and more than half of the undiscovered conventional gas assessed on onshore federal lands (Map 3-3). Oil and coal resources extracted in Alaska are predominantly from the Tundra Ecoregion (i.e., North Slope). As of 2001, Alaska accounted for 17% of the crude oil discovered in the U.S. (Energy Information Administration 2001).

Subarctic Ecoregion

Gold is the most dominant mineral extracted in this ecoregion. Other mineral operations within this ecoregion include copper mining, and production of aggregate (e.g., construction sand, gravel, and crushed stone). There are limited discoveries of coal, gas, and oil resources in the central portion of Alaska.

Temperate Desert Ecoregion

Raw, non-fuel minerals extracted throughout this ecoregion include aggregate, gypsum, limestone, trona, shale, and stone. Metallic minerals, predominantly silver and gold, are extracted in the southern portions of this ecoregion. There is very little oil and gas found in this ecoregion. However, coalfields located in the Temperate Steppe Ecoregion extend into this ecoregion and are found throughout southwest Wyoming, and central and southwest Utah.

Subtropical Desert Ecoregion

Minerals predominantly extracted from the western portion of this ecoregion are construction aggregate including construction sand, gravel, and crushed stone. Metallic minerals (e.g., gold, silver, and copper) dominate the central and eastern portion of this region. Gypsum is prominent in southern Nevada. Limited oil and gas reserves are located in southern Arizona and southwest New Mexico. No coalfields are found in this ecoregion.

Temperate Steppe Ecoregion

Construction aggregate is the dominant mineral extracted throughout the southern and central sections of this ecoregion. These construction materials include crushed stone and common clay. While industrial minerals within this region are predominantly extracted for construction purposes, Wyoming contains the world's largest source of trona. Trona is the principal ore from which soda ash is produced. Metallic minerals and precious stones (i.e., gems) are extracted throughout the northern and northeastern portions of the ecoregion.

There are significant deposits of coal concentrated throughout the Colorado Plateau extending into the Rocky Mountains and Great Plains. Significant oil reserves are located throughout the region. The Powder River Basin and the Wyoming Thrust Belt provinces of the Rocky Mountains and Northern Great Plains regions have the second largest concentrations (behind Alaska) of undiscovered conventional oil and gas, respectively, assessed on federal lands (Gautier et al. 1998; U.S. Departments of Interior, Agriculture, and Energy 2003).

Subtropical Steppe Ecoregion

Construction aggregate and metallic minerals dominate the nonfuel minerals extracted in this ecoregion. In addition, potash accounts for a significant portion of minerals mined in New Mexico. The Carlsbad Potash District (in New Mexico) is the largest potash-producing area in the U.S. (Energy Information Administration 2001). There are extensive coalfields throughout northern Arizona and New Mexico. These fields extend up into the Colorado Plateau. No oil and natural gas reserves have been located in this ecoregion.

Mediterranean Ecoregion

Industrial minerals such as aggregate, limestone, and shale dominate mineral extraction throughout this ecoregion. There is no coal mining within this ecoregion, although oil and natural gas extraction is predominant in the San Joaquin, Ventura/Santa Barbara, Los Angeles, and Santa Maria regions.

Marine Ecoregion

Metallic minerals such as gold, silver, aluminum, lead, and zinc are mined in southeast Alaska and in Washington. In western Oregon, aggregate is the most dominant mineral extracted. There are no significant oil, natural gas, or coal resources within this region.

Soil Resources

Soils in the treatment area are diverse and range from the arid, saline soils of the southwest, to the clayey glaciated soils of Montana, to the cold, wet permafrost soils of Alaska. Soils are the result of complex interactions between parent material (geology), climate, topography, organisms, and time (Brady and Weil 1999). Soils are classified by the degree of development into distinct layers or horizons and their prevailing physical and chemical properties (Fanning and Fanning 1989). Similar soil types are grouped together into soil orders based on defining characteristics, such as organic matter and clay content, amount of mineral weathering, water and temperature regimes, or other characteristics that give soil unique properties, such as the presence of volcanic ash or permafrost (Jenny 1980).

Eleven soil orders are represented on public lands in the western U.S. and Alaska (Map 3-4). Soils develop under local conditions of climate, parent material, and vegetation, and so each ecoregion may contain several or all of the soil orders resulting from various combinations of local soil forming factors. Soils are organized here by soil order rather than by ecoregion.

Aridisols are found on over 40% of public lands (105 million acres). They occur across wide parts of the western U.S. in Nevada, Arizona, New Mexico, central Wyoming, southern Idaho, and southern California. These soils are characterized by an extreme water deficiency. They are light colored soils, low in organic matter, and may have subsurface accumulations of soluble materials, such as calcium carbonate, silica, gypsum, soluble salts, and exchangeable sodium. Vegetation on these soils includes scattered desert shrubs and short bunchgrasses, which are important resources for livestock. Aridisols are generally not very productive without irrigation, and may be prone to salinity buildup. Surface mineral deposits often form physical crusts or hardpans that impede water infiltration.

Gelisols occur on over 27% of public lands (71 million acres), almost exclusively in the tundra regions of Alaska. They are underlain by permanently frozen ground (permafrost). Some gelisols in wet environments have developed large accumulations of organic matter, particularly in areas of bogs and wetlands. Soil forming processes take place very slowly above the permafrost in the active layer that thaws seasonally. These soils support tundra vegetation of lichens, grasses, and low shrubs that grow during the brief summers. Plant productivity is low and limited by the extremely short growing season of the northern latitudes, low levels of solar radiation, and poor water drainage. Bare rock is also common in Alaska, comprising nearly 8 million acres.

Mollisols occur on about 15% of public lands (40 million acres). They are found in much of North and South Dakota and northern Montana, as well as in eastern Oregon, Washington, and Idaho where they have developed from basalt and loess parent materials. These soils typically support grasslands and are mineral soils with thick, dark-colored surface horizons rich in organic matter from the dense root systems of prairie grasses. They are one of the most productive soils on public lands and the high organic matter content of Mollisols helps reduce the risk of groundwater contamination by herbicides. Mollisols extend from upland areas to the prairie grasslands, where they are most abundant. Mollisols support a variety of vegetation communities, including grasslands, chaparral-mountain shrub, and forests. Since they have developed primarily under grassland vegetation, mollisols have been used extensively for livestock grazing.

Entisols occur on about 9% of public lands (23 million acres). Entisols occur extensively in eastern Montana, western Colorado, South Dakota, Wyoming, Utah, and central California. They are young, weakly developed mineral soils that lack significant profile development (soil horizons) and are often found in lower elevation, arid and semiarid environments supporting desert shrub and sagebrush communities. Entisols can include recent alluvium, sands, soils on steep slopes, and shallow soils. Soil productivity ranges from very low in soils forming in shifting sand or on steep rocky slopes to very high in certain soils formed in recent alluvium. Productivity is often limited by shallow soil depth, low water holding capacity, or inadequate available moisture, but these soils do support rangeland vegetation and may support trees in areas of higher precipitation.

Alfisols occur on less than 2% of public lands (4 million acres). They can be found throughout the mountains of western Montana and Wyoming and in central Colorado and California. They are characterized by subsurface clay accumulations and nutrient-enriched subsoil. Alfisols commonly have a mixed vegetative cover and are productive for most crops, including commercial timber.

Inceptisols also occur on less than 2% of public lands (4 million acres). Inceptisols are found in northern Idaho and parts of Washington, Oregon, and Montana, as well as southwest Alaska. They are generally young mineral soils, but have had more time to develop profile characteristics than Entisols. They principally occur in very cool to warm, humid and subhumid regions and in most physiographic conditions and often support coniferous and deciduous forests as well as rangeland vegetation. They may form in resistant rock or thin volcanic ash on steep mountain slopes or depressions, on top of mountain peaks, or next to rivers. Productivity is varied and may be high where moisture is adequate.

The other soil orders represent less than 1% of public lands each (1 million acres or less), and therefore, will not be discussed in detail. **Andisols** are soils that have formed on volcanic ash deposits. They have high amounts of volcanic glass and organic matter, giving them a light, fluffy texture. **Histosols** are organic soils that typically form in lowland areas with poor water drainage. While not extensive, histisols are often associated with riparian or wetland resources and can be very important locally.

Spodosols are highly leached, acid soils that typically form on sandy soils under cold, humid conditions at high elevations. **Ultisols** are strongly acid mineral soils associated with advanced soil weathering and are low in nutrients. **Vertisols** have large amounts of expanding clay that causes them to have high shrinking and swelling characteristics.

The concept of soil quality encompasses a soil's capacity to function and to sustain plant and animal productivity, air and water quality, and human health (Soil Quality Institute 2001). It is a function of each soil's inherited properties (texture, type of minerals, depth) as well as more dynamic properties that can change with management (i.e., porosity, infiltration, effective ground cover, and aggregate stability). The ability of a soil to filter, buffer, degrade, immobilize, and detoxify pesticides is a function of the soil quality.

Management activities can result in changes in certain soil properties such as soil porosity, organic matter, biological activity, and susceptibility to erosion. These changes in turn affect the fate of herbicides in soils. For example disturbances that result in increased susceptibility to erosion will affect the off-site movement of certain herbicides that are designed to bind to soil particles. Herbicides can alter soil organism diversity and composition. Compaction or surface disturbance may affect soil activated herbicides from reaching the root zone of target plants.

Biological Soil Crusts

Biological soil crusts (also known as cryptogamic, microbiotic, cryptobiotic, or microphytic crusts) are commonly found in semiarid and arid environments and provide important functions, such as improving soil stability and reducing erosion, fixing atmospheric nitrogen and contributing nutrients to plants, and assisting with plant growth (Belnap and Gardner 1993, Evans and Ehleringer 1993, Eldridge and Greene 1994, Belnap and Giliette 1998, Harper and Belnap 2001). Crusts are composed of a highly specialized nonvascular plant community consisting of cyanobacteria, green and brown algae, mosses, and lichens, as well as liverworts, fungi, and bacteria (Belnap 2001). Biological soil crusts occupy open spaces between the sparse vegetation of the Great Basin, Colorado Plateau, Sonoran Desert, and the inner Columbia Basin, and also occur in agricultural areas and native prairies, and in Alaska.

Biological soil crusts can reach up to several inches in thickness and vary in terms of color, surface topography, and surficial coverage. Crusts generally cover all soil spaces not occupied by vascular plants, which may be 70% or more in arid regions (Belnap 1994). They are well adapted to severe growing conditions, but are influenced by disturbances such as compression from domestic livestock grazing, tourist activities (hiking, biking, and OHVs), mechanical treatment and agricultural practices (extensive tillage and planting), application of herbicides, and military activities (Peterjohn and Schlesinger 1990, Belnap 1995, USGS 2004). Disturbance of biological crusts results in decreased soil organism diversity, nutrients, stability, and organic matter. Trampling may reduce the number of crust organisms found on the surface and increase runoff and the rate of soil loss without apparent damage to vegetation (Eldridge 1996). Burial of crusts by sediments kills non-mobile photosynthetic components (mosses, lichens, and green algae) of the crust (Campbell 1979). Fires can cause severe damage to biological crusts, but recovery is possible, depending on fire size and intensity. Shrub presence (particularly sagebrush) may increase fire intensity, therefore decreasing the likelihood of early vegetative or crust recovery after a burn (USGS 2003).

Micro and Macroorganisms

Microorganisms help to break down and convert organic remains into forms that can be used by plants. Microorganisms, such as mycorrhizal fungi, nitrogen-fixing organisms, and certain forms of bacteria assist plant growth, suppress plant pathogens, and build soil structure. One of the main benefits of mycorrhizal fungi is the improved uptake of nutrients (predominantly phosphorous) and water by plants (Allen 1991). Soil microorganisms are also important in the breakdown of certain types of herbicides.

Macroorganisms, such as insects and earthworms, and small mammals that burrow, mix the soil and allow organic matter on the surface to become incorporated into the soil. These organisms are also part of a food chain which is essential to the cycling of nutrients within the soil. Soil microorganisms are also important in the breakdown of certain types of pesticides.

Soil Erosion

Soil erosion is a concern throughout the western U.S. and Alaska, but especially in many semiarid rangelands. The quantity of soil lost by water or wind erosion is influenced by climate, topography, soil properties, vegetative cover, and land use. While it occurs under natural conditions, rates of soil loss may be accelerated if human activities are not carefully managed.

Tundra lands in Alaska are susceptible to erosion if the thick vegetative mat overlying permafrost is disturbed or removed. Trails quickly turn into widely braided ruts, especially in wetlands and at streambank crossings. The resulting gully erosion can rapidly erode substantial quantities of previously frozen soils. Erosion from aufice and anchor ice is also a concern due to spring breakup flood events leaving disturbed streamchannels. These events cause previously stable riparian areas to form a long-lasting sequence of extensive braided channels, especially in glacial soils.

Rangelands are affected by all four types of water erosion—sheet, rill, gully, and streambank. Sheet erosion is relatively uniform erosion from the entire soil surface and is therefore often difficult to observe, while rill erosion is initiated when water concentrates in small channels as it runs off the soil. Sheet and rill erosion is capable of reducing the productivity of rangeland soils, but often goes unnoticed. Gully and streambank erosion, is far more visible, and may account for up to 75% of erosion in desert ecosystems (Hein 2002). Changes in water flow patterns in arid areas resulting from thunderstorms and fire events can cause an increase in the size and frequency of runoff events and sediment yield to local water sources (Water Science and Technology Board and Board on Environmental Studies and Toxicology 2002).

It is possible to control rates of soil erosion by managing vegetation, plant residues, and soil disturbance. Vegetative cover is the most significant factor in controlling erosion by intercepting precipitation, reducing rainfall impact, restricting overland flow, and improving infiltration. Biological soil crusts are particularly important in protecting the soil and controlling erosion in desert regions, but are easily disturbed by grazing and human activities.

With a decrease in vegetative cover, the potential risk of herbicides entering surface water and groundwater can increase (Purdue Pesticide Program 2001). Herbicides can be transported by surface water runoff, potentially increasing the risk of direct injury to nontarget species, harming aquatic organisms in streams and ponds, and leading to groundwater contamination (University of Missouri Extension 1997).

Differences in chemical solubility, adsorptive characteristics, volatility, and degradability, plus soil properties that effect water movement, biological activity, and chemical retention, affect the amount of a herbicide that may leach to groundwater. The speed at which leaching of chemicals through soil occurs is dependent on the soil characteristics. Soil texture (sand, silt, and clay) affects the movement of water and herbicides through soil. The coarser the soil, the faster the movement of percolating water and the lower the opportunity for adsorption of dissolved chemicals. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer. These soils also have far more surface area on which herbicides can be adsorbed (LaPrade 1992).

Wind erosion is most common in arid and semiarid regions where lack of soil moisture greatly reduces the adhesive capability of soil (Brady and Weil 2002). In addition to moisture content, soil particle size (texture), mechanical stability of aggregates and clods, and presence of vegetation also affect the ability of wind to move soil. While wind erosion on rangelands is difficult to quantify, the presence of natural vegetation on most rangelands is generally sufficient to keep wind erosion from becoming a serious problem. Most wind erosion problems result from bare, exposed soils with weak or degraded soil structure, such as along trails or on sand dunes or disturbed surfaces. Herbicides can be potentially transported by blowing soils after application. Herbicides bound to soil particles may be moved offsite by serious wind erosion events.

Soil Compaction

Soil compaction occurs when moist or wet soil aggregates are pressed together and the pore space between them is reduced. Compaction changes soil structure, reduces the size and continuity of pores, and increases soil density. Wheel traffic, large animals, vehicles, and people can cause soil compaction. Generally, clayey- or silty-textured soils are more susceptible than sandy or rocky soils. Plant litter and roots, and soil organic matter, structure, moisture, and texture all affect a soils ability to resist compaction. In areas of rangeland where compaction exists, compacted soil extends generally less than 6 inches below the soil surface, although it can be as deep as 2 feet under heavily used tracks and roads (USDA Natural Resource Conservation Service 1996). Compaction becomes a problem when the increased soil density limits water infiltration, increases runoff and erosion, or limits plant growth or nutrient cycling (Soil Quality Institute 2001).

Water Resources and Quality

Water Resources

Water resources in the western U.S. and Alaska are important for fish and wildlife habitat and a variety of human needs, such as domestic consumption, industrial activities, crop irrigation, livestock watering, and recreation. Numerous legal and policy requirements have been established to manage water resources for these multiple needs, including the Clean Water Act, the Colorado River Basin Salinity Control Act, and EO 11988 (*Floodplain Management*).

Water resources are classified as surface water or groundwater. Surface water resources include rivers, streams, lakes, ponds, reservoirs, and wetlands. Major river systems (e.g., Colorado, Columbia, Snake, Missouri, Arkansas, Rio Grande, and Yukon rivers) and their tributaries are important sources of water in the western U.S and Alaska.

The quantity and quality of surface water resources are affected by precipitation, topography, soil type, vegetation, agricultural practices, urbanization, and general land use practices, especially for large tracts of public land. The alteration of vegetative cover from land use practices can have significant impacts on water infiltration, soil erosion, and stream sedimentation.

The largest quantities of useable freshwater occur as groundwater, which provides drinking water for more than 97% of the rural population without access to public-water supplies, and between 30 and 40% of the water used for agriculture (Alley et al. 1999). Groundwater is obtained primarily from wells that tap into aquifers. Aquifers are layers of permeable rocks that are recharged with freshwater from precipitation that percolates through the unsaturated zone to the water table, typically in upland, mountainous areas. Recharge rates generally range from a tiny fraction to about one-half of the average annual precipitation. Streams are commonly a significant source of recharge to groundwater downstream from mountain fronts and steep hillslopes in arid and semiarid areas.

As shown on Map 3-5, eight hydrologic regions have been identified in the treatment area - Alaska, Pacific Northwest, California, Upper Colorado, Lower Colorado, Rio Grande, Missouri, and Great Basin (Seaber et al. 1987). Most of the public lands occur in arid to semiarid environments in the Great Basin and Colorado drainage basins.

Alaska Hydrologic Region

The BLM administers approximately 108,000 miles (mi) of riparian habitat and nearly 12.6 million acres of wetlands in Alaska (USDI BLM 2005c). This region occupies the entire state of Alaska, and is characterized by an abundance of water resources. Major river systems, such as the Yukon, drain the mountain ranges, and extensive wetlands dot the low-lying plains and coastal regions.

The Yukon and Kuskokwim river drainages are some of the dominant drainages in Alaska. The Yukon River drains an area of more than 330,000 square miles (mi^2), making it the fourth largest drainage basin in North America. Its mainstem, the Yukon River, originates in northwestern Canada and extends through central Alaska, discharging into the Bering Sea (Brabets et al. 2000). Major tributaries of the Yukon River include the Tanana, Nenana, and Chena rivers.

The Kuskokwim River is the second largest drainage in Alaska. The glacially turbid mainstem is approximately 900 mi long, originating from the interior headwaters of the Kuskokwim Mountains and the shadows of the Alaska Range. The Kuskokwim River flows in a southwest direction to the Bering Sea.

Hydrologic processes are strongly affected by the presence of permafrost, which may thaw seasonally or be continuous throughout the year, particularly in the North Slope. In central Alaska, permafrost is discontinuous and an active layer at the surface that thaws during the summer months can supply groundwater for domestic use. The valleys of major rivers have alluvial aquifers with an active layer in the summer months that also supply good quality groundwater. During the winter, permafrost generally extends to the surface, impeding water infiltration and groundwater recharge.

Pacific Northwest Hydrologic Region

The Pacific Northwest Hydrologic Region includes the wet, coastal areas of Oregon and Washington, as well as the semiarid Columbia Plateau in eastern Washington, Oregon, and southern Idaho. The region is drained by the Columbia, Willamette, and Snake River systems, which are important sources of hydroelectric power and irrigation for agriculture.

The coastal areas of Oregon and Washington are influenced by medium to high rainfall levels due to the interaction between marine weather systems and the mountainous nature of the region. Mountains within this area are generally rugged with steep canyons. Tributary streams are short and have steep gradients, creating rapid surface water runoff with relatively short-term water storage, limiting recharge.

The Columbia River Basin drains approximately 259,000 mi^2. The basin extends roughly from the crest of the Coast Ranges of Oregon and Washington, east through Idaho, to the Continental Divide in the Rocky Mountains of Montana and Wyoming; and from the headwaters of the Columbia River in Canada to the high desert of northern Nevada and northwestern Utah. Its mainstem, the Columbia River, originates in two lakes that lie between the Continental Divide and the Selkirk Mountain Range in British Columbia. After flowing a circuitous path for approximately 1,200 mi, it joins the Pacific Ocean near Astoria, Oregon.

The Columbia River has 10 major tributaries: the Kootenay, Okanagan, Wenatchee, Spokane, Yakima, Snake, Deschutes, Willamette, Cowlitz, and Lewis rivers.

The Pacific Northwest Hydrologic Region includes a network of coastal streams and rivers. Many of these are rain-driven systems that are hydrologically flashy, influenced primarily by winter rain storms during the winter. Those streams west of the Cascade Range typically discharge directly into the Pacific Ocean.

The southernmost portion of this hydrologic region extends down to the northern portion of the Great Basin. This area is geologically very new and contains extensive areas of lava and other volcanic rock. The rock substrata is very permeable, therefore streams tend to lose much of their flow through percolation. Only large rivers that lie below the water table contain substantial flows year-round. In most years, high precipitation along the western side of the Cascade Range produces abundant surface water flow in streams flowing off the Cascade Range to the Pacific Ocean. Aridity progressively increases and precipitation decreases east of the Cascade Range, because of rainshadow effects caused by these mountains.

Timing of precipitation east of the Cascade Range coincides with periods of relatively high solar radiation, thus precipitation is rapidly evaporated (Spence et al. 1996). This limits the amount of surface water available to streams in this portion of the region. Generally, those streams that flow year round east of the Cascade Range are fed by snowmelt from higher elevations or by groundwater discharge from aquifers recharged during periods of high precipitation.

Groundwater is an important resource in this region for domestic consumption and irrigation, particularly when surface water supplies are insufficient. It is generally contained in shallow alluvial aquifers along major streams and their valleys.

Lower Colorado Hydrologic Region

The Lower Colorado Hydrologic Region is comprised of the lower reaches of the Colorado River in the desert southwest of Arizona, New Mexico, and southern Nevada. In this region, public lands are mainly restricted to the arid valleys, while many of the upland areas are administered by the Forest Service. The climate is arid, and precipitation is limited to the winter months and periods of heavy storms. Most precipitation during summer evaporates before it can infiltrate into the desert sands.

Surface water flow in the arid basins of the southwest is ephemeral to non-existent most of the year. Spring snowmelt and periods of heavy rain during the winter result in surface water flow in the mountainous areas and along the mountain fronts in the intervening basins. During the rest of the year, surface water flow is absent except after major storms, where flash floods are common along the mountain fronts. Only major rivers draining the Colorado Plateau or the Mogollon Rim, such as the Gila and Bill Williams rivers, show perennial flow.

Groundwater is found in the alluvium of the basins and in the bedrock of the mountainous areas (i.e., deep reservoirs to depths of many thousands of feet). Groundwater is recharged by precipitation in the mountains and from infiltration of stream flow along the base of the mountains. The shallow groundwater reservoirs are used extensively for irrigation and domestic consumption. Irrigation demand and mine dewatering have substantially lowered the water levels in the shallow groundwater reservoirs of the Arizona basins. However, groundwater levels in the basins of southern New Mexico have not been substantially affected by irrigation. Many of the basins have shallow groundwater that surfaces in playa lakes.

Rio Grande Hydrologic Region

This region occupies central New Mexico and western Texas. The Rio Grande and Pecos rivers are major surface water resources, which derive their water from the mountainous regions of southern Colorado and flow through New Mexico to the Gulf of Mexico. Surface water flow is present year-round in the Rio Grande and is caused by spring snowmelt and summer monsoon thunderstorms. Agricultural diversions account for approximately 90% of surface water use and may result in practically no flow during the summer months (Levings et al. 1998).

The Rio Grande aquifer system covers a 70,000-square-mi area of southern Colorado, central New Mexico, and western Texas. It consists of a network of hydrologically interconnected aquifers in basin-fill deposits located along the valleys of the Rio Grande and nearby rivers. These aquifers are generally composed of unconsolidated sediment deposits present in intermountain basins. Groundwater recharge primarily originates as precipitation in the mountainous areas that surround the basins, while most of the precipitation that falls in the valleys is lost to evaporation and transpiration. Potential evaporation may exceed 100 inches per year, while precipitation is frequently less than 8 inches per year (Levings et al. 1998).

Most groundwater withdrawals occur as discharge from pumping wells, of which about 90% is used for irrigation of commercial crops. Most cities and communities in the area, such as Albuquerque, Las Cruces, and Santa Fe, New Mexico, rely on groundwater for municipal use. Groundwater withdrawals in closed basins have caused long-term water-level declines, while withdrawals from wells located near the Rio Grande, or its perennial tributaries, generally do not cause long-term water level declines in the aquifer.

Upper Colorado Hydrologic Region

This region includes the Colorado Plateau, which encompasses parts of southern Wyoming, western Colorado, eastern Utah, and northern Arizona and New Mexico. The upper reaches of the Colorado River and its tributaries drain this region. Precipitation varies greatly with elevation and occurs as winter snows and heavy fall rainstorms.

Perennial surface water flow occurs in major rivers (e.g., Green River and Colorado River). Major streams are fed by snowmelt in the mountainous areas. Dams serve as flood control, domestic supply, and power generation for the major urban centers as well as providing surface water for irrigation. Intermittent flow occurs in tributaries to the major rivers, and ephemeral flow occurs in small canyons. Surface water runoff or groundwater baseflow are the major processes that deliver precipitation and snowmelt to streams. In Colorado, the annual hydrograph for most streams is dominated by snowmelt in the mountains; however, there is also a rain component, which varies by region. For instance, in the southwest portion of Colorado, summer monsoonal flow produces ample rain. The larger rivers in Colorado are perennial, but the smaller rivers and streams are either intermittent or ephemeral.

Groundwater is found in most of the sedimentary rocks of the Colorado Plateau, and is the major source of water for domestic and municipal use. Major aquifer systems are not present; groundwater is localized and can be abundant in some areas and absent in others. Farming and ranching are usually limited to stream valleys, where irrigation water comes mostly from surface water. Groundwater baseflow is the major source of water for perennial flows in the late summer and early fall. Seeps and springs are an historic source of water for Native American tribes and a current source of water for smaller ranches.

California Hydrologic Region

This region includes nearly the entire state of California, as well as parts of southern Oregon. This region is characterized by a Mediterranean climate with winter precipitation and a prolonged summer period, with little precipitation.

The California region is drained by rivers, such as the Sacramento and San Joaquin rivers. Surface water flow in streams is derived mainly from snowmelt in the mountainous areas during the spring months. During the remainder of the year, many streams have no flow or intermittent flow that follows major storms.

Groundwater in the mountainous areas is relatively deep, and is contained in sedimentary units that continue under the intermountain basins and form a deep reservoir that is seldom tapped because of its depth. Shallow groundwater can be found in sands and gravels that fill the basins between the mountain ranges. This shallow groundwater is fed by infiltration of surface water from streams that flow off the mountain ranges. Groundwater in southeastern California is the main source of water for domestic consumption and agricultural irrigation.

Missouri Hydrologic Region

This region covers the largest geographic area, including much of Montana, Wyoming, northeastern Colorado, North Dakota, South Dakota, and Nebraska. This region represents the eastern front of the Rocky Mountains stretching to the Great Plains, most of which is drained by the Missouri and Platte rivers and their tributaries.

Surface water resources are dominated by the major rivers and their tributaries. Precipitation is generally sparse in the summer and fall months, and surface water flow is generally dependent on snowmelt in the mountainous areas. Rivers flow mainly from late spring to early fall and can be dry in some parts of the region during the winter months. Most of the streams in western Montana flow year-round, while in Wyoming only the larger rivers, such as the North Platte, flow year-round. Surface water is directly connected to groundwater through shallow alluvial aquifers that are found along all the major rivers and their tributaries. Groundwater baseflow supplies stream and river flow in the late summer and fall. Surface water is the main source of municipal and irrigation water in the Rocky Mountain region, and irrigation return flow is a major component of surface water flow.

Groundwater in Wyoming and western Montana is found both in the igneous rocks of the uplifts and the basins, although groundwater in the uplifts is generally not used. Groundwater is used extensively for irrigation, much of it becoming irrigation return water that flows into major streams and their tributaries. In addition to irrigation, groundwater is also used for municipal and domestic water supplies. Major aquifers in the Great Plains are the Ogallala Aquifer of eastern Wyoming, Nebraska, and Kansas, and the Dakota Aquifer of North and South Dakota. Many of these major aquifers are overdrawn and the water table has been declining for decades. Recharge to these aquifers comes only from stream infiltration and spring snowmelt.

Great Basin Hydrologic Region

The Great Basin of Nevada and Utah is an arid region located in the rainshadow of the Sierra Nevada Mountains. The Great Basin is characterized by northerly trending mountain ranges and intermountain valleys with closed drainage. Precipitation generally falls as rain and snowfall in the mountains. Streams flowing down from the mountains carry water to the basins, which infiltrates into the alluvial sediments and provides the only substantial recharge to groundwater in the basins. Surface water flow in the basins is derived almost entirely from the mountain streams.

Apart from major rivers (e.g., the Humbolt and Truckee rivers), surface water flow in the basins of Utah and Nevada is intermittent along the mountain fronts and ephemeral in the basins themselves. Surface water flow in the mountainous areas is limited mainly to late spring following snowmelt in the higher areas of the ranges. Agricultural diversions of major streams exiting the mountains are common, and major rivers are used extensively for irrigation. Surface water flow in northern Nevada has been affected by pumpage of groundwater from mining areas into the rivers. The Humboldt River, from Battle Mountain to Winnemucca, Nevada, is dominated by mine discharge.

Groundwater is found in the alluvium of the basins and in the deeper rocks that underlie the alluvial basins. Shallow groundwater in the alluvium of the basins is the main source of water for domestic consumption, irrigation, and power plant cooling. Some areas of the Great Basin, particularly in northern Nevada, have geothermal reservoirs that underlie the shallow groundwater reservoirs. These geothermal waters have been tapped, often inadvertently, by open pit mining and dewatering of areas used for gold mining. The Great Basin contains many of the largest groundwater reservoirs in the United States. These reservoirs are largely untapped at present, but major urban areas like Las Vegas are actively pursuing development of these reservoirs.

Arkansas-White-Red Hydrologic Region

This region occupies the drainage of the Arkansas, Canadian, and Red River basins above the points of the highest backwater effect of the Mississippi River. It includes all of Oklahoma and parts of Colorado, New Mexico, Texas, Kansas, Missouri, and Louisiana. Only a relatively small proportion of public lands are found in this region, primarily concentrated near the headwaters of the Arkansas River in central Colorado and near the headwaters of the Canadian River in northeastern New Mexico.

Surface waters generally originate from precipitation falling in the eastern Rocky Mountains. Precipitation is relatively sparse in the summer and fall months, and surface water flow is typically dependent on snowmelt in the mountainous areas. Surface water resources are used extensively for irrigation of agriculture.

Groundwater resources are extensive in this region and consist primarily of the High Plains (Ogallala) aquifer and alluvial aquifers associated with the river valleys. The High Plains aquifer underlies much of this region and water withdrawals are used almost exclusively for irrigation (Robson and Banta 1995).

Water Quality

Water quality is defined in relation to its specified and/or beneficial uses, such as human consumption, irrigation, fisheries, livestock, industry, or recreation. The quality of surface water is determined by interactions with soil, transported solids (i.e., organics and sediments), rocks, groundwater, and the atmosphere. The Clean Water Act established the basic structure for regulating discharges of pollutants into the waters of the U.S. and is responsible for setting water quality standards for all contaminants in surface waters. Section 313 of the Clean Water Act requires all federal agencies to comply with state water quality standards "...to the same extent as any nongovernmental entity." Thus, the BLM has a responsibility to fulfill their obligations under the Clean Water Act and Safe Drinking Water Act, to maintain waters that meet or surpass designated beneficial uses, to restore impaired water resources in support of their designated beneficial uses, and to provide water for public consumption and use (USEPA 2003e).

Section 303(d) of the Clean Water Act requires that water bodies violating state water quality standards and failing to protect beneficial uses be identified and placed on a 303(d) list (USEPA 2003e). The delisting of 303(d) listed streams is a priority of the BLM.

Nonpoint source pollution is the largest source of water quality problems and comes from diffuse or scattered sources rather than from an outlet, such as a pipe that constitutes a point source. Sediment is a nonpoint source of pollution that results from activities such as grazing and timber harvest. Erosion and delivery of eroded soil to streams is the primary nonpoint source pollution problem of concern to the BLM (USDI BLM 1980).

The most important factors affecting water quality include sediments, microbes, pesticides, nutrients, metals, and radionuclides (Nash 1993). Sedimentation and nutrient loading affect surface waters, while agricultural runoff and industrial wastes can also leach into groundwater. Surface water quality is also affected by solar loading and shade producing vegetation that affect water temperature, flow, total suspended solids (TSS), total dissolved solids (TDS), turbidity, changes in dissolved oxygen, salinity, and acidity.

The susceptibility of aquifers to groundwater contamination relates to geology, depth to groundwater, infiltration rates, and solubility of contaminants. Deep aquifers are often too deep to be affected by surface alteration or shallow waste disposal. However, shallow aquifers may be directly affected by surface alternation and by waste and wastewater disposal. Shallow, unconfined aquifers with rapid recharge rates are generally the most vulnerable to contamination because of the rapid infiltration of groundwater from the surface to the water table.

Water quality data for the surface and groundwater resources of the western states are available from the USGS National Water Information System (NWIS) database (USGS 2002b), the USGS National Water Quality Assessment (NAWQA) Program (USGS 2002c), the USEPA's Index of Watershed Indicators (USEPA 1999b), the USEPA's National Water Quality Inventory (USEPA 2000), the USGS Groundwater Atlas of the United States (USGS 2000), and from state water quality databases. These sources have been used to develop a general assessment of water quality in the hydrologic regions of the western states, including Alaska, where the BLM has substantial land management responsibility. Data from the USEPA's Index of Watershed Indicators characterizes the condition and vulnerability of each of the 2,262 subbasins in the U.S. (Map 3-6). Information on general groundwater quality (based on concentration of TDS) was compiled from the USEPA's National Water Quality Inventory (USEPA 2000; Map 3-7).

Alaska Hydrologic Region

Surface and groundwater resources in Alaska are both of relatively good quality. The lack of industrial and agricultural development reduces the risk of contamination of water resources. Human activities, such as mining, oil drilling, and waste disposal in small villages contribute to localized surface and groundwater pollution. Oil drilling adds petrochemicals to both surface and groundwater, and waste disposal adds nitrates and colliform bacteria. Public lands have localized surface and groundwater contamination from oil drilling.

Pacific Northwest Hydrologic Region

Surface water quality has been degraded in the agricultural areas of eastern Washington and Oregon and in southern Idaho by contamination resulting from agricultural and grazing practices. Elevated levels of nitrates, phosphates, and other nutrients are found in these waters. In Montana, agricultural practices in the Bitterroot Valley have added nutrients to surface water. Fish farming has also contributed to elevated nutrient levels in streams and rivers of Washington. Irrigation return waters in the Snake River Basin are contributing nutrients and pesticides to surface waters (Clark et al. 1998). Herbicide use results in elevated levels of these chemicals in surface waters during the growing season; however, these levels typically decline after the growing season.

Groundwater is generally of good quality for most uses across the Pacific Northwest. Rivers and streams with lower water quality are primarily the result of thermal modifications, pathogens, habitat alterations, and concentrated agricultural activities in areas such as the Willamette Valley and the Columbia Plateau (Wentz et al. 1998; Williamson et al. 1998; USEPA 2000). Elevated levels of nitrates and pesticides have been detected in the groundwater in the Snake River Basin and the Columbia Plateau.

Lower Colorado Hydrologic Region

High surface water temperatures in this region affect the water quality. Total dissolved solids concentrations can be elevated, especially along major rivers associated with extensive agriculture in their river valleys, such as the Salt and Gila rivers of Arizona. Agricultural land use practices and mining have been the major contributors to surface water degradation in this region. Public lands in this region are used mainly for grazing and mining, resulting in localized impacts to surface waters. These impacts include increases in turbidity, sedimentation, salinity, and possible chemical contamination. High erosion rates can be expected wherever large percentages of exposed soil occur, a very common result with grazing animals in this region (Bogan et al. 2003).

Groundwater quality in this region is dependent on the rocks that host the groundwater reservoir. Shallow groundwater reservoirs are mainly in alluvium or Late Tertiary sedimentary beds dominated by lakebeds and evaporites, causing saline groundwater with elevated concentrations of TDS. In mining districts, concentrations of metals are elevated in the groundwater, and in areas of extensive grazing, shallow alluvial groundwater may show elevated concentrations of nitrates and bacteria. Deep groundwater reservoirs are usually contained in carbonate rocks, leading to groundwater of good quality and low concentrations of TDS.

Rio Grande Hydrologic Region

Elevated levels of TDS associated with agriculture in the Rio Grande River valley can pose a problem for surface water quality. Agricultural practices along the Rio Grande have also contributed nutrients and pesticides to surface waters (Levings et al. 1998). The upper reaches of the Rio Grande in Colorado and the tributaries to the Rio Grande in southern Colorado have shown elevated metal concentrations due primarily to the Creede, Colorado mining district.

Most of the groundwater resources utilized in the Rio Grande basin are used for irrigation and livestock watering, although drinking water is also an important use. Nitrate concentrations may exceed USEPA standards, particularly in agricultural areas such as the San Luis and Rincon valleys. Pesticides have been detected in the groundwater in both agricultural and urban areas, but generally do not exceed USEPA standards. Volatile organic compounds (VOCs) may be present in shallow groundwater in urban areas such as Albuquerque and Santa Fe (Levings et al. 1998).

Upper Colorado Hydrologic Region

In this region, surface waters generally flow out of the southern Rocky Mountains and work their way to major rivers. Water quality in the southern Rocky Mountains is generally good, except in historic mining areas. But as the surface waters pass through the Colorado Plateau country, quality declines due to agricultural practices, evaporation, a change in the nature of the bedrock, and urban wastewater disposal practices (Spahr et al. 2000). Concentrations of nutrients and pesticides increase as the waters pass through this area. Groundwater quality in this region appears to be influenced mainly by the nature of the bedrock. In areas of sedimentary rock, concentrations of TDS, along with radon, uranium, and metals, can be high. Mesozoic rocks in this region may host uranium, selenium, evaporite, and copper deposits. In areas of the Colorado Plateau administered by the BLM, grazing and mining are the main activities, often leading to local groundwater contamination from metals, especially the uranium-rich areas of the Colorado Plateau.

California Hydrologic Region

Surface water resources in California show elevated concentrations of TDS from high salinity, particularly in the southern portion of the region. Groundwater and surface water diversions are used for agricultural irrigation in California. Because of the arid nature of the climate, much of this irrigation water evaporates, leading to irrigation return waters that flow back into streams with elevated levels of salt, nutrients and pesticides. In the agricultural areas of the Central Valley of California (San Joaquin and Sacramento River basins), nutrient loadings to streams and accumulation of pesticides in aquatic organisms and streambed sediments are a problem (Dubrovsky et al. 1998; Domagalski et al. 2000). Nitrate concentrations in streams generally meet USEPA drinking water standards, but at levels that can pose a problem for aquatic life.

Groundwater in southern California has naturally high concentrations of TDS from the presence of evaporite beds in the sedimentary rocks that underlie the desert areas. In agricultural areas, extensive fertilizer use, combined with heavy irrigation to overcome the high evaporation rates, have resulted in elevated concentrations of nitrates in shallow groundwater reservoirs. Pesticides are present in shallow groundwater reservoirs, but at concentrations generally below USEPA drinking water standards. In agricultural areas, groundwater is used for irrigation, leading to substantial declines in shallow groundwater tables and contamination of groundwater resources by agricultural practices. In the desert areas administered by the BLM, groundwater is generally not affected by pesticides. The low recharge rate for groundwater in these areas means that any application of herbicides would not be likely to enter and affect groundwater resources.

Missouri Hydrologic Region

In the high Rocky Mountains of this region, surface water has low concentrations of dissolved solids and meets all aquatic and drinking water standards, except in areas of historic mining. As surface water leaves the mountains and enters the plains and valleys surrounding the mountainous area, the water quality changes. In Colorado, agricultural land use practices and urban wastewater disposal degrade the water quality by adding nutrients and pesticides (Dennehy et al. 1998). In Wyoming, dewatering from mining and petroleum extraction have resulted in localized increases in concentrations of dissolved solids and metals in surface waters. Grazing activities in the Great Plains affect surface water quality by contributing sediments and nutrients. Bacterial contamination of surface water by domestic livestock is considered a significant non-point source of water pollution (Bohn and Buckhouse 1985, George 1996). Areas of extensive agriculture often show elevated nutrients and pesticides in the surface water. Agricultural practices have contributed nutrients and pesticides to surface waters in basins along major rivers in this region.

Groundwater in this region is generally of good quality and low in TDS, except in areas of historic and present-day mining, where there are elevated concentrations of sulfate and metals in the groundwater. In areas of the Rocky Mountains administered by the BLM, mining is the principal source of groundwater contamination. A secondary source of contamination is the geology of the bedrock, where rocks rich in uranium and radon contribute to groundwater. This is particularly evident in Wyoming and in the South Platte River basin of Colorado (Dennehy et al. 1998). Shallow alluvial groundwater in agricultural areas has elevated concentrations of nutrients and pesticides. Shallow groundwater along the Colorado Front Range and in large urban areas of the Rocky Mountains shows local evidence of contamination by wastewater, petroleum by-products, and nutrients and/or pesticides used on lawns and golf courses. In the Great Plains, groundwater has nitrate concentrations that often exceed the USEPA limit of 10 parts per million (ppm) and also has elevated concentrations of pesticides.

Great Basin Hydrologic Region

Water quality in the rivers and streams of this region has been affected by agricultural land use along the major rivers, urban waste disposal practices, the chemical composition of rocks in the river basins, and by past mining activity. Public lands in the Great Basin generally exclude urban and agricultural areas, but include most of the areas of past mining. Agricultural practices have contributed nutrients and pesticides to surface waters in basins along major rivers. Urban areas, such as Reno, Las Vegas, and Salt Lake City, have added nutrients and synthetic organic compounds to surface waters as well. Past mining activity has added metals to surface waters in localized areas throughout the Great Basin. The chemical makeup of near-surface rocks has contributed arsenic, uranium, and radon to surface waters (Bevans et al. 1998).

Groundwater quality in the Great Basin is determined mainly by the chemistry of the rocks that host the groundwater reservoir. Carbonate rocks and sandstones have relatively low concentrations of TDS and good water quality. Groundwater in the central parts of basins with playa lakes, and in areas with evaporite beds, generally has elevated concentrations of salts and TDS. Groundwater in mining areas often has high localized concentrations of mercury, arsenic, and other metals. In areas of extensive agriculture, shallow alluvial aquifers are often contaminated with nitrates and pesticides.

Arkansas-White-Red Hydrologic Region

Surface water quality is typically moderate in this region, and poor in areas with extensive agricultural or livestock production. The upper reaches of the Arkansas River, where most public lands are located, rely primarily on spring snowmelt for recharge and are generally of better water quality.

Groundwater quality is relatively good in this region. The dissolved-solids concentration of water in the aquifers in eastern Colorado and eastern New Mexico is generally less than 500 milligrams per Liter (mg/L), but may exceed 1,000 mg/L in small areas of Colorado. Concentrations less than 250 mg/L are found in northeastern Colorado and are the result of relatively large recharge rates in areas of sandy soil that contains few soluble minerals (Robson and Banta 1995).

Wetland and Riparian Areas

Wetlands are generally defined as areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation that is typically adapted for life in saturated soil (USDI BLM 1998). Wetlands include bogs, marshes, shallows, muskegs, wet meadows, estuaries, and riparian areas. According to the 1987 Corps of Engineers Wetland Delineation Manual, an area must exhibit evidence of at least one positive wetland indicator from each of the following parameters to be defined as a wetland (Environmental Laboratory 1987):

- **Soils** - The substrate is predominately undrained hydric soil, or the soils posses characteristics that are associated with reducing soil conditions;
- **Hydrology** - The area is inundated either permanently or periodically at a mean water depth of less than 6.6 feet or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation; and
- **Vegetation** - The land supports predominately hydrophytes. Hydrophytes are macrophytic plants with the ability to grow in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content and depleted soil oxygen levels.

Riparian and wetland areas comprise approximately 9% of public lands (USDI BLM 2005c). The benefits of these vital areas, however, far exceed their relatively small acreage. The functions of wetland and riparian areas include water purification, stream shading, flood attenuation, shoreline stabilization, groundwater recharge, and habitat for aquatic, semiaquatic, and terrestrial plants and animals (USEPA 2001).

The BLM administers approximately 12.8 million acres of wetlands. Of these, approximately 12.6 million acres are found in Alaska (USDI BLM 2005d).

The BLM has surveyed 92% of wetland acreage in the lower 48 states. Only a small fraction of the wetlands in Alaska have been surveyed due to their pristine nature and lack of immediate development pressure. Seventy-five percent of wetlands in the lower 48 states were evaluated were judged to be functioning properly (USDI BLM 2005d). Ninety-eight percent of Alaska wetlands are assumed to be functioning properly. The remaining Alaska wetlands have been placed in the "Unknown" category because some questions have been raised about development impacts.

The BLM defines properly functioning wetlands as those that: 1) support adequate vegetation, landform, or debris to dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, thereby reducing erosion and improving water quality; 2) filter sediment and aid floodplain development; 3) improve flood-water retention and ground-water recharge; 4) develop root masses that stabilize islands and shoreline features against cutting action; 5) restrict water percolation; 6) develop diverse ponding characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, water-bird breeding, and other uses; and 7) support greater biodiversity (Prichard et al. 2003). This assessment does not take into consideration the habitat value of the wetland to fish and wildlife.

About 22% of wetlands are considered to be functional, but at risk and trending downwards in functional capability, and 3% are non-functional, in terms of their ability to dissipate stream energy. Public lands with poorly functioning wetlands tend to be located in the southwestern U.S.

Riparian areas, according to the BLM, are green zones along flowing-water features such as rivers, streams, and creeks (Gebhardt et al. 1990). These areas exclude streams where water flows for only brief periods during storm runoff events (ephemeral streams). The BLM administers approximately 144,000 miles of riparian habitat in the treatment area. Of this, approximately 107,650 miles are found in Alaska (USDI BLM 2005d).

It is estimated by the BLM that 48% of surveyed riparian areas in the lower 48 states and 100% of riparian areas in Alaska are properly functioning in terms of having adequate vegetation, landform, or large woody debris present to dissipate stream energy associated with high waterflows (USDI BLM 2005d). Nine percent of riparian areas in the lower 48 states are considered non-functional, and 43% functioning but at risk (USDI BLM 2005d). Poorest functioning riparian areas are found in the southwest and Montana, while most riparian areas in Alaska, Colorado, and Utah function properly.

Vegetation

The composition and distribution of plant communities in the western U.S. have been influenced by many factors, including climate, drought, insects, diseases, wind, domestic livestock grazing, cultivation, browsing by wildlife, and fire (Gruell 1983). Other activities that have a direct and/or indirect effect on plant communities include logging, minerals extraction and reclamation activities, recreational activities, and ROW development including road construction and maintenance. In addition, competition with other species, influenced by the introduction of nonnative invasive plant species, has had a profound effect on native vegetation.

Before European settlement, naturally occurring fire was an important influence on the landscape of the West, and plant communities are adapted to the occasional intense fires that burned over the landscape (Gruell 1983). The exclusion of fire following European settlement has caused significant changes in vegetative species composition in the western U.S., especially in areas adapted to fire (Swetnam 1990). Where fire-adapted communities previously limited the expansion of juniper, sagebrush, and other less fire-tolerant species, exclusion of fire has resulted in invasion of these species into the surrounding ecosystems (Gruell 1983). The circumstance has also contributed to accumulation of hazardous fuels.

Vegetation within the treatment area has been classified into 14 subclasses (Table 3-4). The subclasses differentiate vegetation on the basis of growth form (tree, shrub, or herb), life history strategy (evergreen or deciduous, annual or perennial), and percent of canopy closure (forest or woodland) or hydrologic influences. The following discusses important vegetation subclasses for each ecoregion.

Tundra Ecoregion

Located at high latitudes in northern and western Alaska, plant communities in the Tundra Ecoregion are adapted to withstand an extremely short growing season, continuous permafrost, and limited rooting depths. Slow-growing dwarf shrubs, grasses and sedges, and cryptogams (lichens) are the dominant vegetation types in this region. Approximately 39 million acres of public lands occur within this ecoregion.

Perennial graminoid communities are found on over 13 million acres (Map 3-8). Along Alaska's coastal regions to the north, west, and southwest, cottongrass-tussock communities are the most widespread plant systems. Cottongrass occurs as the dominant species in extensive patches in flat, poorly drained areas, and is associated with other sedges, dwarf shrubs, lichens, mosses, dwarf birch, Labrador tea, and cinquefoil. Similar plant communities are also found at low elevations in the mountainous North Slope and Alaska Peninsula regions.

Deciduous shrublands (both dwarf and non-dwarf) are found in many of the same areas as perennial graminoid communities, as well as higher elevation alpine areas. Deciduous dwarf-shrubland occurs on over 10 million acres and is characterized by shrubs that are less than 2 feet tall, a reduced stature that is attributable to extremely harsh growing conditions. Characteristic plant species include dwarf birch, willow, huckleberry, and Labrador tea and other shrubs. A variety of forbs and graminoids are found in the understory, and lichen species may be an important component. At high elevations in mountainous areas, dwarf Arctic birch, crowberry, and dwarf blueberry are also common.

Deciduous shrubland species occur on over 6 million acres and are generally the same as those found in deciduous dwarf-shrublands, but are taller because of slightly better growing conditions. Willow, dwarf birch, alder, huckleberry, Labrador tea, and heath species are common. These communities may be successional to forest or woodland, or may be the climax vegetation where frozen and poorly drained permafrost soils limit tree growth. Stunted black spruce and other tree species are occasionally scattered throughout shrub communities.

In areas underlain by permafrost, nearly 3 million acres of sedge-dominated wet meadows, bogs, and wetlands are scattered among the shrublands. Along major rivers and streams, riparian communities composed of alder, willows, and stunted stands of spruce and birch can be found. In shrublands, pure stands of stunted alder shrubs are found in wet drainages, at the head of streams, along river terraces, or on slopes. Some evergreen spruce woodlands, spruce hardwood forests composed of white spruce, paper birch, and alder, and black spruce forests also occur, in low amounts, in the Tundra Ecoregion.

Subarctic Ecoregion

Located within the central continental region of Alaska, the Subarctic Ecoregion primarily consists of evergreen forests and open lichen woodlands collectively known as the boreal forest, or taiga. The climate in this region is characterized by low precipitation (10 to 20 inches average annual precipitation), extreme ranges of temperature, low humidity, and high evaporation rates. However, as this is a diverse area, there are also large portions of this region that are semiarid. Approximately 43 million acres of public lands occur in this ecoregion.

Over 20 million acres of evergreen woodlands and mixed evergreen-deciduous woodlands can be found throughout this region. Within the lowland areas of interior central Alaska, evergreen woodlands are often composed of pure stands of black spruce, with an understory of willow, dwarf birch, crowberry, blueberry, lichens, and mosses. Within the mountainous regions of central and south-central Alaska, woodlands are also common, typically supporting a number of boreal tree species: white spruce, black spruce, tamarack, balsam poplar, paper birch, and aspen.

Deciduous shrubland occurs on 10 million acres predominantly at higher elevations in the mountainous areas of this region. These shrublands are composed of a wide variety of low growing shrubs, herbs, grasses, and sedges, rooted in mosses and lichens. Mountain avens, low growing willows, dwarf birch, Labrador tea, blueberry, green alder, moss campion, and black oxytrope are all common species. Along riparian areas, deciduous tree species are prevalent. Paper birch, aspen, and balsam poplar are all found in these deciduous forest riparian communities. Extensive sphagnum bogs occur in old river terraces, ponds, and sloughs. These scattered wetlands are composed of sphagnum and other mosses, sedges, bog rosemary, Labrador tea, rose, birches, willow, bog cranberry, soapberry, and blueberry. About 2 million acres of forested communities also occur in the Subarctic Ecoregion. Mixed evergreen-deciduous forests, supporting many of the same species as woodlands, can be found in mountainous areas between elevations of about 1,000 and 3,000 feet (timberline). Spruce-hardwood forests consisting of white spruce, birch, aspen, and poplar, with an undergrowth of mosses, and berries are common.

Temperate Desert Ecoregion

The Temperate Desert Ecoregion is composed of arid lands in the rain shadow of the Pacific mountain ranges, including the Great Basin, Columbia Plateau, and Wyoming Basin. Plant communities, which are adapted to pronounced summer drought and cold winters, are composed primarily of xerophytic semidesert shrubs. Approximately 105 million acres of public lands occur in this ecoregion.

Evergreen shrublands in the form of sagebrush communities occur on nearly 74 million acres (Map 3-9). These shrublands typically consist of fairly dense to open vegetation, with shrubs that are 2 to 6 feet high and an understory of perennial and annual grasses and forbs (Cronquist et al. 1972). On the drier sites, shrub density is generally high, while on more mesic sites individuals are more robust and widely spaced, with greater coverage of herbaceous species.

In the plains and tablelands of the Columbia River and Snake River plateaus and the Wyoming Basin, representative shrubs in sagebrush communities include big sagebrush, black sagebrush, low sagebrush, Mormon tea, and bitterbrush (Cronquist et al. 1972). Important perennial grasses include bluebunch and western wheatgrass, Sandberg bluegrass, Idaho fescue, and Great Basin wildrye. Medusahead and downy brome are introduced annual grasses that have become abundant in these communities where the native herbaceous understory has been depleted, particularly in lower precipitation zones. They have an adaptive advantage over seedlings of most existing grass species

TABLE 3-4
Vegetation Classification System

Order	Class	Subclass
Tree Dominated	Closed Tree Canopy	1. Evergreen Forest
		2. Deciduous Forest
		3. Mixed Evergreen-Deciduous Forest
	Open Tree Canopy	4. Evergreen Woodland
		5. Deciduous Woodland
		6. Mixed Evergreen-Deciduous Woodland
Shrub Dominated	Shrubland	7. Evergreen Shrubland
		8. Deciduous Shrubland
	Dwarf-Shrubland	9. Evergreen Dwarf-Shrubland
		10. Deciduous Dwarf-Shrubland
Herb Dominated	Herbaceous Vegetation	11. Perennial Graminoid
		12. Annual Graminoid or Forb
		13. Perennial Forb
		14. Riparian/Wetland

Source: Developed by the BLM based on Federal Geographic Data Committee Vegetation Subcommittee's National Vegetation Classification Standard (USDI BLM 1997).

in their ability to take advantage of limited moisture early, short lifespans, and prolific seed production. Where repeated fire or grazing have removed the native vegetation, these invasives, as well as invasive forbs, will dominate the site taking advantage of what moisture exists and outcompeting the native vegetation. They then dry out and become fuel, burning very intensely and carrying fire into previously unburned areas, thus repeating and expanding the cycle.

In the Great Basin and northern Colorado Plateau, common shrubs in salt desert shrub communities are shadscale, fourwing saltbush, spiny hopsage, and greasewood. These communities occur from valley bottoms to mid-elevations in areas with shallow water tables and accumulated salts. Understory vegetation is generally sparse, with a large amount of bare soil or desert pavement exposed (MacMahon 1988). Species such as inland saltgrass, Indian ricegrass, bottlebrush squirreltail, fescues, and galleta grass may be found in this understory layer. Fires are generally absent due to the sparse fuels, and efforts to reestablish native plant communities are complicated by the dry conditions.

In the mountainous regions, sagebrush communities can be found scattered throughout the forested areas and sagebrush communities dominate the foothills adjacent to the forested habitat. These higher elevation sagebrush communities are dominated by big sagebrush and other shrubs including antelope bitterbrush, mountain mahogany, and snowberry. The herbaceous component of these plant communities often contains Idaho fescue, bluebunch wheatgrass, various needlegrass and bluegrass species as well as a variety of forbs.

Pinyon-juniper (evergreen) woodlands occur on nearly 14 million acres. These communities can be found in small areas in central Oregon, and at elevation zones above sagebrush communities throughout the rest of the ecoregion. Young pinyon-juniper trees are easily killed by fire, which historically had limited their expansion into sagebrush communities (West and Van Pelt 1987). Stands of pinyon-juniper have established in many locations, and form dense canopies that cause the loss of understory plants. These closed-canopy pinyon-juniper stands generally do not have enough understory shrubs to carry a surface fire, and do not burn until conditions are met to carry a crown fire. Old-growth pinyon-juniper stands occur on rocky slopes where surface fuels are limited, and have a historical fire return intervals are about 100 to 200 years (Federal Regime Condition Class 2004).

Deciduous shrublands typically occur at similar elevations as sagebrush, on arid, saline soils on nearly 3 million acres. Dropping their leaves during times of drought enable plants such as greasewood, hopsage, catclaw acacia, and smoketree to survive the harsh conditions. Many of these species are fairly tolerant of alkaline and saline conditions, and occur as lesser members of sagebrush and pinyon-juniper communities.

Other vegetation classes include the perennial bunchgrass grasslands of Oregon, Washington, and

Idaho (6 million acres), and the evergreen forests that occur at elevations above woodlands (over 1 million acres). Dominant tree species in these forests include ponderosa pine and Douglas-fir. In a few areas, mountains are high enough to support subalpine fir and Engelmann spruce.

Subtropical Desert Ecoregion

The Subtropical Desert Ecoregion occupies southeast California, southern Nevada, Arizona, and New Mexico, and western Texas, and includes the Chihuahuan, Sonoran, and Mojave deserts. Vegetation is adapted to dry conditions, and includes numerous xerophytic plants, such as small, hard-leaved or spiny shrubs, cacti, or hard grasses, which are widely spaced and provide little ground cover. Large portions of these hot deserts have no visible plants and are made of shifting sand dunes or nearly sterile salt flats. Approximately 29 million acres of public lands occur in this ecoregion.

Although major fires were not historically common in this region due to the wide spacing between plants and sparse fuels, the invasion of fire-prone species (e.g., red brome, downy brome, and buffelgrass) has shortened the fire interval in some areas, resulting in significant changes in plant communities.

Evergreen shrub communities are prevalent in desert habitats on over 23 million acres of public lands. On the plains of the Sonoran Desert, shrublands of creosote bush and saltbush species cover extensive areas in nearly pure stands. Individual shrubs are typically widely spaced, with large amounts of bare ground in between.

Large plants, such as the treelike saguaro cactus, prickly pear cactus, ocotillo, creosote bush, and smoke tree often form communities with a near-woodland appearance. They are commonly associated with blue palo verde, bursage, mesquite, desert ironwood, allthorn, jojoba, acacia, and many species of cactus, yucca, and agave.

In the Mojave Desert, Joshua tree shrublands are widespread. Other common shrubs in this region include creosotebush, bursage, thornbush, shadscale, all scale, spiny hopsage, and greasewood. The Mojave Desert is especially rich in annual plants, which are abundant during the rainy season in winter and spring (Brown 1982).

Shrublands occurring adjacent to shallow playa lakes and desert washes, and in other moist habitats, have a unique species composition. Greasewood and catclaw acacia, which occur as scattered individuals in many plant communities throughout the ecoregion, often form pure stands in desert washes. Mesquite is another shrub species that may be found growing along washes and watercourses. Shrubs associated with alkaline soils near playas include mesquites, whitethorn acacia, blue palo verde, ironwood, desert willow, and canyon ragweed.

Evergreen shrublands in the Chihuahuan Desert include such species as mesquite, tarbush, acacia, and creosotebush. Shrubs have recently increased in density in the Chihuahuan Desert, which is thought to have historically existed as open grassland or grassland scattered with shrubs (Buffington and Herbel 1965). Evergreen shrublands grade into grasslands, with the relative abundance of each plant community determined by such factors as fire, grazing, climate change, and seed dissemination (Holechek et al. 1995).

Perennial grasslands occur on nearly 4 million acres in the high plains of southeast Arizona (in the Chihuahuan Desert), where they are best developed on deep, well-drained soils on level sites (Brown 1982). Black grama and tobosa grasses are characteristic, along with sideoats and hairy grama, bush muhly, vine and curly mesquite, pappus grass, tanglehead, and threeawns. Shrubs and succulents characteristic of this grassland include yucca, bear grass, agaves, sumac, ocotillo, acacias, mimosas, and cacti.

Deciduous and evergreen woodlands occur in select areas on over 1 million acres, predominantly on higher elevation slopes (pinyon-juniper woodlands) and in eastern New Mexico (oak and mesquite woodlands).

Temperate Steppe Ecoregion

The Temperate Steppe Ecoregion, which is typified by a semiarid continental climate, includes the Rocky Mountains and the Great Plains. Vegetation communities adapted to this climate include steppe, or shortgrass prairie, and semidesert, as well as the evergreen and deciduous forests and woodlands of the Rocky Mountains. Approximately 19 million acres of public lands occur in this ecoregion.

Perennial grassland communities are widespread in this ecoregion (over 4 million acres), which includes the prairie grasslands of the Great Plains, the Palouse grasslands of Oregon, Washington, and Idaho, and the mountain grasslands of the Rocky Mountains.

Prairie grasslands, which occur on the broad, flat belt of land that slopes eastward from the foothills of the Rocky Mountains, vary in height in response to precipitation. Dominant grasses in the shortgrass communities are buffalograss and blue grama, which occur with other herbs, as well as some woody species, including mesquite, sagebrush, and yucca.

Mixed grass communities include both warm-season (e.g., blue grama) and cool season species, such as needlegrasses, wheatgrasses, and fescues grass species. Shrubs, including juniper, sagebrush, rabbitbrushes, and forbs are also important components of mixed grass communities (Brown 1982).

The Palouse grasslands, or northwest bunchgrass prairies, are dominated by bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, and rough fescue. Many of the introduced species are Mediterranean annuals that are well adapted to grazing and the predominantly winter precipitation regime.

Perennial mountain grasslands are scattered throughout areas at elevations from 3,000 to over 9,000 feet in the Rocky Mountains, particularly in western Montana. These grasslands are part of the vegetation mosaic created by the highly complex environment of the Rocky Mountains. Important grasses in these communities include bromes, bluegrasses, oatgrasses, sedges, wheatgrasses, fescues, needlegrasses, hairgrasses, reedgrasses, bentgrasses, and junegrass. Forb components vary with site, latitude, and management. Shrubs include several species of sagebrush, rabbitbrushes, snakeweed, shrubby cinquefoils, wild roses, horsebrush, and prickly pear (Mueggler and Stewart 1980).

Evergreen forests occur on over 2 million acres in the mountain regions, with species composition that varies by altitude. Subalpine forests are composed of Engelmann spruce, subalpine fir, and mountain hemlock. Below this zone, Douglas-fir, western white pine, grand fir, western larch, lodgepole pine, and ponderosa pine are common. Lodgepole pine or ponderosa pine forests may occur at the lowest elevations, and often grade into grasslands or evergreen shrubland. Fire is an important component of these low elevation forests, and lodgepole pine is specifically adapted to regenerate after fire.

Deciduous forests may occur along streams and rivers in the eastern portion of this ecoregion. Eastern species such as ash, hackberry, elm, birch, and bur oak may be found. Deciduous forests composed of quaking aspen are prevalent throughout the Rocky Mountains up into Alaska (DeByle and Winokur 1985). Aspen may form extensive pure stands or exist as a minor component of other forest types.

The most common type of shrubland in this ecoregion is sagebrush steppe. Sagebrush-dominated communities occur on the plains and lower mountain slopes on nearly 8 million acres. Chaparral shrublands and pinyon-juniper woodlands (2 million acres) are also found in some of the lower elevation areas on warm, dry sites.

Subtropical Steppe Ecoregion

The Subtropical Steppe Ecoregion, located in northern Arizona, New Mexico, and Texas, is composed of plateaus and high plains. Because of its altitude, the climate is semiarid, rather than arid. This region is composed primarily of grassland vegetation, with locally found shrubs and woodlands. Pinyon-juniper woodlands are common on the Colorado Plateau. To the east, in New Mexico and Texas, grasslands grade into savanna woodlands or semideserts composed of xerophytic shrubs and trees. Approximately 13 million acres of public lands occur in this ecoregion.

The perennial graminoid communities in this region are composed of xerophytic grasses, with shrubs and low trees growing singly or in clumps, and occupy over 4 million acres. Common grass species include blue and hairy grama, buffalograss, threeawn species, sideoats, bluestem, and wolftail. Shrubs and trees, such as mesquite, oaks, and junipers, often grow in open stands among the grasses. The perennial grasslands grade into evergreen woodlands, with the respective coverage of each vegetation class dependent on the amount and type of disturbance to which a particular area is subjected.

Evergreen woodlands of drought-tolerant juniper and pinyon pines consist of a relatively open canopy on dry sites at mid-elevations on nearly 4 million acres. Plant composition in pinyon-juniper woodlands exhibits wide geographic variation. In the Colorado Plateau and the central and southern Rockies, doubleleaf pinyon replaces singleleaf pinyon and is associated with Rocky Mountain juniper, Utah juniper, and oneseed juniper (Cronquist et al. 1972). In the dry mountains of southern New Mexico and Arizona, alligator juniper, Emory oak, gray oak, and Mexican pinyon dominate (Brown 1982). The understory layer of shrubs, grasses, and forbs in these communities is composed of representatives from adjacent sites above and below the woodland zone. Important understory species include big sagebrush, western and bluebunch wheatgrass, blue grama, cliffrose, bitterbrush, Indian ricegrass, mountain mahogany, rubber rabbitbrush, and Mormon tea (Garrison et al. 1977).

Fire frequencies were historically about 100 to 200 years in pinyon-juniper woodlands (Federal Regime Condition Class 2004). Fires easily kill young trees and frequent fires maintain the sagebrush-grassland communities (West and Van Pelt 1987). Drought and competition from grasses probably helped slow the invasion of juniper into adjacent shrublands, particularly at lower elevations. Many pinyon-juniper sites may have historically cycled between grass-shrub and pinyon-juniper communities, with fire as the chief driving force (West and Van Pelt 1987).

At higher elevations (up to 7,000 feet), chaparral is a common type of evergreen shrubland on over 4 million acres, with pinyon-juniper and oak-juniper woodlands also occurring. Vegetation communities consist of dense to moderately open stands of evergreen and sclerophyllous shrubs of relatively uniform height. Most chaparral shrubs are deep-rooted, sprout readily from the root crown, and regenerate quickly after burning (Brown 1982). Shrub live oak is common, and associated with mountain mahogany, manzanita, yellowleaf silktassel, sumac, hollyleaf buckthorn, pointleaf and Pringle manzanita, desert ceonothus, and other oak species. Grass species may include sideoats and hairy grama, cane bluestem, plains lovegrass, threeawns, and wolftail. Forbs are not particularly abundant, except for a brief period after burns (Brown 1982).

Evergreen forests occur at the highest elevations in this region. Over 7,000 feet, forests of ponderosa pine, Douglas-fir, lodgepole pine, limber pine, and aspen may be found. Engelmann spruce, corkbark fir, limber pine, and bristlecone pine occur in subalpine forests.

Mediterranean Ecoregion

The Mediterranean Ecoregion occupies most of California (excluding deserts in the southeastern portion of the state) and a portion of southern Oregon. This region supports a distinctive assemblage of hard-leaved evergreen trees and shrubs, commonly known as chaparral, which are adapted to withstand severe summer droughts and frequent fires. Coniferous forests and oak woodlands are also characteristic of the region. Approximately 6 million acres of public lands occur in this ecoregion.

Evergreen shrubland occurs on over 2 million acres. Along coastal areas a type of chaparral known as maritime chaparral is common. Inland evergreen shrublands are found in the low hills of mountainous regions, often forming a mosaic pattern with deciduous (oak) woodlands, grasslands, or evergreen forests. Important chaparral species include manzanita, wedgeleaf ceanothus, hollyleaf buckthorn, poison oak, chamise, Christmasberry, mountain mahogany, California scrub oak, blue oak, and interior live oak (Holechek et al. 1995). Chaparral shrubs are adapted to recurrent fire, and the ecosystem depends on periodic fires for its persistence. Herbaceous vegetation is generally lacking in chaparral communities, except after fire.

Nearly 1 million acres of deciduous woodlands and evergreen woodlands also occur in foothills throughout California, typically on sites that are more mesic than those occupied by chaparral. Deciduous oak woodlands include stands of Oregon white oak, California black oak, blue oak, valley oak, and mixed oak. On cooler, moister sites in the Coast Ranges, oak woodlands merge with mixed hardwood forests in which tanoak, California-laurel, and Pacific madrone are common. Evergreen live oaks are common associates, and conifer species such as Coulter pine, digger pine, Douglas-fir, and grand fir may also be present. Understory vegetation varies by location and may include poison oak, snowberry, serviceberry, blackberry, wildoats, bromes, bluegrass, ryegrass, and needlegrass.

Evergreen woodland communities composed of live oaks occur in moist, frost-free areas such as the coastal hills from San Francisco into southern California, where adequate moisture and mild temperatures allow them to carry out photosynthesis through the winter. Evergreen oak woodlands are composed of species such as canyon live oak, interior live oak, coast live oak, and Engelmann oak. Oak woodlands may exist as open, park-like savannas, occupying a transition zone between grasslands and denser woodlands. Shrubs are generally absent because they cannot compete with trees for moisture on drier sites. Evergreen woodlands also include some endemic tree species such as Monterey cypress, Torrey pine, Monterey pine, and Bishop pine.

In the mountains of California and southern Oregon, evergreen forests are the dominant vegetation type, and occupy nearly 2 million acres of public lands. These forests are a diverse assemblage of many conifer species, and are adapted to a long, warm growing season, relatively mild winters, and periods of summer drought. Tree species include ponderosa pine, Douglas-fir, white fir, sugar pine, incense-cedar, Jeffrey pine, red fir, and giant sequoia (Szaro 1995). At elevations between 6,500 and 9,500 feet, subalpine forests composed of mountain hemlock, California red fire, lodgepole pine, western white pine, and whitebark pine occur.

Evergreen forests also occur along coastal northwestern California as redwood-dominated communities. Other common tree species forests include Douglas-fir, hemlock, and cedar. The understories are dominated by Pacific rhododendrons, western azaleas, salal, California huckleberry, sword fern, and redwood sorrel. Pine-cypress forests also occur along the coast, while mixed forests of tanoak, coast live oak, madrone, and Douglas-fir occur further inland.

For the most part, annual and perennial graminoid communities are located in the valleys and plains of the Mediterranean Ecoregion. While it is generally believed that the Central Valley, the largest grassland expanse in California, was historically dominated by perennial grassland communities, other vegetation communities (e.g., oak woodlands, chaparral, annual grasslands, and desert scrub) may have also been present (Blumler 1992, Hamilton 1997). Large portions of the native vegetation have been replaced by annual grasses, however, as a result of introduced species, fires, and overgrazing by livestock of early Spanish settlers (Sims 1988). Annual grasses include introduced species such as wild oat, slender oat, soft chess, rigput brome, red brome, wild barley, and foxtail brome. Common forbs include redstem filaree, broadstem filaree, turkey mullein, true clovers, and burr clover. Perennial grasses, which are found in moist, lightly grazed or relict areas, include Idaho fescue and purple needlegrass (Garrison et al. 1977). With the development of irrigation, the California grassland ecosystem has become intensively utilized for agriculture.

Marine Ecoregion

The Marine Ecoregion Division occupies the Cascade and Coast ranges of western Washington and Oregon, and the Coast Mountains of southeastern Alaska, along the Pacific Coast. The mild, rainy climate produces conditions that are hospitable for dense forest communities, which are characteristic of this region. Approximately 4 million acres of public lands occur in this ecoregion.

In the Cascade and Coast ranges, complex, multi-storied evergreen forests occupy over 1 million acres, with species composition varying by altitude and climate. At lower elevations, Douglas-fir, western redcedar, western hemlock, grand fir, silver fir, Sitka spruce, and Alaska yellow-cedar are the dominant tree species. Subalpine forests composed of mountain hemlock, subalpine fir, whitebark pine, and Alaska yellow-cedar extend to timberline, which varies from 7,700 to 10,000 feet. In the drier climates of the eastern Cascade Range, forests dominated by ponderosa pine are common. Evergreen forests are often associated with understory plants such as vine maple, huckleberry, elderberry, salal, Oregongrape, twinflower, and sword fern (Franklin 1988).

The area between the Cascade and Coast ranges is also characterized by dense evergreen forests. Much of the land in this intermountain region once existed as Douglas-fir, western redcedar, and western hemlock forests, but has since been developed for agricultural and urban uses.

Evergreen forests are also the predominant vegetation type found in the Coast Mountains of southeastern Alaska. Forests in this region are restricted to low elevation, coastal rainforests dominated by Sitka spruce and western hemlock. Associated species include Alaska yellow-cedar and mountain hemlock.

Along the major river channels, deciduous riparian forests composed of broadleaf trees such as black cottonwood, red alder, willow, and birch are common. In poorly drained areas, wetlands characterized by sphagnum moss, sedges, and willows occur.

Vegetation types with minor coverage in the Marine Ecoregion include Oregon white oak woodlands, which occur as scattered stands at low elevations, and prairies (perennial graminoid communities), which now occur only as remnant patches in the Willamette Valley and Puget Sound lowlands. Both of these community types are being lost as a result of succession by evergreen forests and development.

Noxious Weeds and Other Invasive Vegetation

Noxious weeds are undesirable plants that infest either land or water resources, and may cause physical and economic damage, or have other adverse effects on humans. They are designated and regulated by state and federal laws, such as the Federal Noxious Weed Act, because they are detrimental to agriculture, commerce, and/or public health. Noxious weeds are generally non-native invasive plants that have been accidentally or intentionally introduced. Weed infestations are capable of destroying wildlife habitat; reducing opportunities for hunting, fishing, ,camping and other recreational activities; displacing many threatened and endangered species; reducing plant and animal diversity because of weed monocultures; and costing millions of dollars in treatment and loss of productivity to land owners.

Invasive plants have been introduced into the U.S. through a variety of pathways. Some non-native species were intentionally introduced for beneficial reasons and later became invasive. Examples are purple loosestrife, which was originally introduced in ballast water dumped from ships coming from Europe and is still sold as an ornamental plant in garden centers in many states, and saltcedar, which was introduced for erosion control. Many other invasive plants have been introduced unintentionally via air, water, rail, or road transportation pathways. Common methods of introduction include contaminated seed, feed grain, hay, straw, and mulch; movement of contaminated equipment across uncontaminated lands; animal fur and fleece; spreading of gravel, roadfill, and topsoil contaminated with noxious weed seed; and plants and seeds sold through nurseries as ornamentals (USDI BLM 1996).

Once introduced, invasive plants are spread primarily by vehicles, humans, wild horses, livestock, wind, water, and wildlife. Initially, invasive weeds may get established in disturbed sites such as trailheads, along roads and trails, firebreaks, landing pads, oil and gas development sites, wildlife and/or livestock concentration areas, and campgrounds, but may also invade relatively undisturbed sites.

The BLM estimates that nearly 36 million acres of public lands were infested with weeds in 2000, and that invasive plants and noxious weeds are spreading at a rate of about 2,300 acres per day (USDI BLM 2000h). The states with the largest weed infestations on public lands are Utah, Arizona, and Oregon (Table 3-5). The most dominant invasive plants consist of grasses in the *Bromus* genus, which represent nearly 70% of the total infested area. A single species, downy brome, occupies an estimated 10 million acres alone. Other important weed species that occupy over 100,000 acres include halogeton, Mediterranean grass, medusahead, houndstongue, leafy spurge, Canada thistle, saltcedar, spotted knapweed, rush skeletonweed, Russian knapweed, diffuse knapweed, and hoary cress.

The BLM treated approximately between 250,000 and 320,000 acres of noxious weeds during 2001 through 2004. Treatments included a combination of chemical, mechanical, manual, biological, and cultural controls, and herbicides have been used to create fire breaks in shrublands as well as improve forage for livestock and wildlife. Over half of the acres were treated in Montana each year, and over 35,000 acres were treated in Idaho each year. In 2004, the BLM inventoried nearly 8.9 million acres for weeds, and evaluated weed treatments on over 330,000 acres of treatment lands (USDI BLM 2005c).

Vegetation Condition and Fire Regimes

In support of national-level fire planning and risk assessment efforts, the Forest Service has developed Fire Regime Condition Classes (FRCC) showing vegetation condition and fire frequency on public lands administered by the USDI and USDA (Schmidt et al. 2002). This assessment excludes public lands in Alaska (86 million acres), as well as 25.5 million acres of agricultural, barren, and urban/developed lands in the lower 48 states. These classes were created to represent qualitative measures describing the degree of departure from historical fire regimes. This departure may have resulted from activities such as fire exclusion, timber harvesting, livestock grazing, introduction and establishment of exotic plant species, introduced insects or disease, and/or other management activities, which have altered key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings.

Departures from historical fire regimes have been grouped into three classes, as shown on Map 3-10. **Condition Class 1** lands (82.7 million acres of public lands) are characterized by fire regimes that are within their historical range of vegetation variability characteristics, fuel composition, and fire frequency, severity, and pattern. Fire behavior, effects, and other associated disturbances are comparable to those taking place prior to management practices that do not mimic the normal fire regime. The structure and composition of vegetation and fuels are similar to the historical regime, and the risk of losing key ecosystem components to fire is low. These areas can generally be maintained within the historical fire regime with treatments such as prescribed fire. Wildland fire use for resource benefit may also be used to maintain these areas.

Condition Class 2 lands (41.3 million acres) have fire regimes that have been moderately altered from their historical conditions. They experience either an increased or decreased fire frequency of one or more return intervals, resulting in changes to fire size, intensity, and severity, and/or landscape patterns. Vegetation composition and structure and fuels have been moderately altered from their historical range, and they have a moderate risk of losing key ecosystem components due to fire or other causes. These lands may need moderate levels of restoration treatments, such as prescribed fire and hand or mechanical treatments, to be restored to the historical fire regime.

Condition Class 3 lands (13 million acres) have fire regimes that have a high departure from the historical condition, and the risk of losing key ecosystem components to fire or other causes is high. Vegetation composition, structure, and diversity, as well as fuels, have been significantly altered from their historical range. Due to these alterations, Condition Class 3 areas are especially susceptible to severe and intense wildland fires. These areas often need high levels of restoration treatments, such as hand or mechanical treatments, before prescribed fire can be used to restore the historical fire regime (Schmidt et al. 2002). Almost 70% of the Class 3 lands occur in the Temperate Desert Ecoregion, primarily in Evergreen Shrubland (5.7 million acres) and Evergreen Woodland (2.4 million acres) plant communities. The Subtropical Steppe Ecoregion represents another 1.5 million acres spread between Evergreen Shrublands, Evergreen Woodlands, and Perennial Graminoid communities. Evergreen Forests of the Mediterranean Ecoregion represent an additional 1 million acres of Class 3 lands. In addition, areas where downy brome is the dominant vegetation (11.4 million acres) have been identified as a special class of Condition Class 3 lands. Nearly all (99%) of the downy brome on public lands occurs in the Temperate Desert Ecoregion, primarily in Evergreen Shrublands (8.5 million acres) and Evergreen Woodlands (1.5 million acres). Like Condition Class 3 areas, these areas experience frequent, severe, and intense wildfires and are far removed from their natural fire regimes. These areas need extensive restoration and often require several treatments to control downy brome and reestablish the normal brush/perennial grass vegetation.

Non-timber Forest Products

Non-timber forest products encompass all plant materials other than timber that are extracted from forests for human use (National Network of Forest Practitioners 2005). They include medicinal plants (e.g., ginseng, goldenseal), wild foods (e.g., mushrooms, berries, roots, syrups), decoratives and floral greens (e.g., salal, ferns, boughs), flavors and fragrances (e.g., sassafras, balsam fir), fibers (e.g., cedar bark, sweet grass, lichens), wild native seeds and transplants for restoration and nursery stock, plant dyes, arts and crafts materials, and resins and saps. These forest products are harvested for a variety of reasons, including for subsistence, cultural, spiritual, commercial, recreational, and educational purposes.

Native American tribes and Alaska Natives traditionally used forest products for tools, food, construction materials, medicine, and religious ceremonies. These included bark for housing, branches and stems for utensils and tools, and wood for containers (Chamberlain et al. 1998). Much of the knowledge gained from Native American tribes and Alaska Native groups has influenced the development of the herbal medicinal industry today in the U.S. A discussion of Native American and Alaska Native plant uses is discussed in the Cultural Resources section of this chapter, and in Appendix D of the PER.

During FY 2004, approximately $176,000 worth of non-timber forest products was sold by the BLM. The actual value of non-timber forest products harvested on public lands is substantially greater (USDI BLM 2005d). Over 60% of non-timber forest product sales on public lands were in western Oregon, and about 15% of sales were in Colorado. Other important states for non-timber forest product sales are Nevada and Utah.

Special Status Species

There are over 150 plant species occurring on or near public lands in the treatment area that are federally-listed as threatened or endangered, or proposed for listing. The number of listed species or species proposed for listing may change depending on future evaluations of each species status. In addition, BLM policy requires that actions do not adversely impact special status species. These are species that are listed under the ESA, given some form of special designation to denote rarity by the state, or are listed as sensitive by the BLM. Special status species, other than those already listed under the ESA, are in potential danger of becoming listed under the ESA. Special status plant species are distributed throughout the western U.S., including Alaska. A list of these species can be found in Appendix H.

For this PEIS, the BLM has consulted with the USFWS and NOAA Fisheries since 2001 on listed species,

TABLE 3-5
Estimated Acres of Weed Infestations on Public Lands in 2000

State	Bromus species[1]	Halogeton	Mediter-ranean grass[2]	Medusa head	Centaurea spp.[3]	Hounds-tongue	Other	Total
Alaska[4]	--	--	--	--	--	--	--	--
Arizona	5.007.000	5.000	3.190.600	0	37	0	86.000	8.288.637
California	517.000	4.000	243.000	261.000	35.000	0	69.000	1.129.000
Colorado	1.952.000	372.000	0	0	23.000	408.000	329.000	3.084.000
Idaho	2.814.000	--[4]	0	15.000	214.000	500	376.000	3.419.500
Montana	896.000	300	0	0	149.000	6.000	167.000	1.218.300
Nebraska[4]	--	--	--	--	--	--	--	--
North Dakota	0	0	0	0	0	0	1.000	1.000
New Mexico	30	21	0	0	7.000	0	41.000	48.051
Nevada	0	0	0	2	72.000	6	147.000	219.008
Oklahoma[4]	--	--	--	--	--	--	--	--
Oregon and Washington	5.139.000	151.000	0	676.000	48.000	113	393.000	6.407.113
South Dakota	0	0	0	0	2	65	2.000	2.067
Texas[4]	--	--	--	--	--	--	--	--
Utah	6.948.000	3.063.000	94.000	25	51.000	604	130.000	10.286.629
Wyoming	1.395.000	1.500	0	0	47.000	27.000	188.000	1.658.500
Total	24.668.030	3.596.821	3.527.600	952.027	646.039	442.288	1.929.000	35.761.805

[1] Includes downy, rigput, Japanese, and red bromes.
[2] This refers to *Schismus barbatus*.
[3] Includes spotted, Russian, diffuse, squarrose, and meadow knapweeds and yellow and malta starthistles.
[4] No data were reported for this state.
Source: BLM (2000h).

species proposed for listing, and their critical habitats that could be affected by the proposed treatments. As part of the consultation process, the BLM prepared a *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* that provided a description of the distribution, life history, and current threats for each species (USDI BLM 2005b). Information contained in the BA will be used as guidelines by BLM field offices when developing local projects.

Fish and Other Aquatic Organisms

The BLM administers lands directly affecting almost 110,000 mi of fish-bearing streams and 3 million acres of reservoirs and natural lakes. These habitats range from isolated desert springs of the Southwest to large interior rivers and their numerous tributaries.

For this section, the eight geographic regions used to describe water resources in the treatment area are also used to describe aquatic organisms and their habitats (Map 3-5). Key fish species have been identified for each region. These species are ecologically representative of the region(s), use major habitat types within the region, and strongly influence the aquatic community structure. As a result of species distributions and ecological similarities between regions, some key species may occur in more than one geographic region.

Alaska and the Pacific Northwest

The most significant group of native fishes found in Alaska and the Pacific Northwest, in terms of their ecological, cultural, and commercial importance, is the salmonid family. All members of this group, which include salmon, trout, char, and whitefish, require relatively pristine, cold freshwater habitats during part or all of their life cycles, and as such, depend greatly on the conditions of the surrounding forests and rangelands to ensure their survival (Meehan 1991).

Most salmonids use large stream and river systems with direct ocean access. In Alaska, significant streams within public lands include the Colville River and Yukon River systems. The most significant system in

Pacific Northwest is the Columbia River Basin. With its headwaters in British Columbia, the Columbia River extends over 1,200 mi to the Pacific Ocean.

Salmonid productivity within a freshwater system is dependent on the underlying stream productivity and the period of use by salmonids during their life cycle. Five general factors determine the suitability of aquatic habitat for salmonids—flow regime, water quality, habitat structure, food (energy) source, and biotic interactions. All salmonids require suitable habitat for spawning, incubation, and rearing. Generally, adults require spawning gravel (less than 2 inches in diameter) and overhead streambank or vegetative cover from predation, while eggs and newly hatched salmon (alevins) require stable gravel and cool (less than 57 °F) and highly oxygenated water (Meehan 1991). Bull trout, which tend to spend most, if not all of their life in inland waters, require water less than 42 °F for spawning and rearing of newly hatched young. As salmonids prefer cold water, temperatures above 77 °F are lethal to most species in this family (Meehan and Bjornn 1991).

Migrant salmonids pass through several distinct habitats while traveling to and from feeding or breeding habitats, utilizing the full extent of the watershed. The importance of each habitat type differs by species. Chinook salmon, for example, spawn in the mainstem of a river. Upon emerging from the gravel, individuals either start their migration to the sea within their first year (ocean-type) or mature within rivers for 2 to 3 years before migrating to sea (stream-type). In contrast, resident trout populations, such as rainbow, bull, and cutthroat trout, may spend their life (5 to 6 years) in various freshwater systems, including small streams or lakes, and do not migrate to the sea (Meehan and Bjornn 1991).

Various fish species have been introduced into aquatic systems throughout Alaska and the Pacific Northwest. Most of the non-native species have been introduced to promote sportfishing opportunities. Some have escaped from fish farms. Introduced salmonids (such as brook, brown, lake, and hatchery-raised rainbow trout), centrarchids (such as bass and sunfish), and percids (such as walleye) now support much, if not most, of the non-native sport fishing opportunities within these regions (Mills 1994).

A variety of aquatic invertebrates occur in Northwest and Alaskan streams. These species can be quite susceptible to instream activity (e.g., removal of large woody debris), or disturbances in riparian zones. The diversity of aquatic insects is naturally low in glacier-fed streams. Streams flowing through conifer forest, however, support a diverse aquatic invertebrate fauna, including many mayflies, stoneflies, and caddisflies (Whittier et al 1988). The diversity of freshwater mollusks is also usually highest in montane, spring-fed streams and pools (Forest Ecosystem Management Assessment Team 1993).

The Arid Environment

In arid regions, hydrologic inputs that drive aquatic systems come in pulses of short duration. Although rain may trigger biological processes, such as reproduction, after long dry periods, a severe rainfall that creates flash flooding can exert considerable pressure on fish species and community structure (Naiman 1981). The natural hydrology of southwestern desert rivers and streams are highly variable and episodic (Rinne and Stefferud 1997). These natural flow regimes have been considered optimum for sustaining native fish populations (Poff et al. 1997). Although many streams of the U.S. deserts have been highly modified, reducing the impacts of flash floods on fish communities, these sudden rain inputs may still be detrimental. Carrying heavy silt, these floods may remove or destroy habitat features such as shoreline vegetation, leaving fish species susceptible to rising water temperatures (Naiman 1981).

Because there is limited hydrological connection among water bodies within the desert, fish distribution is also limited. Some streams continually flow through the humid desert regions, terminating in closed lakes or dissipating in the sand, while other streams originate from subterranean sources, emerging as springs. Springs occur throughout the desert ecosystem, ranging from quiet pools or trickles to active aquifers. Many larger springs emit warm water, with temperatures above the mean annual air temperature, and range from fresh to highly mineralized, carrying large amounts of dissolved materials or extremely low dissolved oxygen levels (Naiman 1981). Although each spring or pool is species-poor, most aquatic inhabitants of each pool are short-lived (1-2 years) and native to only a single locality (Naiman 1981, Page and Burr 1991).

In addition, aquatic species have been introduced, either on purpose or accidentally into this ecosystem, changing the ecologic balance in favor of many of the non-native species. Invasive fish reduce numbers of native species through competition, hybridization, predation, and spread of pathogens to which they have developed resistance in their home waters, but to which native species have none (Rinne 1995, 2003). Overall, non-native fish species now outnumber natives in numbers of species, population density, and often biomass at many localities (Platania and Bestgen 1988; Griffith and Tiersch 1989; Douglas et al. 1994).

Large reservoirs and diversions have been constructed on various rivers and streams at least partially for the purpose of delivering irrigation water for agricultural purposes. Additionally, domestic livestock grazing has impacted some rangelands and historical grazing pressures in riparian areas have reduced the function of some aquatic habitats.

Lower Colorado River and the Rio Grande

These regions cover portions of Nevada, Arizona, New Mexico, and Texas. Grasses and shrubs cover large expanses of the southwest region. This vegetation helps to reduce runoff and erosion during the rainy season. During the dry seasons, dormant vegetation and vegetative litter provide this same function and are critical for the overall health of these rangeland systems. Livestock grazing in the region has reduced the quality of vegetative communities, resulting in increased runoff into streams during heavy rainfall, and localized lowering of water tables (Naiman 1981, Rinne and Minckley 1991). These impacts, combined with upper basin modifications, including dams, have impacted fish habitat throughout the lower Colorado and Rio Grande rivers.

The Colorado River, which was once a warm, silted, swift river, is now a cold, clear series of artificial impoundments. These impoundments are a significant threat to desert waterways, and in some instances can end a stream's existence, as has occurred in the lower reaches of the Salt and Gila rivers in Arizona (Cole 1981). The Glen Canyon Dam on the Colorado River, upstream of Lee's Ferry, eliminated the seasonal variation in the river's discharge, ionic composition, temperature, and sediment load in the gorge of the Grand Canyon. Not only has the impoundment altered the flow of the river, it has altered the river's potential for fish habitat downstream (Cole 1981). As a consequence, most native fish populations in the Colorado River Basin have declined substantially throughout much of the species' ranges.

The Family Cyprinidae is the most dominant native fish group within the lower basin region, followed by the Family Catostomidae. The Cyprinidae family is composed mainly of minnow species, including the threatened Colorado pikeminnow and bonytail chub, while the Catostomidae family includes the threatened razorback sucker (Starnes 1995). Impoundments have had the greatest impacts on these fish communities (Minckley and Deacon 1991).

Bonytail chubs were historically common, migrating throughout the mainstem of the Colorado River and many of its tributaries, including the Green, Gunnison, Yampa, and Gila rivers, before the construction of large dams (Kaeding et al. 1986). Although bonytails continue to be found in low numbers from several man-made lakes, including Lake Mohave, the temperature and physical and chemical composition of these lakes is very different from those in which the fish evolved (Minckley 1973, Minckley and Deacon 1991).

The headwaters of the Rio Grande River originates in the Rocky Mountains of southwestern Colorado and the river meanders approximately 1,900 mi across Colorado, New Mexico, and Texas before terminating at the Gulf of Mexico (Water in the West 2002). Public lands within the Rio Grande region are limited to the upper and middle reaches of this drainage. Most precipitation in the basin falls as snow near its headwaters or as rain near its mouth, while little water is contributed to the system along the middle reaches of this river, particularly within the Chihuahuan Desert.

Historically, riparian woodlands in the Rio Grande River Valley were a mosaic of various-aged stands dominated by cottonwood and willow (Cassell 1998). However, conversion of much of this land to residential and agricultural uses has modified this floodplain area, significantly reducing the quantity and quality of wetland and riparian habitat (Cassell 1998; Levings et al. 1998). These changes, combined with instream modifications, have reduced fish habitat considerably throughout the region.

Prior to the construction of dams like the Cochiti Dam, the Rio Grande River had characteristics similar to the Colorado River, and was considered a swift, warm, muddy river (Scurlock 1998). The settling effects of dam reservoirs have resulted in slower, clearer, colder water. This modification of water quality has had a debilitating effect on the range of the Rio Grande silvery minnow, a species that once extended from Española, New Mexico, in the Rio Grande River Valley to the Gulf of Mexico; and in the Pescos River, from Santa Rosa, New Mexico, to the confluence with the Rio Grande River in south Texas (Federal Registry 1994). Currently, it is found only in a 170 mi reach of the middle Rio Grande River in New Mexico. Much of its decline may be attributed to modification of stream habitat by impoundments, water diversion for agriculture, and stream channelization.

Many non-native fish species have adapted well to the instream modifications to both the Lower Colorado River and Rio Grande River (Maddux et al. 1993; Douglas et al. 1994). Usually more aggressive than native fish and able to outcompete them for resources, these non-native species include walleye, bass (large and smallmouth), and rainbow, brook, and brown trout (Douglas et al. 1994).

Great Basin

The Great Basin covers an arid expanse of approximately 190,000 mi^2 and is bordered by the Sierra Nevada Range on the west, the Rocky Mountains on the east, the Columbia Plateau on the north, and the Mojave and Sonoran deserts on the south. The Great Basin is the area of internal drainage between the Rocky Mountains and the Sierra Nevada Range. Streams in this area never reach the ocean, but are instead confined, draining to the base of the basin, and typically resulting in terminal lakes, such as Mono Lake and the Great Salt Lake, marshes, or sinks that are warm and saline (Moyle 1976).

Many Great Basin fish are adapted to extreme conditions. Trout are predominantly found in lakes and streams at higher elevations within the basin (Behnke 1992). Bonneville cutthroat trout have persisted in the isolated, cool mountain streams of the eastern Great Basin, while Lahontan cutthroat trout populations occupy small, isolated habitats throughout the basin. These trout species are unusually tolerant of both high temperatures (>80 °F) and large daily fluctuations in temperature (up to 68 °F). They are also quite tolerant of high alkalinity (>3,000 mg/L) and dissolved solids (>10,000 mg/L; Behnke 1992).

Water diversions, subsistence harvest, and stocking with non-native fish (particularly rainbow trout) have caused the extirpation of the Bonneville cutthroat trout from most of its range. Although Lahontan cutthroat trout were once common in desert lakes, including Pyramid, Walker, Summit, and Independence lakes, and large rivers, such as the Humboldt, Truckee, and Walker rivers, they have declined in numbers overall, disappearing in many areas (Hudson et al. 2000).

The decline of Lahontan cutthroat trout abundance is a result of habitat loss, interbreeding with introduced rainbow trout, and competition with other species of trout; these factors continue to be the primary threats to this species (Coffin and Cowan 1995, Dunham 1998).

Minnows and pupfish are the dominant fish species at lower elevations and are found in thermal artesian springs and streams (Cole 1981, Feldmeth 1981). Various native and non-native minnows, (e.g., dace, chubs, shiners) are common throughout streams and lakes of the basin. Pupfish, however, are very site-specific and live, by choice, at the extreme upper limit of their zone of thermal tolerance (Feldmeth 1981).

Pupfish are able to survive extreme environmental conditions, tolerating water temperatures as high as 115 °F, salinity as high as 142 parts per thousand (ppt; ocean water is typically 33 ppt), and oxygen concentrations as low as 0.13 mg/L (Page and Burr 1991). Because of the high water temperatures, pupfish have developed behavioral traits to regulate body temperature. They have been observed migrating to shallow pools in the morning and remaining there throughout the day, returning to deep water at night. While some pupfish populations are isolated in extremely variable environments (i.e., rapidly fluctuating water levels and temperature gradients), others are isolated in stable springs with constant temperatures (Biological Resource Research Center 2001, NatureServe Explorer 2001).

The most significant problem facing these fish are the limited water supply. Desert fishes have a tenuous hold on survival under natural conditions, occurring only in the few permanent springs, rivers, and lakes, and their existence has been placed in doubt by human activities (Deacon and Williams 1991). Pumping groundwater for agriculture has threatened several pupfish populations, including the Devil's Hole pupfish (Deacon and Williams 1991).

Aquatic invertebrates are probably diverse within the Great Basin region though relatively little is known about them (Hershler and Pratt 1990). Streams flowing within mountainous forest region support diverse aquatic invertebrate fauna including mayflies, stoneflies, and caddisflies. Small springs contain diverse molluscan fauna (Hershler and Sada 1987). Spring biotic communities are usually less diverse than stream ecosystems and are often habitat for endemic species because they are predictable, benign habitats that have served as refugia during dry periods.

The Upper Colorado River Basin

The Colorado River is the primary river of the southwestern U.S., draining approximately 242,000 mi^2

from portions of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California. The headwaters of the Colorado River are located in Rocky Mountain National Park in Colorado, from which the river flows southwest, toward the Gulf of California.

The Colorado River Basin is divided into two basins: the Lower and Upper basins, with a dividing line near Lee's Ferry, Arizona. Three distinct aquatic zones have been identified in the Upper Colorado Basin (Joseph et al. 1977). The upper (headwater) zone is characterized by cold and clear water, a high gradient, and a rocky or gravel substrate. Resident salmonid populations are predominant in this zone. An intermediate zone occurs as the stream flows out of the upper zone. Within the intermediate zone, water discharge rates and temperature increase, and water is turbid during spring runoff and after heavy rainfall. The substrate is generally rocky with occasional expanses of sand. The lower (large-river) zone has warm water, meandering sections, and a low gradient in flat terrain. Minnows and suckers are the dominant fish communities of the intermediate and lower zones.

The construction of reservoirs, such as Fontenelle and Flaming Gorge, has had profound effects on water flow and quality throughout the upper basin region; lower summer water temperatures have resulted, and spawning of native fish has virtually ceased (Carlson and Carlson 1982, Wullschleger 2000). The humpback chub, for example, prefers deep, fast-moving, turbid waters often associated with canyon bound segments of the rivers (Valdez and Clemmer 1982). Historically, this species occurred in great numbers throughout the Colorado River system from the Green River in Wyoming to the Gulf of California in Mexico. Today, due to lower water temperature and migration routes blocked by dams, this species can only be found in limited deep, canyon-bound portions of the Colorado River (Douglas and Marsh 1996).

Native salmonids in the upper zone of the Upper Colorado River Basin, including the Gila and Apache trout, are disappearing with the introduction of rainbow, brook, and cutthroat trout for sport fishing (Miller et al. 1982). The habitat immediately downstream of constructed reservoirs favors these non-native salmonids (Platania 2003). In addition, non-native species effectively outcompete native species for available resources, and interbreed with native species (Joseph et al. 1977; Rinne and Minckley 1991). Populations of native species within lakes are also declining as a result of competition with, and predation by, introduced non-native species, such as carp, northern pike, and red shiner (Rinne and Minckley 1991).

California

California has two distinct fish habitat regions: northern and southern California. The northern region extends from the Oregon border south to Sacramento (the most southern reaches of salmon distribution in North America). This region includes rain-fed coastal streams, snow-fed streams of western Sierra Nevada, and the Central and San Joaquin valleys. Habitat characteristics are very similar to those observed in the western Pacific Northwest, with a dominance of evergreen forests throughout the area. Streams in the coastal region usually have steep drainages and are characterized by extreme seasonal flow, flooding in the winter and becoming intermittent in summer (Moyle 1976). Water flow in snow-fed streams is more constant than in coastal streams, a condition to which native fish are adapted.

Fish habitats within southern California are located predominantly within the arid southeast region of the state and include numerous rivers and lakes. Native fish communities, such as pupfish and minnows in the lower elevations and cutthroat trout in the mountainous regions, and their aquatic habitats exhibit characteristics similar to those seen in the Lower Colorado and Great Basin regions.

Missouri River Basin

The Missouri River Basin encompasses 529,350 mi^2 and flows for over 2,340 mi, from its headwaters at the confluence of the Gallatin, Madison, and Jefferson rivers in the Rocky Mountains at Three Forks, Montana, to its confluence with the Mississippi River at St. Louis, Missouri.

The Missouri River historically carried a heavy silt load, collected from tributaries in the northern part of its drainage. Its wide and diverging channel created shifting sandy islands, spits, and pools, resulting in fish species suited to its turbid and dynamic conditions. Many of the fish communities within the upper reaches of the Missouri River are considered benthic fishes, and include sturgeon and minnows (Duffy et al. 1996; Scarnecchia et al. 2002).

Public lands in Montana occur predominantly in the northeastern portion of the state. The surrounding habitat, referred to as the Milk River Basin, has relatively high densities of depressional wetlands dominated by shortgrass prairies. The upper reaches of the Missouri River and its major tributaries maintain the healthiest fish populations in the basin (White and Bramblett 1993). However, dams built along the mainstem of the Missouri River, such as the Fort Peck Dam in Montana, have limited fish migration patterns and water flow, as well as the movement of silt downstream, resulting in declining fish numbers and reduced quality spawning and rearing habitat (Hesse et al. 1989). This combination of habitat loss and poor dam management has contributed to the decline of many native mainstem species including paddlefish, sturgeon, and several species of chub.

Native species such as the sicklefin chub, sturgeon chub, and pallid sturgeon prefer silty rivers with a diversity of depths and velocities forming braided channels, sand bars, sand flats, and gravel bars, all of which were historically common along the Missouri River (Gilbraith et al. 1998; Scarnecchia et al. 2002). All three species have been affected by changes in the Missouri River. Although the chub species have managed to effectively reproduce where habitat conditions allow, the pallid sturgeon has been unable to adapt well to the present river conditions, resulting in a significant decline in its abundance (Duffy et al. 1996). The endangered pallid sturgeon, a bottom feeder, may soon become extinct, as changes in water flows continue to affect food sources, spawning habitat, and the timing of reproduction (USFWS 1990).

Introduced species, such as rainbow trout, have been stocked throughout Montana. Rainbow trout have adapted well to the wide range of habitats available within the basin. The species has successfully integrated into this aquatic system, and has caused a severe reduction in the range of native cutthroat trout through hybridization and competition (Walleyes Unlimited 2002). Other introduced species that have adapted well to the modifications of the Missouri River drainage in Montana include smallmouth bass, walleye, and white crappie.

The Missouri River drainage includes all of Wyoming east of the Continental Divide, and represents 74% of the state's surface area. Typically, streams along the southern boundary of Wyoming originate from the mountainous region of northern Colorado and are characterized by high gradients, cobble and boulder substrates, and riparian areas dominated by conifers and willows. This area of Wyoming drains into the North Platte River drainage, comprising 24% of the surface area of Wyoming. Native and introduced salmonids such as rainbow, brook, and cutthroat trout dominate fish communities within this region.

As streams flow onto the arid, desert plains, they are characterized by low gradients, meandering or braided channels, silt, sand, and gravel substrates, with riparian areas dominated by cottonwoods, willows, shrubs, and grasses. Central and northern Wyoming are considered high cold desert. Native and non-native minnows and suckers dominate fish communities.

Special Status Species

There are over 100 aquatic animal species occurring on or near public lands that are federally listed as threatened or endangered, or are proposed for future listing. Included in the total number are 59 species/subspecies of fish, 13 species of mollusk, and 6 aquatic arthropods. A complete list of these special status species may be found in Appendix H. Please note that this list is dynamic, and will likely change throughout the time period considered by this PEIS.

Special status aquatic animal species are found on public lands throughout the United States. A number of listed salmon populations are found in rivers of the Pacific Coast states. In arid habitats, many special status fish species are found in the rare and fragile desert wetlands and springs, as well as in the major rivers such as the Colorado and the Rio Grande. In the deserts of the Great Basin and Colorado Plateau, terminal lakes, marshes, and sinks provide important habitats for special status fish species that are adapted to their warm, saline conditions.

Special status mollusks occur predominantly in the Snake River of Idaho, and in thermal habitats and small springs and wetlands in New Mexico, Arizona, and Utah. Aquatic arthropods of special concern occur predominantly in the vernal pools of California.

Wildlife Resources

Public lands sustain an abundance and diversity of wildlife and wildlife habitat. Public lands provide a permanent or seasonal home for more than 3,000 species of amphibians, reptiles, birds, and mammals.

Wildlife populations are found in areas where their basic needs—food, shelter, water, reproduction, and movement—are met (Anderson 2002). The area where the needs of a particular population are met is its habitat. Many animals have special behaviors and physical traits that allow them to successfully compete with other animals in only one or a few habitats; many threatened and endangered species fall into this category. Other animals, such as mule deer, coyote, and American robin are less specialized and can use a wider range of habitats.

Several features make some habitats better for wildlife than others. In turn, the more of these features that are present, the greater diversity of wildlife species will likely be present. These features include:

- Structure – shape, height, density, and diversity of the vegetation and other general features of the terrain.
- Vertical layers – layers of vegetation (e.g., herbaceous, shrub, and forest canopy).
- Horizontal zones – vegetation and other habitat features that vary across an area.
- Complexity – an integration of vertical layers and horizontal zones.
- Edge – the area where two types of vegetative communities meet, such as a forest and shrub community.
- Special features – unique habitat features needed for survival or reproduction, including snags (dead trees), water, and rock outcrops.

Of the 165 million acres of rangeland administered by the BLM within the western States, 52% have been inventoried for habitat quality. Of those acres, 42% are rated as excellent or good, 41% are rated as fair, and only 16% are rated as poor (USDI BLM 2005d). The BLM also administers 55 million acres of forestlands and woodlands. Of these acres, 16% have been rated as healthy and providing good habitat for wildlife, while 25% are in need of restoration, including mechanical thinning, fuels reduction, and prescribed fire. The condition of the remaining acres is unknown (USDI BLM 2004a).

An important activity of the BLM is to manage vegetation to improve wildlife habitat. Plants, which are an important component of habitat, provide food and cover. Food is a source of nutrients and energy, while good cover reduces the loss of energy by providing shelter from extremes in wind and temperature, and also affords protection from predators. The following section describes the important characteristics of wildlife and habitat in the eight ecoregions that comprise the treatment area, focusing primarily on the vegetative characteristics of habitat and how wildlife use this vegetation.

Tundra Ecoregion

Because of the short growing seasons and low summer temperatures, vegetation in tundra areas exhibits simple structure, few layers, limited complexity, low primary productivity, low decomposition rates, low stress tolerance, and high susceptibility to physical disturbance. Thus, on an annual basis, the tundra supports fewer wildlife species and numbers than other ecoregions, although it does support large populations of some wildlife, such as shorebirds and waterfowl, during summer.

Wildlife species in tundra habitats fall into three categories: (1) resident species that remain active year-round, (2) resident species hibernating in winter, and (3) migratory species present for only a portion of the year (Lent 1986). Resident species that remain active year-round include the ptarmigan, raven, snowy owl, Arctic fox, lemming, muskox, and caribou. Hibernating species include the Arctic ground squirrel, hoary marmot, and grizzly bear. The great majority of the 97 or so bird species using the tundra are migratory (Pitelka 1979).

Except for the wood frog, there are no amphibians or reptiles in the Tundra Ecoregion. Because they are cold-blooded animals, the climate is too cold for these groups. Wood frogs are unique in that they partially freeze in winter; up to one-third of the water in a wood frog's body may turn to ice for a period of several weeks (USGS 2004).

The tundra has low species diversity; tundra insect fauna, for example, is only 1 to 5% as rich in species as the insect fauna found at temperate latitudes (Bolen 1998). Wildlife populations are also constrained by the low plant productivity, and can show large fluctuations in response to annual changes in plant productivity. Animal population peaks can markedly alter vegetation and other habitat features in some instances, leading to sharp declines in population numbers. The brown lemming is the classic example of a cyclic species, with extreme fluctuations in numbers. Lemmings clip and consume large amounts of dormant vegetation under the snow during winter. During periods with large populations of lemming, lemmings remove much of the vegetation during winter, resulting in limited food during summer, and also limited protective cover against predators. As lemming populations decline due to starvation and predation, species that prey upon lemmings, such as the snowy owl and Arctic fox, also show marked population declines.

The widespread occurrence of shallow lakes and wetlands during the summer creates ideal conditions for insects, especially mosquitoes. Mosquitoes have adapted to the harsh winter by overwintering in an egg stage that is resistant to drying, hatching as larvae when warmer weather and moisture returns in the spring. Plant-eating insects are rare in the Tundra Ecoregion, likely due to the low growth rate of the vegetation. Nearly all insects prey on animals, biting the animal or burrowing into its skin or flesh.

Insect fauna provides an important prey base for migratory shorebirds and waterfowl. To cope with the short summer and limited food supplies, migratory birds tend to nest almost immediately upon arriving on the breeding grounds, and young hatch when insects and vegetation are most abundant. Waterfowl, other small birds, and small mammals are preyed upon by Arctic fox, snowy owl, gyrfalcons, peregrine falcons, and rough-legged hawks (World Wildlife Fund 2002).

Even resident populations of the tundra can be quite mobile in their search for suitable food and cover. Arctic foxes may travel hundreds of miles in search of new denning areas, while caribou may go years without using certain winter ranges. Ptarmigan congregate by the thousands in favorable winter valleys in winter, but disperse widely during the summer.

Suitable habitat for denning or burrowing species may be limited in areas with continuous or near-continuous permafrost. Burrowing species must select areas where the permafrost is not near the surface. The presence of deep snowdrifts is important for denning wolverines, polar bears, and brown bears. Talus slopes and cut banks are important habitat features used by denning Arctic foxes. Raptors tend to nest along river and coastal bluffs because of the generally flat, treeless character of the Arctic tundra.

Subarctic Ecoregion

The Subarctic Ecoregion, or boreal forest, is the largest ecoregion in North America. The vegetation is similar in structure and dominated by relatively few species of spruce, firs, larch, and other conifers, and some hardwoods such as birch and aspen. Boreal forests are structurally more complex than tundra, and thus support a greater diversity of wildlife species. These forests provide habitat for large mammals, such as grizzly bear, black bear, wolf, moose, and wolverine; small mammals, such as red fox, beaver, marten, and weasels; birds, such as spruce and ruffed grouse, owls, and raven; and the amphibian, wood frog.

Many species have unique adaptations to survive in subarctic forests. Herbivores typically graze on herbaceous and shrubby vegetation during the summer, but shift to a high fiber diet of conifer needles and woody shrub browse during winter.

White-winged crossbills are an example of a species that have adapted to the abundant cone seeds in boreal forests. These birds move in large flocks when cone supplies are abundant, but are nomadic when cone supplies are limited. White-winged crossbills also breed opportunistically, when cone supplies are most abundant.

Bog vegetation occurs widely throughout the Subarctic Ecoregion. Bogs are characterized by a spongy underfoot of peat that provides a rooting layer for most vegetation, and is often overlain by sphagnum moss. In Interior Alaska, bogs are often underlain by permafrost. Bogs tend to have limited structural complexity, as trees and shrubs are often sparse in bogs. Thus, fewer wildlife species are found in bogs than upland forests. The high water table of bogs also discourages burrowing species.

Fires, which are normal, recurring events in boreal forest ecosystems, help maintain ecosystem productivity and biodiversity (Rowe et al. 1974; Adams et al. 2000). Large area fires are common due to the uniformity of the vegetation and presence of a continuous layer of surface fuels, the moss and lichen layer. Fires can also destroy the rich growth of lichens found in the northern portions of the boreal forest. These lichens are an important food source for barren-ground caribou, comprising 60 to 80% of the winter diet of caribou (Boertje and Garner 1998, Bolen 1998). Fire may be necessary to maintain lichen ranges in the long term, because in old stands, competition from sphagnum moss, shade from trees, or the old age of lichens may limit lichen productivity (Andreev 1954, Viereck 1973, Zoltai 1974, Maikawa and Kershaw 1976).

After a fire of adequate severity, birch, aspen, and willow can revegetate the area, either sprouting from surviving roots or establishing from seed where adjacent seed sources exist. Willow, in particular, is the mainstay of the moose's winter diet, and moose populations thrive in such burned areas. However, because lichens are slow growing, it can take decades before the biomass of lichens for winter caribou grazing reaches its preburn levels (Joly et al. 2002). Schaefer and Pruitt (1991) observed that burned areas did not provide suitable winter habitat for caribou, but that fires could enhance the quality and abundance of summer forage.

Temperate Desert Ecoregion

Vegetation structure in the Temperate Desert Ecoregion tends to reflect the areas' precipitation pattern and temperature regimes (Jones 1986). Sagebrush is co-dominant with perennial bunchgrasses in the wetter, northern part of the ecoregion, but sagebrush dominates in the southern, drier portion (Paige and Ritter 1999). Trees are mostly limited to the pinyon-juniper woodlands found at higher elevations, and along watercourses.

Northern, cooler desert regions, such as the Great Basin Desert, support far fewer wildlife species than southern, warmer deserts found in the Subtropical Desert Region (Bender 1982, Brown 1982). The shorter growing season of the northern deserts results in lower plant productivity and a lower diversity and abundance of animal prey. Thermal regimes in northern deserts also limit the activity of wildlife, especially cold-blooded animals such as amphibians and reptiles, to short periods each year.

The Great Basin Desert, which is the largest desert in North America, is dominated by two structurally and floristically simple plant communities---sagebrush and saltbush. Because most precipitation in that region falls during the winter when plants are dormant, there is not sufficient moisture during the growing season for the development of plant structure and diversity needed to support an abundance of wildlife species. This desert supports large populations of pronghorn antelope, and also provides critical habitat for sage-grouse, species that use sagebrush for food and cover. The BLM has developed a conservation strategy for sage grouse (USDI BLM 2005c).

Desert habitats have some of the most unusual wildlife in the treatment area. Desert animals are adapted to survive under extreme environmental conditions, including low, erratic rainfall, and highly variable temperatures. Many small desert mammals require no free water, but survive on their own metabolic water and through water conservation measures, such as being active only at night and excreting uric acid rather than urea. Spadefoot toads have a special appendage on their hind foot that allows them to burrow into the soil to avoid daytime heat, and breeding activities are timed to occur during periods with summer thunderstorms.

Special features, such as water, rock outcrops, and soil, are critical habitat components in desert environments. Permanent and temporary water sources are scarce in this ecoregion, but their importance cannot be overstated. Riparian areas are especially important in the desert. For example, of the 148 species of breeding birds in the Great Basin Desert, 131 are dependent upon riparian areas for all or part of their life requisites.

Talus slopes, cliffs, and rock outcrops provide nesting and feeding habitat, thermal and escape cover, and resting sites for wildlife. Common reptiles that use these features include the common garter snake, western rattlesnake, and sagebrush lizard. Rodents and other small mammals use rock features to hide from predators, and to avoid temperature extremes. Bats use caves and rock outcrops as roost and nursery sites. Deep, rugged cliffs are used by desert bighorn sheep for lambing, escape, and thermal cover. Raptors, including golden eagles and several species of hawks use cliffs and rock outcrops as nest and perch sites. The canyon walls of the Snake River provide nesting habitat for one of the highest densities of predatory birds in the world (USDA Forest Service and USDI BLM 1997).

Soil characteristics determine the number of subsurface sites available to wildlife in the desert. Lack of vegetative structure in deserts is often offset by subsurface space created by deep and diverse soils. Subsurface sites provide shelter from daytime heat, protection from predators, and sources of food for prey species, such as snakes.

Wildlife habitat in this ecoregion has undergone great change during the past century, usually to the detriment of native species. For example, cool-season bunchgrasses once dominated large areas of the Columbia Plateau. Much of the grassland community has since been lost with the conversion of lands to agricultural and urban uses. Changes in fire regimes and grazing by domestic livestock have modified significant portions of the remaining grassland habitat. Species associated with native perennial bunchgrass communities, including the Columbian sharp-tailed grouse, kit fox, and Idaho ground squirrel, have declined in numbers more than other species' groups in the region. These species rely on grassland vegetation for plant and insect forage, nesting and brood-rearing habitat, and hiding cover.

Much of the sagebrush habitat in the Temperate Desert Ecoregion has also been lost or modified during the past several decades, resulting in habitat fragmentation. This loss is a result of conversion to agricultural and urban uses, grazing, altered fire regimes, and the encroachment of downy brome, other weeds, and woody species such as juniper, ponderosa pine, lodgepole pine, and Douglas-fir (USDA Forest Service and USDI BLM 1997). The best sagebrush habitat occurs where there is a mix of multi-age sagebrush with associated perennial bunchgrasses and forbs, interspersed with open wet meadows or riparian areas. These are key habitat components for sage-grouse and other wildlife. During winter, sage-grouse feed almost exclusively on the leaves of sagebrush (Patterson 1952; Wallestad et al. 1975).

Subtropical Desert Ecoregion

The Subtropical Desert Ecoregion is composed of the Mohave, Sonoran, and Chihuahuan deserts. In contrast to the cooler deserts of the Temperate Desert Ecoregion, the hotter deserts of the Subtropical Desert Ecoregion tend to have a more diverse flora and fauna. The northern limits of many species common in Mexico are found in this ecoregion, such as hummingbirds, coati-mundi, and jaguar. The Sonoran Desert is the most floristically diverse of the three deserts, and as a result, has the greatest diversity of wildlife. The desert tortoise, which is federally-listed as a threatened species (in the Mojave Desert only), is found in this ecoregion. Long-lived and once common, desert tortoises have suffered population declines due to adverse impacts associated with human activities (USFWS 1994).

The ecoregion is characterized by widely dispersed desert plants that provide little ground cover for wildlife. Canopy cover rarely exceeds 50%, and there is usually extensive bare ground between plants. In the Mojave and Sonoran deserts, several species of cacti, ocotillo, and creosote bush are large enough to provide near-woodland habitat used by a diversity of wildlife species, while other regions have only drifting sand dunes with sparse vegetation that are used by few wildlife.

Like species in the Temperate Desert, wildlife in the Subtropical Desert have evolved numerous means to deal with water scarcity and other rigors of the hot desert. Presence of standing water in winter and new herbaceous growth in spring provide water and forage for most wildlife (Laudenslayer and Boggs 1988). During summer and fall, some species, such as the kangaroo rat and other rodents, derive water from the seeds in their diet. Saguaro, as well as most other species of cactus, has spines that protect them from many grazing animals. However, collared peccaries and many desert rodents can avoid, or digest, cactus spines and obtain water from the plants succulent tissues.

Black-throated sparrows secrete a highly-concentrated urine and dry feces, and thus need little drinking water. In contrast, most other desert-living bird species show few adaptations for coping with water scarcity and simply fly to water sources to meet their needs. Reptiles and small mammals are active mostly at night and retreat to cool burrows, or seek shelter under vegetation or in rock outcrops to avoid the midday sun and reduce water loss. The yucca night lizard, for example, is restricted to desert regions with downed litter of yucca and agave plants (Jones 1986).

Salt balance is an important physiological function in desert animals. Chuckwallas, a desert lizard, eat the fleshy tissue of cacti, and are able to excrete salt from their nostrils by sneezing, without losing much water. Many other lizard species also have salt glands for excreting salt.

The structure of live vegetation structure is probably the most important habitat feature in these deserts. Shrubs and tall cactus are used by lizards for feeding and breeding, and lizards climb onto creosote bushes during the day to avoid the hotter ground temperatures. Vertical structure provides nesting, feeding, and breeding niches for birds. Cacti provide roosting and breeding habitats for bats that small shrubs do not provide. Horizontal vegetation structure is also important, as some species of birds prefer either open or closed habitats, and many species of lizards require more open areas for foraging, but closed habitat to avoid the heat and predators (Pianka 1966, Rottenberry and Wiens 1980).

The extensive root systems of certain desert plants, such as creosotebush, provide access to subsurface openings for toads, salamanders, lizards, snakes, and small mammals. Creosotebush areas found in the Chihuahuan and Sonoran deserts have little vegetative structure, but have a rich diversity of wildlife because of favorable soils that allow access to subsurface space.

Desert wildlife have evolved characteristics that are adaptive to the attributes of certain plant species. Desert iguanas feed heavily on creosotebush buds, especially during the spring, and their distribution is closely related to the distribution of creosotebush (Norris 1953).

Several birds rely on the saguaro and other cacti for roosting and nesting, including elf owl, cactus wren, and woodpeckers. Cavity-nesting birds often select vegetation with spines, perhaps to discourage nest predation by small mammals and reptiles. The Gila woodpecker and gilded flicker both excavate nest cavities in the saguaro cactus, but due to differences in bill structure, the gilded flicker must excavate its cavity near the top of the cactus, while the Gila woodpecker can excavate cavities near the base of the trunk.

Perennial grasslands comprise nearly 4 million acres in the Subtropical Desert. Collared peccaries use a bunchgrass known as sacaton for resting cover, and also feed on its roots. Masked bobwhites are also closely associated with these grasslands. These birds were extirpated from Arizona by 1900, but are being reintroduced to these grasslands.

Temperate Steppe Ecoregion

The Temperate Steppe Ecoregion is comprised of prairie grasslands, evergreen and deciduous forests, and sagebrush and chaparral shrublands. Grasslands occur in an environment with irregularities in weather patterns, including wet and dry spells, which occur often enough to impose severe stresses on wildlife. In a drought year, for example, reduced moisture and higher temperatures can greatly affect the abundance and quality of vegetation used for food and cover, often leading to substantial population declines in some species, especially birds.

The characteristics and habitats of grassland animals differ from those of animals that inhabit shrublands and forests. Many grassland species live in burrows, including prairie dogs, ground squirrels, pocket gophers, burrowing owls, black-footed ferrets, and badgers. Burrows provide a place to hide from predators, a more stable microclimate during hot summers and cold winters, and shelter from grassland fires (Brown 1982).

If an animal cannot hide in a burrow, it must be a fast runner to avoid predation. The swift fox can travel at 25 miles per hour (mph), while the pronghorn can run at 70 mph. Even quail and grouse often run instead of flying to escape predation, staying close to the ground and using the vegetation as cover.

Grassland animals tend to occur in large social groups. For example, millions of bison occurred on the Great Plains in presettlement days and millions of prairie dogs have been found in a single prairie dog town. Wildlife species living in grasslands tend to be more social than their forestland counterparts. Prairie dogs live in large, highly organized social units, while their eastern woodland counterpart, the woodchuck, rarely interacts with its own species. Flocking species are also more prevalent in grasslands than in forestlands. Socialization enables the members of a flock to more readily detect predators, but also to convey other information, such as mating status, which is difficult to ascertain in open grassland where sound is muffled and perches are few. Raptors are also more common in grasslands than other habitats, as open spaces favor animals with good vision and provide an abundance of prey items.

Compared with other habitats, grasslands tend to have low bird species diversity and abundance (Wiens and Dyer 1975). Although grasslands are highly productive, they are structurally simple and less complex than other habitat types, and thus provide birds with few niches to exploit. Bird species tend to differentiate themselves based on the cover and height of the grassland vegetation, with the horned lark and burrowing owls selecting areas with low, scattered vegetation, and the savanna sparrow and bobolink select high, dense herbaceous cover.

Grasslands found in the proposed treatment area include the Great Plains, shortgrass prairie, intermountain grasslands, and the Palouse grasslands. The mixed prairie of the Great Plains constitutes the eastern range for many grassland animals, including the prairie dog, pronghorn, swift fox, and desert cottontail. It was also the home of the bison. The shortgrass prairie to the west of the Great Plains, and east of the Rocky Mountains, is where true grassland animals are found. Many of the species found here cannot survive in the tallgrass and mixed prairies because they are less able to see and flee from predators.

Wildlife found in the intermountain grasslands associated with the Rocky Mountains are similar to those found in grasslands to the east, except species that need a year-round supply of green grass do not occur. Deer, elk, and pronghorn survive in the intermountain grasslands by foraging upon shrubs and other woody vegetation during winter. Ground squirrel diversity is especially high in the intermountain grasslands, with 19 of the 22 species of ground squirrels in North America found in this region. Much of the Palouse grasslands have been converted to agriculture or lost to shrubland encroachment, greatly reducing their value to sharp-tailed grouse and other wildlife that were once common.

Evergreen and deciduous forests are found at higher elevations and along streams and other aquatic areas.

The plant species composition of coniferous forest stands, and the types of wildlife that use them, varies with altitude. Aspen is an important component of many deciduous forests. Aspen typically is found in moist areas and become established after fire or other disturbance has cleared a suitable area. Beaver use aspen limbs and foliage for food and to build dams and lodges. Snowshoe hare feed upon aspen twigs and bark during winter, and aspen buds are important in the winter diet of ruffed grouse. Badgers, ground squirrels, and other burrowing animals provide bare ground needed by aspen seeds to germinate.

Subtropical Steppe Ecoregion

This region is composed primarily of grassland vegetation, with local occurrences of shrubs and woodlands. Grassland wildlife species found in the Temperate Steppe Ecoregion are also found here, and include pronghorn, mule deer, white-tailed deer, coyote, badger, and black-tailed jackrabbit. The northern limit of distribution of several mammals, including the Mexican ground squirrel and gray fox, occurs in the grasslands of this ecoregion (Bailey 1997).

Woodlands formed of pinyon pine and several species of juniper (pinyon-juniper woodlands) are found on about 4 million acres, and are also found in other ecoregions. The canopy of these woodlands is generally open, and the trees are far apart. Open stands of pinyon-juniper with abundant vegetation below the trees provide the best wildlife habitat. These woodlands generally do not have the structure and complexity to support a large diversity of wildlife as compared to other forest types, although a study in Utah showed that avian species diversity in pinyon-juniper woodlands was similar to species diversity in other woodland and forest types (Paulin et al. 1999).

Reptiles are not common in pinyon-juniper woodlands. Birds feed on pinyon-juniper seeds and berries, find nesting cavities within juniper trunks, and use the stringy and fibrous juniper bark for nesting material. The pinyon jay, plain titmouse, and common bushtit are obligate to these woodlands, and 144 different species of birds were observed in pinyon-juniper woodlands in New Mexico (Short and McCulloch 1977). Avian species diversity is usually greater in pinyon-juniper woodlands than in adjacent grasslands (Sieg 1991).

Abert squirrel, pinyon mouse, wood rat, gray fox, and other small mammals eat berries, seeds, and the inner twigs from pinyon-junipers. Mule deer, white-tailed deer, elk, pronghorn antelope, and desert bighorn sheep may occur throughout the year in pinyon-juniper woodlands. Leaves and berries of pinyon pine and juniper trees are eaten by large mammals.

Most food habit studies have shown that the value of pinyon-juniper woodlands to wildlife is usually related to the quantity and composition of the vegetation growing in association with pinyon-juniper. As pinyon-juniper stands mature, the trend is toward increased tree density and finally, dense canopy cover. The dense canopy cover shades out plants found below pinyon-junipers, reducing the variety of plant types that can provide food and cover for wildlife. Small mammal, deer, and elk use of pinyon-juniper woodlands declines as tree canopies become more dense, although some species, like pinyon mice and pinyon jays, may favor denser stands (Short and McCulloch 1977, Willis and Miller 1999).

Mediterranean Ecoregion

The vegetation of this region is dominated by grassland, shrubland, and forestland habitats. Many shrub (chaparral) and forest/woodland plant species have thick, hard, evergreen leaves. The number of wildlife species using shrub habitats is limited by the lack of trees in shrublands. However, wildlife species diversity can also be limited in evergreen woodlands due to the paucity of shrubs in these communities, as shrubs are often unable to compete with trees for the limited moisture.

Due to their tough, leathery texture, the leaves of vegetation in chaparral communities is resistant to wilting, and thus provide cover for wildlife even during the frequent droughts typical of the region. Wildlife species found in chaparral tend to be species that nest on the ground or in shrubs, such as ground- and shrub-nesting birds and rodents, or prey upon ground- and shrub-dwelling species, including coyote, skunk, and bobcat.

Although this ecoregion supports a diverse vertebrate fauna, including numerous species of reptiles and rodents, only a limited number of species are closely tied to the chaparral. These include the mountain quail, California thrasher, wrentit, brush rabbit, California mouse, and dusky-footed woodrat.

Mountain quail favor slopes covered with chaparral. They feed on acorn mast, fruits, and seeds in the fall, leafy foods during winter, and bulbs in the spring and summer. Thrashers and wrentits find good food and cover in the chaparral, and are more often seen than heard in the dense vegetation. The brush rabbit does not use burrows regularly as most other species of rabbits do, perhaps due to the dense chaparral cover. Woodrats construct stick dens that are also used by the California mouse. Since homes are constructed of sticks, woodrats are vulnerable to fires in chaparral communities.

Chaparral communities are adapted to fire, and wildlife respond by retreating to burrows, hiding in rock crevices, or escaping from the area. After a fire, seed-eating birds, such as mourning doves, move into the area to feed on seeds exposed by fire. Mule deer seek out the temporary community of herbaceous plants that develop during the first year or two after the fire. Many of these plants produce bright flowers that attract nectar-feeding insects and birds.

Deciduous and evergreen woodlands provide vegetation structure and complexity that benefits a variety of wildlife species. The habitat often occurs in a mosaic-like pattern of conifer stands intermixed with deciduous tree stands. The shrub and herbaceous stratum are often poorly developed in these woodlands. Mature woodlands are important to cavity nesting birds, and oak mast crops are an important food source for birds and mammals, such as scrub and Steller's jays, acorn woodpecker, wild turkey, mountain quail, California ground squirrel, western gray squirrel, black bear, and mule deer (Anderson 1988). Amphibians that reside in the forest detritus layers include Mount Lyell salamander, ensatina, and relictual slender salamander (McDonald 1988).

Annual and perennial grasslands are found in central and coastal California. Annual grassland habitats consist largely of non-native annuals that have displaced native perennials (Kie 1988). Habitat structure and wildlife abundance are dependent upon the mix of plant species at a site. Sites with western bracken fern exhibit a taller, more diverse structure than sites with shorter grasses. Many wildlife species use grassland habitats, but some require special habitat features, such as cliffs, caves, ponds, or shrubby areas for breeding, resting, and escape cover.

Marine Ecoregion

The Marine Ecoregion is dominated by evergreen, and to a lesser extent, deciduous forests located along the Pacific Coast. These forests are managed by the BLM primarily for timber production and wildlife habitat.

Temperate forests are among the most productive habitats in the world (Whittaker 1975). The energy produced by temperate forests, along with their structure and complexity, provide habitat to a diversity of wildlife. Temperate forests are also routinely subject to disturbances that increase variability in the environment and create edge habitat. In turn, the succession of vegetation types that follow a disturbance provide habitats for a succession of wildlife species.

In general, deciduous trees support more wildlife than evergreen trees (Glenn-Lewin 1977). Conifer forage is less palatable than deciduous forage, which means that there are fewer animals that can consume the foliage, and in turn, be consumed by predators. Conifer foliage is also relatively unpalatable to decomposing organisms, such as fungi and bacteria, so the decomposition of coniferous matter is often a slow process (Hunter 1990). Deciduous trees generally have more structural complexity than conifers, providing more places for animals to feed and seek shelter.

Conifers do possess characteristics that are critical to the survival of many wildlife species. Spruce grouse are dependent on conifer foliage to survive the winter. Conifer stands also provide crucial winter cover to elk, deer, and other wildlife by blocking wind and keeping snow from reaching the ground, covering browse, and restricting animal movements. However, the foliage that captures snowfall also intercepts light in the spring, reducing the amount of light that can reach the forest floor, warm the soil, and stimulate the growth of herbaceous vegetation and shrubs used by these wildlife.

As this ecoregion is characterized by abundant rainfall, there is an abundance of moisture on the forest floor, as well as in ponds and streams, to support a diversity of amphibians. All frogs and toads in this region lay their eggs in water. Most salamanders lay their eggs in or near water, while others lay their eggs on land under logs (Ensatina), in rock outcrops (western red-backed salamander), or both (clouded salamander). Many of these amphibians spend a portion or most of their lives out of water, living under moist logs, dead wood, or forest litter, or in burrows or root or rock crevasses.

Few reptiles are found in this ecoregion. The alligator lizard is the only widely distributed species found in forested habitats, and the painted turtle and western pond turtle are the only turtles common in the area. The most common snake is the northwestern garter snake.

Birds have adapted to exploit the different layers of vegetation in the forest. Ruffed grouse, winter wren, American robin, eastern towhee, and dark-eyed junco are often found near the forest floor or in shrubs. Woodpeckers and creepers are seen moving up and down the trunks of trees in search of insects. Nuthatches and chickadees exploit the cone seeds, while warblers and kinglets glean insects from the upper deciduous forest canopy.

Like birds, mammals exploit the vegetation types and strata found in the forest. Shrews, mice, and moles are fossorial or live near the forest floor. Rabbits and hares reside near the ground and seek shelter in dense herbaceous or shrub vegetation. Wide-roaming species that live near the ground include black-tailed deer, elk, black bear, mountain lion, and bobcat. Deer and elk tend to remain in dense forest stands during the day to seek shelter, but move to more open shrublands and grasslands at night to feed, and thus favor forest habitat interspersed with shrubland/grassland habitats. Bears favor large stands of contiguous forest, but also use shrublands with abundant berries and other forage.

Several special habitat features have been identified in forests that are important to wildlife. Snags, which are dead or dying trees, are critical to many species of wildlife. Cavities in snags provide shelter and nesting sites for woodpeckers, owls, and other cavity-using wildlife, while dead and dying bark often harbors large numbers of insect prey for birds. Edges are places where different plant communities or successional stages meet, such as between a forest clearing and dense forest stand. A large number of species are found at edges, and some species reach their maximum population densities there (Hunter 1990). For some species of birds, however, nest predation is higher for individuals nesting near edges than for those nesting in the forest interior.

A number of species rely on old-growth forests for most or all of their life requisites. Old-growth forests in the Marine Ecoregion generally consist of conifer trees with a diameter over 3 feet at the base of the tree, and are more than 200 years old (Bolen 1998). These forests also contain a multilayered canopy and numerous snags and logs. Vaux's swifts depend on large, hollow snags for nesting and roosting habitat. Marbled murrelets use the stout branches of old-growth trees for nest platforms. Spotted owls nest in tree cavities and feed on flying squirrels. Banana slugs, Pacific giant salamander, Olympic salamander, and Oregon slender salamander are other species that prefer the rotting logs and moist soil conditions found in old-growth habitats.

Special Status Species

There are over 75 terrestrial animal species occurring on or near public lands in the treatment area that are federally listed as threatened or endangered, or proposed for listing. Included in the total number are 10 species of arthropod, 7 species of amphibian, 5 species of reptile, 20 species of bird, and 27 species of mammal. A complete list of special status animal species may be found in Appendix H. Please note that this list is dynamic, and will likely change throughout the time period considered by this PEIS.

Special status animal species are found on public lands throughout the U.S., although only two species (the spectacled eider and Steller's eider) are given special status in Alaska. Special status arthropods are largely butterflies that occur mostly in open habitats. Special status amphibians occur in wetland habitats throughout the west, and special status reptiles occur in warm habitats of California and the southwest. Special status birds and mammals breed on and migrate through public lands throughout the western United States.

Livestock

Approximately 165 million acres of public lands are open to livestock grazing, with use levels established by the Secretary of the Interior and administered through the issuance of grazing permits/leases. The majority of the grazing permits issued by BLM involve grazing by cattle, with fewer and smaller grazing permits for other kinds of livestock which would include primarily sheep and horses.

The BLM administers grazing lands under 43 CFR Part 4100 and BLM Handbooks 4100 to 4180, and conducts grazing management practices through BLM Manual Handbook H-4120-1 (*Grazing Management*; 1984). Management of livestock grazing is authorized and enforced through both permits and leases, and is commonly carried out through the development and implementation of allotment management plans (AMP) and/or terms and conditions of the grazing permit or lease. The grazing permit establishes the allotment(s) to be used, the total amount of use, the number and kind of livestock, and the season of use. The grazing permit may also contain terms and conditions as appropriate to achieve management and resource condition objectives. Allotment management plans further outline how livestock grazing is managed to meet multiple-use, sustained-yield, and other needs and objectives, as determined through land use plans.

Geographically specific rangeland health standards and guidelines are identified for each state to help direct the grazing program for those states. Each year the BLM conducts reviews of land within their jurisdiction to determine the level of compliance with the rangeland health standards. At a minimum, grazing is managed to ensure that 1) watersheds are in or making significant progress towards properly functioning physical condition; 2) ecological processes including the hydrologic cycle, nutrient cycle, and energy flow are maintained; 3) water quality complies with state water quality standards; and 4) habitats are or making significant progress towards being restored or maintained for all special status species including federally-listed threatened or endangered species. Reviews of rangeland health standards are often conducted when grazing permits or leases expire, particularly when those permits or leases are within high priority watersheds.

Public lands provide an important source of forage for many ranches and help to support the agricultural component of many communities scattered throughout the west. In FY 2004, the total number of grazing permits/leases in force was 17,962, with a total of 12.7 million Animal Use Months (AUMs) authorized (Table 3-6; USDI BLM 2005d). Grazing authorizations produced approximately $11.8 million in annual revenues (USDI BLM 2005c).

Wild Horses and Burros

The BLM, in conjunction with the Forest Service, manages wild horses and burros on BLM- and Forest Service-administered lands through the Wild Free-Roaming Horse and Burro Act of 1971. In FY 2004, wild horse and burro populations on public lands totaled over 37,000 animals, with nearly half of these animals living in Nevada (Table 3-7). Another 24,000 animals are held in holding pens. The population of wild horses and burros is approximately 14,000 animals above the Appropriate Management Level (AML). The AML is an estimate of the number of wild horses and burros that public lands can support while maintaining a thriving natural ecological balance (USDI BLM 2005d).

Wild horse herds grow at an average rate of 20 percent annually. Management is accomplished by carefully controlling horse and burro populations so that their numbers do not exceed the carrying capacity of the land. This is done by primarily gathering animals periodically so that numbers are near the AML. Fertility control is being used in some herd management areas (HMAs) as a means to reduce the population growth rate. This has shown to be very effective thus far and will likely be used on a larger scale in future years.

TABLE 3-6
Grazing Permits and Leases in Force, Number of Operators, and Active Animal Unit Months during Fiscal Year 2004

State	Leases and Permits	Active AUMs
Arizona	759	662,185
California	581	425,170
Colorado	1,585	653,971
Idaho	1,903	1,338,540
Montana, North Dakota and South Dakota	4,281	1,365,770
Nevada	645	499,340
New Mexico, Oklahoma, and Texas	2,295	1,865,538
Oregon and Washington	1,586	1,055,531
Utah	1,531	1,220,757
Wyoming and Nebraska	2,796	1,954,033
Total	17,962	12,689,124

Source: BLM Public Land Statistics (USDI BLM 2005d).

When horse and burro populations begin to exceed the AML, excess animals are gathered and offered to the public through periodic adoption programs. In FY 2004, 6,407 wild horses and burros were adopted in the United States. Forty percent of these were adopted in the eastern U.S. Nearly 200,000 animals have been adopted since 1972 (USDI BLM 2005d). In 2001, the BLM implemented a program to further reduce the wild horse and burro population to approximately 27,000 animals by 2005 or 2006. Animals are managed within 206 Wild Horse and Burro HMAs. Public lands inhabited by wild horses or burros are closed to grazing under permit or lease by domestic horses and burros. The Wild and Free Roaming Horse and Burro Act mandates that wild horses and burros can only be managed in areas where they were found in 1971. Those that stray onto non-designated public and/or private lands are removed.

Paleontological and Cultural Resources

Paleontological Resources

The BLM is responsible for managing the public lands and their various resources so that they are utilized in a manner that will best meet the present and future needs of this Nation. The western U.S. has a fossil record that includes almost all of the geologic periods from the Cambrian (500+ million years ago) to the more Recent (the last 10,000 years), and nearly every imaginable ancient environment. Many fossil deposits are of national and international importance, and many thousands of different kinds of fossils were originally made known to the scientific world from specimens first found in the west.

The BLM manages fossils as a natural heritage resource on the lands it administers under the general guidance of the FLPMA and NEPA. Fossils are managed to promote their use in research, education, and recreation, and paleontological localities are an important consideration in developing land use management decisions. More than 200 properties, totaling more than 5 million acres, are managed either wholly or in part for paleontological values or contain paleontological values that may require special management strategies in the future. Significant paleontological resources can also be found on other public lands estimated to total over 20 million acres. Because of the increasing interest and activity related to fossils over the past 3 decades, it is estimated that there are more than 50,000 fossil sites documented on public lands. Table 3-8 lists the localities that include many of these sites.

Cultural Resources

Cultural resources include archaeological, historic, or architectural sites, structures, or places with important public or scientific uses, and may include definite locations (sites or places) of traditional cultural or religious importance to specific social or cultural groups. Cultural resources are concrete, material places and things that the BLM locates, classifies, and ranks. The BLM manages cultural resources according to their relative importance, to protect significant cultural resources from inadvertent loss, destruction, or impairment, and to encourage and accommodate the appropriate uses of these resources through planning and public participation.

This summary presentation just begins to describe the range in age and variety of cultural site types located on BLM lands throughout the western U.S. and Alaska. The cultural heritage known for the various areas extends back 11,000 to 13,000 years before the present (BP). As one moves forward in time, the number and variety of sites increases mainly as a result of the increase in Native populations and, after 1500 AD or so, European and Euroamerican immigration and increases in population.

Table 3-9 summarizes the number of acres of public lands inventoried for cultural resources, the number of properties found on public lands, and the number of properties listed in the NRHP.

American Indian and Alaska Native Cultural Resources

This review uses the culture area approach as defined in the *Handbook of North American Indians* (Sturtevant 1978-2001). See Map 3-11 for the location of these areas. These regions represent areas within which specific cultural groups shared certain cultural characteristics and histories. Each culture area section provides a brief review of the archaeology and ethnography of that area. Table 3-10 summarizing examples of major types of archaeological sites likely to be in each culture area follows this section.

Arctic and Subarctic (Alaska)

Archaeological research suggests that the earliest human migrants crossed into the New World via the Bering Land Bridge, likely following large herbivorous Pleistocene animals, such as mastodon, woolly mammoth, horse, and bison. In this culture area, typical artifacts from the period 13,000 to 9,000 Before Present (BP) include lanceolate projectile points, bifacial knives and scrapers, and retouched flake tools (Ames and Maschner 1999, Dixon 1999). Cultural resource sites from this time period include open campsites, habitations or campsites located in caves or rockshelters, and sites where game animals were killed and/or processed.

As the post-glacial climate in Alaska warmed, prehistoric cultures became more established. Early aboriginal groups, with a subsistence strategy similar to that of the Paleoindians, used tool assemblages dominated by microblades, small wedge-shaped cores, and burins.

TABLE 3-7
Wild Horses and Burros on Public Lands during 2004

State	Wild Horses			Wild Burros		
	Free-Roaming Population	Adopted	Removed	Free-Roaming Population	Adopted	Removed
Arizona	270	184	36	1,863	113	325
California	2,608	677	684	1,521	209	305
Colorado	767	150	3	0	38	0
Idaho	634	103	292	0	7	0
Montana, North Dakota, and South Dakota	161	35	0	0	10	0
Nevada	17,679	122	4,751	1,306	1	17
New Mexico, Oklahoma, and Texas	115	841	31	0	175	0
Oregon and Washington	3,070	442	850	15	24	0
Utah	2,605	167	627	140	21	0
Wyoming and Nebraska	4,381	298	1,981	0	67	0
Total	32,290	5,699	9,252	4,845	945	647

Source: BLM Public Land Statistics (USDI BLM 2005d).

Cultures from 9,000 to 6,000 BP often are referred to as the Microblade Tradition (Dumond 1987). In addition to open campsites and sites with skin-covered tents, semi-subterranean houses are documented for this period (Anderson 1984). By 6,000 BP, the Northern Archaic Tradition had arisen in the boreal forests of the interior, represented by small, seasonal campsites and tool assemblages composed of lanceolate and side-notched projectile points and scrapers (Dumond 1987). Technological advances during the period 6,000 to 250 BP led to the development of several distinct cultures. Tool kits of the widespread Arctic Small Tool Tradition included small stone endblades and sideblades inserted into the shafts of arrows or spears (Dumond 1987). Populations of Arctic Small Tool Tradition people developed highly specialized maritime technologies (kayaks, umiaks, dogsleds, toggling harpoons, bow and arrows, and ground slate tools). Habitations, in the form of semisubterranean houses, often were clustered in villages (McCartney 1984, Dumond 1987).

At present, the Alaska Natives and Indians are the dominant native groups of Alaska. In general, the Inuit (Eskimo and Aleut) inhabit the coastal areas and adjacent tundra, while Indians (Athabaskan or Tlingit) inhabit the interior forests and southeast Alaska, though both groups have tremendous intra-cultural diversity and overlapping resource exploitation areas. Terrestrial and marine mammals and fish are the primary source of food for both groups; plants being of lesser importance, given the short growing season.

Kelp and berries are the principal plant foods, with mushroom, wild parsnip, wild rhubarb, and lupine roots also gathered. Dune grass is used to weave baskets and mats (Kehoe 1992). Dried grasses were coated in sea mammal oil and used as wicks in lamps (Lantis 1984, Kehoe 1992). Alaskan Indians have focused their subsistence activities on marine whales and seals, seasonal fish runs, and inland caribou herds and a variety of other land mammals.

Edible plant resources of the interior include a wide variety of berries, fern roots, lily bulbs, mushrooms, wild onions, wild rhubarb, rose hips, and various roots (Kehoe 1992). Birch bark continues to be used for the manufacture of many utilitarian objects, including baskets, shelters, cooking pots, and canoes. The wood of birch, spruce, and willow has been used for bows, arrows, snowshoe frames, wooden tools, and house and canoe frames. Ropes and fishing nets have been made from willow bast, nettle fibers, and spruce roots. Additional uses of spruce roots include containers, basketry, sewing thread, and twine (McClellan and Deniston 1981).

Northwest Coast

Archaeological evidence for occupation of this culture area dates back to about 11,000 BP, though faunal remains from the Olympic Peninsula suggest human presence earlier than 12,000 BP (Lyman 1991). Early peoples' subsistence systems focused on maritime

TABLE 3-8
Interpreted Paleontological Sites on Public Lands

State	Interpreted Locations
Colorado	• Dinosaur Diamond Byway • Gard Park Fossil Area • Kremmling Cretaceous Ammonitie Locality • Rabbit Valley Trail Through Time • Fruita Paleontology Area
Idaho	• Malm Gulch Area of Critical Environmental Concern (ACEC)
Utah	• Cleveland Lloyd Dinosaur Quarry • Copper Ridge Sauropod Dinosaur Tracks • Mill Canyon Dinosaur Trail • Warner Valley Dinosaur Track Site
Wyoming	• Red Gulch Track Site ACEC • Big Cedar Ridge Fossil Plant Area ACEC • Dry Creek Petrified Tree Environmental Education Area

resources, and typical artifacts consist of large chipped stone projectile points, microblades, compound harpoons, and grinding stones (Ames and Maschner 1999). Due to the damp climate and acidic soils in this region, faunal remains and tools made from perishable items dating to this period are rarely preserved. In addition, the changing sea levels over the last 10,000 years have inundated many of the older occupation or processing sites.

By about 5,000 BP, sea levels rose and stabilized, and distinctive cultural patterns emerged. Bone and ground stone tools were prevalent from Southeast Alaska to Puget Sound, as were large settlements and specialized maritime subsistence strategies. There is evidence of sedentism (pithouses and shell middens in western Washington) from 3,500 BP, and it appears that by 3,000 BP, trade networks with Plateau cultures were well established (Nelson 1990). Petroglyph sites begin during this period (Boreson 1998, Ames and Maschner 1999).

By 1,000 BP, most Northwest Coast groups occupied village sites on a year-round basis. Many village sites were located for defensive purposes and included fortifications, suggesting the presence of warfare, social complexity, and competition for resources (Ames and Maschner 1999). Typical artifacts include composite woodworking tools, netsinkers, bone and antler tools, and copper and iron tools. Archaeological sites in the Northwest Coast region are generally difficult to locate because of dense vegetation and poor preservation (Nelson 1990).

Food resources currently used by native Northwest groups include salmon, halibut, cod, candlefish (an important source of dietary oil), clams, whales, elk, deer, mountain sheep, and bear. Plant food sources, which are numerous in this culture area, include edible ferns and lilies, the tuber of the wapato, over 40 fruits and berries, edible nuts, leaves, and shoots, and certain types of algae, seaweed and kelp. Many groups used controlled burning to maintain prairies, and berry and nut-producing areas along the coast from California to British Columbia (Suttles 1990, Ames and Maschner 1999).

Forest resources are used extensively, particularly western redcedar and yellow-cedar, for canoes, for plank house construction, and for specialized ritual purposes such as totem poles and masks. Sitka spruce has often been used for houses and canoes, and western hemlock and Douglas-fir saplings have been used to construct fish weirs. Red alder, Rocky Mountain maple, and yellow-cedar have been used for spoons, bowls, masks, and dishes; and western yew has been used for bows, wedges, clubs, and digging sticks. Plant materials used to make rope and cordage include the limbs of western redcedar, the stipes of bull kelp, the roots of cedar and spruce, and the fibers of stinging nettle and Indian hemp. Materials used in basketry include cedar roots, cattail, tule, bear grass, and various sedges and grasses. The inner bark of red and yellow-cedar is used for baskets, mats, skirts, capes, towels, and diapers. There are numerous medicinal plants in the Northwest region, including devil's club, kinnikinnick, hogfennel, and tobacco (Suttles 1990).

TABLE 3-9
Cultural Resources on Public Lands

State	Number of Acres (in millions)	Number of Acres Surveyed	Percent of Acres Surveyed	Number of Properties Recorded
Alaska	85.5	106,171	0.1	3,330
Arizona	12.2	810,320	6.6	11,576
California	15.2	1,773,872	11.7	27,770
Colorado	8.4	1,432,063	17.1	38,337
Idaho	12.0	1,969,141	16.4	14,328
Montana, North Dakota, and South Dakota	8.3	1,308,029	15.8	9,858
Nevada	47.8	2,100,376	4.4	43,782
New Mexico, Oklahoma, and Texas	13.4	1,379,712	10.3	34,012
Oregon and Washington	16.4	1,533,886	9.3	12,210
Utah	22.9	1,732,730	7.6	37,524
Wyoming and Nebraska	18.4	2,448,950	13.3	38,834
Total	261.8	16,595,250	6.3	271,561

Source: BLM Public Land Statistics (USDI BLM 2005d).

Southwest

Between 11,500 and 8,000 BP, human groups practiced a highly mobile hunting and gathering subsistence strategy. In general, the oldest archaeological sites in this culture area are located near now extinct springs, large and small Pleistocene lakes (playas), or major drainages, and consist of open camps, animal kill sites, animal processing sites, or caves.

Archaeological sites dating from 8,000 to 2,000 BP are either open campsites located near water sources, containing chipped and ground stone tools, or are in rockshelters or caves, where well-preserved twined sandals, wood artifacts, and basketry are often recovered (Kehoe 1992). Horticulture was introduced into the southwest as early as 4,500 BP, although domestic crops did not substantially contribute to the diet until later (Woodbury and Zubrow 1979). Typical artifacts of the period include stemmed projectile points used with atlatls, basketry, scrapers, grinding slabs, and cobble tools. Remains of surface structures, made of posts and brush or other material, are documented beginning midway through the period in the west (Irwin-Williams 1979). The first pit house sites and storage pits are documented late in this period (Woodbury and Zubrow 1979). Petroglyphs and pictographs are first produced during this time period (Schaafsma 1980).

Researchers have subdivided the southwest, starting from about 2,000 BP, into the Anasazi, Mogollon, Hohokam, and Hakataya geographical-cultural areas. The Anasazi occupied variable topography during the generally cooler and moister climates; the Mogollon inhabited well-watered, forested and mountainous regions; the Hohokam were located in low, dry deserts; and the Hakataya occupied the hot desert regions bordering the lower Colorado River (Woodbury 1979). Parts of the region were intensively occupied and socially and economically linked to the civilizations of the Mexican Classic Period, when sedentary cultures began to emerge (Irwin-Williams 1979).

Maize was cultivated in earnest by about 2,200 BP, and was soon followed by beans, squash, cotton, and other crops (Irwin-Williams 1979; Woodbury and Zubrow 1979). By 1,700 BP, some inhabitants of the region had developed sophisticated irrigation, pottery, storage pits, and pit house villages. Eventually, small to large permanent towns of multi-story, above ground structures (pueblos) were developed. Sites dating to this period may include features such as irrigation canals, wells, storage pits, and roads. Typical artifacts consist of pottery (used for the storage of crops), basketry, and small corner-notched projectile points indicating the adoption of the bow and arrow by 1,500 BP (Woodbury and Zubrow 1979).

TABLE 3-10
Culture Areas, Prehistoric Occupation Periods, and Selected Common Site Types

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
Arctic and Subarctic	*13,000+ to 9,000 B.P.* Open campsites Cave or rockshelter occupation sites Animal kill and lithic processing sites	*9,000 to 6,000 B.P.* Semi-subterranean houses Open campsites and tent camps	*6,000 to 250 B.P.* Semi-subterranean house villages Open campsites and tent camps
Northwest Coast	*12,500+ to 6,000 B.P.* Open campsites Cave or rockshelter occupation sites		*6,000 to 250 B.P.* Large, cedar plank pithouse villages Fortified sites Seafood capture or processing sites Pictograph and petroglyph sites
California	*11,000(?) to 8,000 B.P.* Open campsites Animal kill or processing sites	*8,000 to 5,000 B.P.* Open campsites and coastal villages Plant or seafood processing sites	*5,000 to 250 B.P.* Large coastal villages Burial mounds Extensive seafood, sea mammal, and plant processing sites Pictograph and petroglyph sites
Great Basin	*11,500+ to 8,000 B.P.* Open campsites Cave occupation sites Lithic processing sites	*8,000 to 4,000 B.P.* Cave or rockshelter occupation sites Pithouse villages Plant and lithic processing sites Fishing sites	*4,000 to 250 B.P.* Cave or rockshelter occupation sites Small pithouse villages Plant and lithic processing sites Storage pits Pictograph and petroglyph sites
Southwest	*11,500 to 8,000 B.P.* Open campsites Animal kill and lithic processing sites Cave occupation sites	*8,000 to 2,000 B.P.* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Waddle and daub structures Lithic processing sites Pictograph and petroglyph sites	*2,000 to 250 B.P.* Pithouse villages Storage pits Above-ground structures (Pueblos) Below-ground structures (Kivas) Irrigation ditches and roads Navajo hogans and pueblitos Pictograph and petroglyph sites
Plains	*12,000 to 8,000 B.P.* Open campsites Cave or rockshelter occupation sites Animal kill and lithic processing sites	*8,000 to 2,000 B.P.* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Tipi ring sites Cairns and cairn lines Animal kill, lithic, and plant processing sites	*2,000 to 250 B.P.* Open campsites and tipi ring sites Waddle and daub structures Earthlodge villages Burial mounds Storage pits Cave or rockshelter occupation sites Small pithouse villages Cairns and cairn lines Animal kill, lithic, and plant processing sites Pictograph and petroglyph sites
Plateau	*12,500 to 8,000 B.P.* Open campsites Cave or rockshelter occupation sites Fishing sites Lithic processing sites	*8,000 to 4,000 B.P.* Open campsites Small pithouse villages Cave occupation sites Animal or fish processing sites Lithic processing sites Plant processing sites	*4,000 to 250 B.P.* Pithouse and longhouse villages, often with burials Open campsites Cave occupation sites Storage pits Animal or fish processing sites Lithic and plant processing sites Pictograph and petroglyph sites

The Pueblo Indians are best known for their agricultural development of corn, beans, and squash. In addition, wild plants (e.g., amaranth, chenopods, wild onion, wild celery, sage, grass seeds, juniper berries, pine nuts, acorns, walnuts, agave, prickly pear, and cholla) were eaten (Bodine 1979, Plog 1979). Other plants are used for clothing, shelter, and medicine. Baskets are made from yucca fibers, cotton is used for weaving, blankets are made from small palms, yucca roots are used for hair washing, and gourds are used as containers (Bodine 1979, Kennard 1979, Plog 1979, Schroeder 1979).

The Yuman groups (Colorado River Tribes) living along the Colorado and Middle Gila rivers have traditionally cultivated corn, squash, pumpkins, melons, beans, and cotton (Maxwell 1978). Important animal foods include small game and fish, and important plant resources include prickly pear, saguaro, mesquite, and numerous nuts and berries (Maxwell 1978, Jorgensen 1980). Yuman groups living on or near the Colorado Plateau practiced agriculture in the canyons in summer, then hunted deer, antelope, big horn sheep, and rabbits in the fall. They also gathered pinyon nuts, juniper berries, various cacti, and other plants for both subsistence and domestic purposes (Khera and Mariella 1983, McGuire 1983, Schwartz 1983).

Southern Athapaskan or Apachean-speaking tribes occupied much of eastern Arizona, portions of New Mexico around the Pueblos, southeastern Colorado, western Oklahoma, and parts of western and southern Texas beginning about 700 BP. Following contact with the indigenous Pueblo peoples, the Navajo readily adopted maize, bean, and squash agriculture. The Western Apache, Jicarilla, and Lipan cultivated crops less intensively, and the remaining groups did not adopt any agricultural practices. With arrival of the Spanish, the Navajo readily adopted the raising of horses, sheep, goats, and cattle, and cultivated orchards and other introduced crops (Basso 1983, Opler 1983, Tiller 1983, Witherspoon 1983).

Traditional plants gathered by the Apacheans include agave crowns, saguaro cactus fruit, yucca, prickly pear, mesquite beans, acorns, pinyon nuts, numerous berries, grass seeds, wild root crops, and various greens or young plants. Yucca has been used to make shampoo, and the sap of Spanish bayonet and other plants has been used to make dyes. Common basketry plants include sourberry, willow, martinia, and bata mota. At least 29 species of plants have been used for medicinal purposes. Various large and small game animals were hunted for food and hides.

Great Basin

Two of the oldest archaeological sites in this culture area are the Tule Springs campsite (11,000 BP) and Danger Cave (9,000 BP; Aikens 1983). Typical artifacts of the period from 11,000 to 8,000 BP include leaf-shaped and long stemmed projectile points, occasional fluted points, specialized scrapers, chipped stone crescents, and drills (Warren and Crabtree 1986). This period also includes the earliest evidence of basket making (Adovasio 1986). Inhabitants of the region likely were highly mobile hunter-gatherers with a generalized big game hunting and collecting economy.

The warm and dry climatic conditions during 8,000 to 7,000 BP limited human subsistence activities. Sites dating to this period are rare, and include caves (Aikens 1983) and rockshelters in drier areas, or pithouse villages located in valley bottoms near permanent streams and springs (Elston 1986). Generalized hunting and collecting remained the major subsistence practices, although seed collecting and processing activities gained importance, as indicated by bedrock mortars and milling stones. Root collecting and fishing also gained importance during this period (Mehringer 1986). Typical artifacts include projectile points used with atlatls, basketry, twined sandals, and various wooden implements (Aikens and Madsen 1986).

By about 4,000 BP, subsistence systems were broad based and resource-rich areas were heavily exploited seasonally. The shift in styles of projectile points over time indicates the adoption of the bow and arrow. While caves continued to be occupied (Aikens 1983), many locations along major rivers contained small pithouse villages with associated storage facilities (Butler 1986). Horticulture was introduced in the eastern Great Basin and Owens Valley by Southwest cultures around 1,500 BP. Outside of these areas, hunting and gathering remained the primary form of subsistence. An expanded reliance on pinyon nut gathering, as evidenced by mortars and pestles, also occurred during this period (Aikens and Madsen 1986, Elston 1986). Petroglyphs are common by 3,000 BP and pictographs by 1,000 BP (Schaafsma 1986).

Prior to the acquisition of the horse in the late 1700s, Shoshone and Northern Paiute in the High Desert region and western Wyoming fished for salmon in the spring and dug camas roots in the summer. These groups traveled to the mountains of southeastern Idaho and northern Utah to hunt deer and elk in the fall. After the development of equestrian culture, ranges and territories extended into present-day Wyoming and Montana, in seasonal pursuit of buffalo.

In the high desert, the single-leaf pinyon nut was an important staple, along with plant resources such as chenopod, blazing star, grass seeds, mesquite, salvia, various cacti, and gourds (Egan 1917; Steward 1939, 1997; Thomas et al. 1986). The Western Shoshone wore hats made from twined sage bark or willow and clothing made from bark, grass, or fur. A large number of plants have also been used for basketry in this region (Adovasio 1986; Fowler 1986; Thomas et al. 1986). The Eastern Shoshone pursued game more extensively, while fish were a substantial part of the Northern Paiute diet (Liljeblad and Fowler 1986, Murphy and Murphy 1986, Shimkin 1986).

The aboriginal groups of the low desert, such as the Ute, Southern Paiute, Kawaiisu, Owens Valley Paiute, and Panamint, exhibited seasonal migration by traveling into the deserts and valleys in the winter and mountains in the summer. With the introduction of horses, these groups ranged onto the Plains, and adopted a Plains pattern, such as buffalo hunting and use of long-pole tepees (Conetah 1982, Janestki 1991, Kehoe 1992).

Plants utilized within the low desert region included berries, roots of sego and bullrush, some cacti, pinyon, and mesquite beans. Low desert tribes also hunted large and small animals (Kelly 1964, 1976; Kelly and Fowler 1986; Kroeber 1976). Plant materials used to make cordage included sagebrush bark, juniper bark, dogbane, yucca, and nettle. Tule reeds have multiple uses, in such items as balsa rafts, mats, and blankets (Callaway et al. 1986). Present day Moapa Paiutes still use desert fan palms for making baskets, food, and shelter (Moapa Memories 2002). Jimson weed, tobacco, nettle, and red ants are some of the traditional medicines used by Native groups in this region (Zigmond 1986).

Plateau

Because of the arid climate during the period from 12,500 to 8,000 BP, resources in this culture area were concentrated along the margins of rivers and major tributaries. Archaeological sites dating to this period include caves, rock shelters, and open camps. The low frequency of early sites is generally attributed to the low population densities of the highly mobile hunter-gatherers who occupied the Plateau. Stemmed and unstemmed lanceolate projectile points, microblades, cobble tools, scrapers, gravers, and bifaces are common artifacts associated with the period. Although groups engaged in fishing, intensive utilization of riverine resources did not occur until later, when climatic conditions stabilized (Ames et al. 1998; Ames and Maschner 1999).

A gradual increase in moisture from 8,000 to 4,000 BP helped expand the range of sagebrush steppe and stimulate the productivity of root crops across the region. Human groups continued to practice highly mobile subsistence strategies with an increasing reliance on salmon (Chatters and Pokotylo 1998). Other than the addition of large side-notched points and a decrease in the overall size of projectile points, evidence of atlatl use, the tool kit is similar to that of the preceding period. The appearance of individual or small numbers of pit houses along major drainages signified the rise of semi-sedentary settlement strategies, and hopper mortars and milling stones provide evidence for the increased importance of roots and other plant resources in the diet. Other site types include large open sites lacking evidence of habitations, caves, short-term camps, resource extraction sites, and resource processing sites, generally located farther from the major drainages (Ames et al. 1998).

A cooling climate around 4,000 BP helped to stabilize salmon productivity by restricting the seasonality of the salmon migrations (Butler and Schalk 1986). In response, inhabitants of the Plateau intensified their use of salmon, storing it for year-round consumption, and structuring their subsistence strategies to coincide with seasonal salmon migrations. Semi-permanent villages of various-sized pit houses, and longhouses appearing about 1,500 BP, were located mainly along rivers and major tributaries and occupied during the winter months; some of the habitations were eventually used for human burials. Camps positioned at strategic resource locales in the uplands and mountains were used on a seasonal basis. Cave sites produce well-preserved wood and fiber artifacts. The adoption of the bow and arrow; specialized fishing technologies including nets, harpoons, and barbed bone points; and the continued presence of grinding and pounding tools are evidence of increasingly complicated subsistence strategies (Ames et al. 1998). Petroglyphs and pictographs, dating as early as 3,500 BP, are most common near the larger settlements on major rivers (Boreson 1998).

The hallmark of northern and southern Plateau cultures is still salmon fishing. For many Plateau groups, plant resources also constitute a large portion of the diet. Significant plant resources utilized by these groups include root crops of camas, bitterroot, lomatium, balsamroot, and yellowbells, and various berries. These plant resources have not only provided food, but have also been used for such functions as shelter, clothing, basketry, and medicine. Some Plateau groups traditionally burned habitats to enhance the production of usable plant material, including berries (Chatters 1998, Ross 1998).

In the southern Plateau, traditional dwellings were semi-subterranean and constructed from wood and large mats made of tule bulrushes or cattail reeds, sewn together with Indian hemp (Schuster 1998). The main firewoods of the region are Douglas-fir and ponderosa pine, with alder wood preferred for cooking or smoking salmon. Douglas-fir saplings have been used for fish net poles, greasewood twigs for sewing needles, Indian hemp for fishing nets and other weaving purposes, and cattail leaves for weaving bags. Rose wood has been used in cradleboards, and has been hung in homes to repel ghosts. Medicinal and religious plants include mullein, willow bark, and tobacco (Hunn 1990, Hunn and French 1998).

In the northern Plateau, tule reeds and cedar bark were used for covering structures, and tule was also used for matting, bedding, and to shroud corpses. Sources of baskets and bags include birch bark, cedar bark, cedar and spruce roots, and Indian hemp (for cordage). Underground storage casks were made from cottonwood bark, canoes were made from white pine bark, snowshoe frames were made from maple boughs, and mats used to dry salmon were made from willow shoots. Sources of dye include huckleberries and the inner bark of Oregongrape, and sunflower root was used to make shampoo (Kennedy and Bouchard 1998, Miller 1998).

California

The Lake Mojave sites, dating to over 10,000 BP, represent some of the oldest archaeological materials in this culture area. These sites include evidence of big game hunting and gradual expansion into the use of plant resources. Open camp and processing sites suggest that there were few early occupants of the region who maintained a highly mobile subsistence strategy. Artifacts include large, fluted projectile points, leaf-shaped points, shouldered points, chipped stone crescents, scrapers, knives, and choppers (Wallace 1978).

Between 8,000 and 7,000 BP, an arid environment caused lakes and marshes to dry, forcing people to adapt to new environments (Moratto 1984). Based on the presence of milling stones, a shift from big game hunting to plant and seed collecting occurred between 8,000 and 5,000 BP. Artifact assemblages are surprisingly homogeneous, consisting mostly of heavy, deep-basined milling and hand stones, with occasional projectile points that were likely used with atlatls (Wallace 1978).

About 5,000 BP, transition began toward a more diversified subsistence economy that included the exploitation of marine and terrestrial resources. Inland sites show evidence of intensive plant processing indicated by the presence of mortars and pestles. Archaeological and climatic evidence from the last 2,000 years indicates that subsistence and settlement patterns in California remained quite stable. Coastal groups relied on marine resources; northern groups relied on riverine resources, especially salmon; central and southern groups relied on lake and marsh resources; and groups throughout the state relied on deer and acorns. The presence of bedrock mortars in the Sierra Nevada foothills indicates continuous use of the same areas. There is also evidence that widespread burning of forests was conducted to stimulate plant growth and provide forage for deer, a universal food source (Bendix 2002, Driver and Massey 1957, Lewis 1973). The earliest petroglyphs appear to correlate with similar ones from the Great Basin dating 3,000 BP, while very elaborate, perhaps ceremonial, pictographs are thought to be no more than 1,000 years old (Clelow 1978).

Coastal groups have long exploited coastal marine and inland oak forest resources, where they collect acorns and hunt large and small game. A variety of plants provide building materials, basketry materials, clothing, and medicine. The redwood tree was used to construct permanent dwellings and large canoes, as well as clothing made from its bark. Juniper and tule were also used to make shelters. Tule reeds are used in basketry (in addition to numerous other plants), boats, clothing, and matting. Materials used to make dyes include green oak galls, burned pepperwood berries, tan oak bark, and alder bark. Medicinal plants include tobacco, angelica, and pepperwood leaf (Loeb 1926, Maxwell 1978).

In the valleys between the Sierra Nevada and coastal ranges, riparian corridors and foothills rich in oak groves provide acorns, a staple diet of many California tribes. Migrating salmon are an important food source, as are berries, bulbs, tubers, and roots. Native groups of the Central Valley and Sierra region hunted waterfowl using snares, nets, arrows, and decoys. Tule growing in wetlands has been an important component of baskets, matting, dwellings, and watercraft. Plants used for cordage and rope include milkweed, Indian hemp, dogbane, and inner willow bark. Medicinal plants include tobacco and horehound (Levy 1978, Wallace 1978).

In the desert region of southeast California, important tribal resources included fish, shellfish, deer, rabbit, rodents, and insects. Additional dietary staples, still used, include wild grass, mescal, pinyon seeds and nuts, and mesquite beans, which are ground into flour and made into cakes (Barrows 1900, Kelly 1964, Kroeber 1976).

In the desert region, dwellings were constructed from a wide variety of plants, including juniper, manzanita, greasewood, mountain oak, and mesquite, with tule, carrizo, ferns, bark, or reeds often used for thatching. Plants used for basketry include tule, sumac, squawbrush, and a variety of rushes and grasses. Yucca and mescal have been used for cordage. A number of plants were used for clothing and sandals, including the inner bark of willow and cottonwood trees, mescal and yucca fibers, and mesquite bark. Creosote bush and milkweed were used as adhesives, and yucca root has been used to make soap. Among the wide variety of medicinal plants are tobacco, jimson weed, wormwood, creosote, and sumac (Bean and Saubel 1972).

Plains

Human occupation of this culture area dates to at least 11,500 BP. Highly mobile hunters occupied sites on a short-term basis or repeatedly over varying lengths of time. These sites, which were frequently located near water sources, often include finely manufactured fluted, stemmed, or lanceolate points in association with skeletons of extinct game species.

Bison hunting has played a significant role in the subsistence economy of Plains groups throughout prehistory. Additional utilized fauna included elk, mountain sheep, deer, antelope, bear, and various small mammals, as well as fish, freshwater mussels, reptiles, and amphibians. Archaeological evidence indicates that roots, bulbs, berries, fruits, and seeds were collected and often processed using a variety of grinding stones (Frison 2001, Vehik 2001).

Typical artifacts of the period from 8,000 to 2,000 BP include medium-sized lanceolate to large, side-notched projectile points, corner-notched dart points, hide scrapers, milling or grinding stones, coiled basketry, and pottery. Although open campsites (often with fire pits), cave or rockshelter sites, and bison kill and processing sites are the most common sites, burials, as well as sites containing housepits and/or food cache pits are also documented throughout this period. In addition, the use of tepees, based on the presence of stone circles at cultural resources sites, is evident (Frison 2001, Vehik 2001).

Petroglyphs and pictographs (rock art) date from this period (2,000 to 250 BP), occurring on rock outcrops in the northern and northwestern Plains and southeastern Colorado (Frison 2001, Gunnerson 2001). With the appearance of the bow and arrow in the northwestern Plains about 1,900 BP, hunting became more efficient. The use of teepees by the more nomadic western and northwestern Plains dwellers became very common throughout the period, to the point where some multiple stone circle sites are labeled villages (Frison 2001). By 1,500 BP, farming of maize, beans, squash, and sunflowers was established in the eastern Plains and spread to sedentary groups living in earth lodge villages along the Missouri River (Maxwell 1978; Kehoe 1992; Wedel 1961, 1983; Wedel and Frison 2001; Wood 2001).

At the time of European contact, plants used for subsistence by Plains groups included prairie turnip, groundnut, ground bean, sunflower, Jerusalem artichoke, serviceberries, mesquite beans, cacti, camas, and grass seeds. Maize, beans, and squash were also cultivated (Maxwell 1978, Wedel 1983, Wedel and Frison 2001). Following the introduction of horses by the Spanish in the 16th century, subsistence patterns of many Plains groups shifted from sedentary, part-time farming and hunting to mounted hunting heavily focused on the migratory herds of bison. During the 1700s, pressure from the Europeans generated movements of woodland groups, such as the Sioux, onto the Plains. By the late 1700s, the dependence on plants for subsistence by these groups waned (Maxwell 1978).

Plains groups have used plants for a variety of purposes, in addition to subsistence. Tobacco has been used in religious ceremonies. Cottonwood and willow were used to provide fuel and building materials, and willow has been used for boat frames. Oak, elm, and huckleberry are also high quality building materials, and poles made from pine have been used for teepee frames. Willow, box elder bark, and nettles have been used to make baskets, which are often colored with a black dye derived from walnuts. Medicinal plants of the plains include mescal beans and sweetgrass. Bowls were made from box elder, and bows from cedar, ash, and hickory. Sage was used to help whiten hides (Brown and Irwin 2001, Voget 2001, Wedel and Frison 2001, Wood and Irwin 2001).

European Settlement Resources

Euro-American contacts with the western U.S and Alaska generally began with exploration or trading, with missionary activities soon following in some of the areas. The earliest exploration occurred in the Southwest and in California in the 1500s, with settlements by the military, missionaries, and colonists in the 1600s in the Southwest, and in the later 1700s in California. In the late 1700s, Spanish, Russian, British, and American exploration and trade extended up and down the West Coast of North America. By the late 1700s and early 1800s, explorers such as Lewis and Clark and fur traders traversed the interior of what is now the western U.S. Table 3-11 shows the types of resources typically present in the Cultural Areas.

The discovery and the promise of precious metals first inspired conquest of Native People through treaty and force, then created the market for the development of agriculture, timber, and fisheries, and finally motivated the construction of a transportation system sufficient to transport people and goods. Although furs and precious metals drew the first adventurers, a more permanent settlement of the West in the late 19^{th} and early 20^{th} centuries was related to agriculture. In most of the arid regions of the West agriculture primarily consisted of ranching. During this time, the Homestead Act and other similar programs transferred most of the irrigable land to private ownership and the adjacent public land was used for grazing livestock by the ranchers who had either homesteaded or purchased those private lands. Beginning about the turn of the 20^{th} century, the federal government reserved tracts of land in the West for management by agencies such as the Forest Service and National Park Service, and, after its formation in the middle of the century, by the BLM. However, no lands were withdrawn from public domain to form these public lands.

The history of the rural western U.S. encompasses several broad themes and periods including exploration, discovery of the region's mineral wealth, conflict, and settlement, and includes the growth of communities dependent upon resource extraction—farming, ranching, logging, fishing, and mining. These communities were in turn linked to local, regional, and national markets through a complex and evolving system of trails, military roads, wagon roads, rail lines, and navigable river corridors, a trend that continues into the modern period. By the mid-20th century, with the region secured and transportation assured, recreation and tourism increasingly comprised the economic base of western communities and military training use escalated in response to the training needs of the modern military.

Public lands in the West contain cultural resources representing all major periods and events in the broad sweep of western history. The most common rural manifestations of these dominant themes include transportation resources such as ferry sites, railroads, trails, and roads; military sites (training grounds and battlefields); and mining resources related to exploration (prospect pits), extraction (adits, hydraulic cuts, and quarries), and processing (smelters and mills). Other resources include homesteading, ranching and farming resources (human and animal shelter and irrigation development); fishery resources (boats, fish traps, and weirs); and logging resources (stumpage, sawmills, and human and animal shelter). Evidence of community development includes rural schools, stores, churches, and community centers. Recreation and leisure sites include cabins, resorts, and trail systems.

Important Plant Uses and Species Used by American Indians and Alaska Natives

Although universally important, plant use by Native American and Alaska Native groups is extremely varied, both by region and by group. Subsistence use of such plant products as roots and tubers, stalks, leaves, berries, and nuts is essential to native people. Vegetation also provides habitat for important wildlife species.

Most Native American and Alaska Native groups constructed a variety of residential shelters and other buildings such as ceremonial lodges and sweat houses using a combination of materials, usually employing a locally derived hardwood as part of the structural frame. The frames were then covered with other readily available materials, such as planks, mats, brush, and other materials. Wood has been burned to cook food, warm dwellings, and facilitate toolmaking. Trees have been fashioned into various types of watercraft and terrestrial hauling devices.

The use of plants for medicinal purposes is widespread, as is the use of tobacco. Plants such as tobacco sweet grass, cedar, and sage, have seen important religious and other ceremonial uses. The use of grasses and other plant resources for basket, box, and tool making also can be observed in the cultures of numerous Native American and Alaska Native groups. Plant products

TABLE 3-11
European Settlement Resource Types

Site Type	Examples	Culture Region
Transportation		
River navigation	Fords, cable ferries, and shipwrecks	All
Overland navigation (both railroad and non-railroad)	Trails, wagon roads, truck trails (public and private), engineered features (bridges, trestles, ballast, track, and ties), and construction camps	All
Exploration and Overland Migration		
Trails (most often at topographic restrictions, such as canyons)	Trail ruts (rock) and trail ruts (earth)	All
Geological landmarks with cultural and historical value	Rock promontories, springs, passes, and meadows	All
Inscriptions	Petroglyphs (chiseled inscriptions), pictographs, and carvings on trees	All
Missions	Schools, churches, agricultural plots, orchards, and housing	All
Military		
Battlefields (Indian wars)	Not applicable	All except Alaska
Training grounds	World War I, World War II, Korean War, and Cold War eras	Great Basin and Plateau
Transportation routes	Trails and wagon roads	All
Agriculture		
Ranching and farming	Home ranch facilities (including foundations), outlying buildings and structures, cultural landscape elements (including fences, stock ponds, dams, stock trails, and river fords), irrigation structures, and archaeological sites	All (except arid, unirrigatable sections of the Great Basin, Plateau, and Desert Southwest)
Commerce/Urban Development		
Urban settlement	Civic, commercial, and domestic	All
Mining		
Resources associated with extraction	Resources associated with prospecting (locating ore) and development (accessing and removing ore), resources associated with placer mining (sluicing), and lode mining (adits, waste rock, and interior tramways)	All
Resources associated with beneficiation and refining	Mills (various types), smelters, tailing piles, tailing ponds, power plants, and refineries	All
Support facilities	Bunkhouses, mess halls, livestock shelters, and trash dumps	All
Transportation systems	Trails, two-track roads, truck trails, rail lines, and construction debris	All
Logging		
Extraction	Stumps, skid lines, and sky-line cables	All
Processing	Lumber mills and power plants	All
Support facilities	Shingle camps, logging camps, and livestock facilities	All
Transportation	Roads, donkey engines, big wheels, rail lines, and flumes	All
Fisheries		
Extraction (except processing-related and support facilities)	Weirs, fish traps, natural features (falls, eddies), and boats	All
BLM Administration and Development		
Administrative facilities	Buildings (administrative, maintenance, and warehouse) and livestock facilities	All
Interpretation	Museums and interpretive signs	All
Recreation (pre-1934)	Camp sites, developed natural features, summer homes, interpretive signs, roads, and trails	All
Recreation (post-1934)	Campground, developed water source, and roads and trails	All

also have been used to make textiles, cordage, and matting, as well as to tan hides. The use of plant dyes, paints, and soaps is widespread.

Visual Resources

The public lands administered by the BLM contain many outstanding scenic landscapes. Visual resources in these landscapes consist of land, water, vegetation, wildlife, and other natural or manmade features visible on public lands. Vast areas of grassland, shrubland, canyonland and mountain ranges on public lands provide scenic views to recreationists, visitors, adjacent landowners, and those just passing through. Roads, rivers, and trails on public lands pass through a variety of characteristic landscapes where natural attractions can be seen and where cultural modifications exist. Activities occurring on these lands, such as recreation, mining, timber harvesting, grazing, or road development, for example, have the potential to disturb the surface of the landscape and impact scenic values.

Public lands have a variety of visual (scenic) values which warrant different levels of management. The BLM uses a system called VRM (Manual 8400) to systematically identify and evaluate these values to determine the appropriate level of scenery management (USDI BLM 1984b). The VRM process involves 1) identifying scenic values, 2) establishing management objectives for those values through the land use planning process, and 3) then designing and evaluating proposed activities to analyze effects and develop mitigations to meet the established VRM objectives.

The BLM Visual Resource Inventory Handbook (Handbook 8410-1; USDI BLM 1986b) sets forth the procedures for inventorying scenic values and establishing VRM objectives, referred to as Management Classes. A visual resource inventory is informational in nature and does not set forth management direction. A visual resource inventory is based on an analysis of three primary criteria influencing visual values: 1) inherent scenic quality, 2) public sensitivity to landscape change, and 3) distance zones from primary travel ways or special areas. These three criteria are ranked for all acres of public land and a final VRM inventory rating is identified.

These ratings are then used during the land use planning process and considered along with other resource objectives to determine final VRM objectives, or classes. BLM policy requires that every acre of BLM land be inventoried and assigned a VRM class ranging from Class I to Class IV. After VRM classes have been established, Bureau policy requires all management activities be designed to meet the assigned classes. Class IV allows for the most visual change to the existing landscape, while Class I allows the least (Table 3-12).

The Visual Contrast Rating Handbook (Handbook 8431-1; USDI BLM 1986c) is used to provide an objective and consistent method for describing landscape character, evaluating visual effects of activities, and developing mitigations to meet VRM objectives. The contrast rating process involves describing the landscape in the context of the basic environmental design elements and features which comprise it. The elements of form, line, color, and texture are used a common language in describing and evaluating landscapes in order to minimize their potential contrast with the natural landscape. Activities or modifications in a landscape which repeat these elements are thought to be in harmony with their surroundings. Modifications which do not harmonize are said to be in contrast with their surroundings. Visual resource design techniques and best management practices (BMPs) are then used in project development to minimize contrast in order to meet the VRM Class objectives established in the LUP.

Wilderness and Special Areas

The BLM manages certain lands under its jurisdiction that possess unique and important historical, anthropological, ecological, biological, geological, and paleontological features. These features include undisturbed wilderness tracts, critical habitat, natural environments, open spaces, scenic landscapes, historic locations, cultural landmarks, and paleontologically rich regions. Special management is administered with the intent to preserve, protect, and evaluate these significant components of our national heritage. Most special areas are either designated by an Act of Congress or by Presidential Proclamation, or are created under BLM administrative procedures.

The National Landscape Conservation System is the primary management framework for these specially designated lands. The NLCS was created in June 2000 by the BLM to bring into a single system some of the agency's premier areas. Of the 262 million acres administered by the BLM, over 43 million acres on 867 BLM units are managed under the NLCS program (Map 3-12 and Table 3-13). The NLCS designations include National Monuments, National Conservation Areas, Designated Wilderness and WSAs, National Scenic and Historic Trails, and Wild, Scenic, and Recreational Rivers, and (USDI BLM 2005c).

Fourteen of the 15 BLM-administered National Monuments are areas designated by the President, under the authority of the Antiquities Act of 1906, for the protection of objects of scientific and historical interest that are located on federal lands. Congress has also created a BLM National Monument to conserve, protect, enhance and manage public lands. National Conservation Areas, Cooperative Management and Protections Areas, Outstanding Natural Areas, National Recreation Areas, and Forest Reserves are designated by Congress to conserve, protect, enhance, and manage public land areas for the benefit and enjoyment of present and future generations. These 13 areas, totaling 14 million acres, feature exceptional natural, recreational, cultural, wildlife, aquatic, archeological, paleontological, historical, educational, and scientific resources. Additionally, the White Mountains National Recreation Area in Alaska is approximately 1 million acres and was designated by the Alaska National Interest Lands Conservation Act of 1980. The White Mountains National Recreation Area is managed for multiple uses with an emphasis on recreational uses (USDI BLM 2005c).

National Wilderness Areas, designated by Congress, are defined by the Wilderness Act of 1964 as places "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Designation is aimed at ensuring that these lands are preserved and protected in their natural condition. Wilderness Areas, which are generally 5,000 acres or more in size, offer outstanding opportunities for solitude or a primitive and unconfined type of recreation; such areas may also contain ecological, geological, or other features that have scientific, scenic, or historical value. The BLM manages 161 Wilderness Areas encompassing 6.5 million acres (USDI BLM 2005c).

Wilderness Study Areas have been designated by the BLM as having wilderness characteristics, thus making them worthy of consideration by Congress for wilderness designation. Currently, the BLM manages 624 WSAs encompassing 15.6 million acres. While Congress considers whether to designate a WSA as permanent wilderness, the BLM manages the area in a manner so as to prevent impairment of the area's suitability for wilderness designation.

National WSR are rivers (or river sections) designated by Congress or the Secretary of the Interior, under the authority of the Wild and Scenic Rivers Act (WSRA) of 1968, to protect remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values and to preserve the river in its free-flowing condition. The law recognizes three classes of rivers—wild, scenic, and recreational. Wild rivers are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and water unpolluted. Scenic rivers are free of impoundments with shorelines or watersheds largely undeveloped, but accessible in places by roads. Recreational rivers are readily accessible by road or railroad, may have some development along their shoreline, and/or may have undergone some impoundment or diversion in the past. The BLM manages all or portions of 38 rivers totaling 2,061 miles as part of the National WSR System (USDI BLM 2005c).

Congress, under the National Trails System Act of 1968, designates areas as National Scenic and Historic Trails. National Scenic Trails offer maximum outdoor recreation potential and provide enjoyment of the various qualities (scenic, historical, natural, and cultural) of the areas through which these trails pass. National Historic Trails are extended trails that follow as closely as possible, on federal land, the original trails or routes of travel with national historical significance. Designation identifies and protects historic routes and their historic remnants and artifacts for public use and enjoyment. A designated trail must meet certain criteria, including having a significant potential for public recreational use or interest based on historical interpretation and appreciation.

The NLCS differs from the National Park System and the National Wildlife Refuge System in several ways. Visitor facilities are often located in adjacent communities, providing local economic opportunities and minimizing new development in the special areas. Traditional land uses, such as livestock grazing, are often permitted in these areas, and the local communities and interested public are encouraged to participate in the planning and management of them. Other special areas managed by the BLM outside of the NLCS framework include Areas of Critical Environmental Concern, Research Natural Areas, National Natural Landmarks, National Recreation Trails, and a variety of other area designations.

TABLE 3-12
Visual Resource Management (VRM) Classes and Objectives and Appropriate Management Activities

VRM CLASS	Visual Resource Objective	Change Allowed (Relative Level)	Relationship to the Casual Observer
Class I	Preserve the existing character of the landscape. Manage for natural ecological changes.	Very Low	Activities should not be visible and must not attract attention.
Class II	Retain the existing character of the landscape.	Low	Activities may be visible, but should not attract attention.
Class III	Partially retain the existing character of the landscape.	Moderate	Activities may attract attention but should not dominate the view.
Class IV	Provide for management activities which require major modification of the existing character of the landscape.	High	Activities may attract attention, may dominate the view, but are still mitigated.

The BLM uses the ACEC designation to highlight public land areas where special management attention is necessary to protect and prevent irreparable damage to important historical, cultural, and scenic values; fish or wildlife resources; or other natural systems or processes.

The ACEC designation may also be used to protect human life and safety from natural hazards. The BLM identifies, evaluates, and designates ACECs through its resource management planning process. Allowable management practices and uses, mitigation, and use limitations, if any, are described in the planning document.

Under current guidelines, ACEC procedures also are used to designate Research Natural Areas, Outstanding Natural Areas, and other natural areas requiring special management attention. The National Natural Landmarks Program recognizes and encourages the conservation of outstanding examples of natural history. National Natural Landmarks are designated by the Secretary of the Interior and are the best examples of biological and geological features in both public and private ownership within the U.S. The Recreational Trails Program provides funds to the states to develop and maintain recreational trails and trail-related facilities for both non-motorized and motorized recreational trail uses.

Among these groups, 903 areas comprising nearly 13 million acres are designated as ACEC; 45 areas comprising over 417,000 acres are designated as National Natural Landmarks; and 164 areas comprising over 323,000 acres are designated as Research Natural Areas. An additional 30 million acres fall under various other designations, such as the Lake Todatonten Special Management Area, the Santa Rosa Mountains National Scenic Area, HMAs, and Globally Important Bird Areas. In addition, there are over 2,950 miles of vehicle routes and trails designated as National Backcountry Byways and National Recreation Trails (USDI BLM 2005c, d).

The BLM also cooperates with the National Park Service in implementing the National Natural Landmark Program as it applies to public lands. The National Park Service, through the National Natural Landmark Program, designates significant examples of the Nation's ecological and geological heritage.

Recreation

Public lands provide visitors with a wide range of recreational opportunities, including hunting, fishing, camping, hiking, dog mushing, cross-country skiing, boating, hang gliding, OHV driving, mountain biking, birding, viewing scenery, and visiting natural and cultural heritage sites. In addition to the recreational opportunities afforded the public by wilderness and other special areas discussed earlier, the BLM administers 205,498 miles of fishable streams, 2.2 million acres of lakes and reservoirs, 6,600 miles of floatable rivers, over 500 boating access points, 300 Watchable Wildlife sites, 55 National Back Country Byways, 5,500 miles of National Scenic, Historic, and Recreational Trails, and thousands of miles of multiple use trails used by motorcyclists, hikers, equestrians, and mountain bikers (USDI BLM 2005c).

The BLM's long-term goal is to provide opportunities to the public for environmentally responsible recreation. Over 4,000 communities with a combined population of 23 million people are located within 25 mi of public lands, and approximately 40 percent of public lands are located within a day's drive of a major urban area (USDI BLM 2005c).

TABLE 3-13
National Landscape Conservation System and Other Special Designation Areas on Public Lands

State	National Landscape Conservation System Area														Non-NLCS Area	
	Outstanding Natural Areas, Forest Reserve Cooperative Management and Protection Areas, and National Recreation Areas		National Monuments		National Conservation Areas		Wilderness Areas		Wilderness Study Areas		Wild, Scenic, and Recreational Rivers		National, Historic, and Scenic Trails		Area of Critical Environmental Concern	
	# of Sites	Acres	# of Sites	Acres	# of Sites[1]	Acres[2]	# of Sites[1]	Acres	# of Sites[1]	Acres	# of Sites	Acres/Miles	# of Sites[1]	Mi[2]	# of Sites	Acres
Alaska	1	998,772	-	-	1	1,208,624	-	-	1	784,238	6	609,280/952	1	418	41	4,545,920
Arizona			5	1,75,007	3	112,542	44	1,396,466	2	63,930	-	-	2	1,003	50	638,110
California	1	7,400	3	291,390	3	10,728,368	76	3,577,778	77	974,769	6	24,800/78	4	1,622	143	1,664,108
Colorado			1	163,892	2	185,144	4	139,524	54	621,737	-	-	-	-	66	621,589
Idaho			1	273,847	1	484,034	1	802	66	1,341,709	-	-	5	1,457	93	563,107
Montana			2	375,027	-	-	1	6,000	40	450,823	1	89,300/149	3	-	43	248,576
Nebraska			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nevada			-	-	3	1,043,422	24	990,319	85	3,822,421	-	-	3	697	36	1,358,234
New Mexico			1	4,114	1	339,100	3	139,281	60	970,532	2	22,720/71	3	60	151	595,001
North Dakota			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oklahoma			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oregon	2	428,156	1	52,947	-	-	4	186,723	97	2,701,190	23	259,522/811	3	-	190	746,278
South Dakota			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Texas			-	-	-	-	-	-	-	-	-	-	1	-	-	-
Utah			1	1,870,800	1	-	3	27,720	99	3,255,490	-	-	3	-	59	1,267,389
Washington			-	-	-	-	1	7,140	1	5,518	-	-	-	-	-	-
Wyoming			-	-	-	-	-	-	42	575,841	-	-	6	213	38	696,894
Total	4	1,434,358	15	4,807,024	13	14,101,234	161	6,471,753	624	15,568,198	38	1,005,652/2,061	12	5,470	903	12,945,445

[1] Figures in the number column do not add up to the total shown at the bottom since areas may cross state lines and are reported in the count for each state.
[2] Acreages/miles for multi-state sites are provided only for the state in which the majority of site is located.
Source: BLM Public Land Statistics (USDI BLM 2005d).

Most BLM lands are managed as Extensive Recreation Management Areas (ERMAs), where management consists primarily of providing basic information and access. Dispersed recreation occurs in ERMAs and visitors have the freedom of recreational choice with minimal regulatory constraints. Significant public recreation issues or management concerns are limited in these areas, and nominal management suffices.

Special Recreation Management Areas (SRMAs) are places where special or intensive recreation management is needed. SRMAs include congressionally recognized areas, such as WSR, parts of the National Trail System, National Recreation Areas, and Wilderness Areas. In addition, administratively recognized areas where issues or management concerns may require special or intensive management are also designated. Areas where visitor use may cause user conflicts, visitor safety problems, or resource damage are also included. These more intensively used areas require direct supervision of recreational activities and of commercial and BLM-regulated recreation operations. Most SRMAs require selective vegetation treatment where hazardous trees and vegetation occur and replanting of vegetation in highly disturbed areas to maintain their appearance and to protect visitors from hazards and/or the adverse effects of plants.

BLM field offices reported 54 million recreational visits to BLM public lands and waters in FY 2004, an increase of 2% from the previous year. The total amount of time spent on public lands, reported as visitor days, was estimated at 69.9 million visitor days, up 5% from the previous year (Table 3-14; USDI BLM 2005d). The greatest number of visitor days occurred in Arizona and California. Overall, developed recreational sites were used about as frequently as non-developed dispersed areas. Recreational use of public lands consists predominately of camping and picnicking, which represented 43% of all visitor days in 2004. Other important recreational activities include non-motorized travel, such as hiking, horseback riding, and mountain biking (10%); off-highway travel (9%); viewing public land resources and interpretation and education (9%); and hunting (7%). The remaining visitor days were associated with driving for pleasure, special events, sports and activities, power and non-power boating, fishing, and swimming. Snow- and ice-based activities, such as cross-country skiing, snowmobiling, and snowshoeing, represented less than 1% of visitor days (USDI BLM 2005c).

Commercial revenues generated by recreation on BLM lands are discussed in the *Social and Economic Values* section.

Rights-of-way

Under FLPMA and the Mineral Leasing Act provisions, the BLM issues ROW grants to authorize the construction, operation, and maintenance of a wide range of projects on public lands. These include petroleum pipelines, electrical transmission lines, telecommunications lines, energy development and distribution facilities, water facilities, communication sites, and roads. Rights-of way for roads, trails, and other infrastructure needs are appropriated for use by the BLM and other federal agencies (e.g., Forest Service, Federal Highway Administration, and Bonneville Power Administration) under Section 507 of FLPMA.

TABLE 3-14
Estimated Recreation Use of Public Lands during Fiscal Year 2004

State	Number of Visitor Days[1] (thousands)		
	Recreation Sites	Dispersed Areas	Total[2]
Alaska	253	908	1,161
Arizona	9,034	1,677	16,562
California	7,515	8,974	16,533
Colorado	1,313	2,687	4,120
Idaho	1,177	3,588	4,705
Montana, North Dakota, and South Dakota	790	2,057	2,854
Nevada	805	4,823	5,629
New Mexico, Oklahoma, and Texas	535	1,229	1,765
Oregon and Washington	1,976	4,247	6,258
Utah	1,818	6,260	8,531
Wyoming and Nebraska	569	1,172	1,744
Total	25,788	37,540	69,866

[1] One visitor day equals 12 visitor hours.
[2] Includes visitor days for recreation lease sites and recreation partnership sites.
Source: BLM Public Land Statistics (USDI BLM 2005c).

In 2004, there were over 89,000 ROWs on public lands, and the BLM processes approximately 4,000 new applications each year. Energy-related applications comprise about 60% of new applications (USDI BLM

2005d). Demand for ROWs on public lands is expected to increase substantially during the next decade due to energy needs, changes in the utility industry, and increased urbanization.

The length and width of a ROW (and resulting acreage of public lands) is dependant on a variety of physical and operational factors, including topography, geology, safety, type of use or uses proposed within the ROW, current technology, and access needs. Rights-of-way may also be subject to controls or limitations prescribed by law or identified within BLM land use plans. The BLM encourages the utilization of ROWs in common where practical in order to minimize adverse environmental impacts. The BLM land use plans identify ROW corridors for existing and future ROW development.

Rights-of-way are issued for short term use of public lands or in perpetuity. Rights-of-way grants generally include provisions which authorize the holder to manage vegetation within and adjacent to the ROW using methods approved by the BLM. The scope and intensity of vegetation management treatments within ROWs are operationally specific and highly variable. Inspections are conducted at periodic intervals to assess vegetation treatment needs within the ROW. Vegetation is usually removed or maintained low to the ground in ROWs. Vegetation can interfere with site access by users of the ROW and ROW facility maintenance, interfere with electric power flow, and pose safety problems for workers and other users of ROWs. The development and maintenance of ROWs has significant impacts on vegetation. The removal of the existing vegetation during construction activities results in increases in bare ground that can facilitate the introduction and spread of nonnative and invasive plant species. The relatively open nature of ROWs makes them attractive to many recreationists, including OHV enthusiasts, horseback riders, and hikers. However these activities can also facilitate the spread of invasive species present on those ROWs.

Social and Economic Values

Social/Demographic Environment

The western U.S., including Alaska, is more sparsely populated than the rest of the U.S., containing about 32% of the total U.S. population, but comprising approximately 65% of the total land area. In 2000, over 89 million people lived in this region, with over 50 million in California and Texas, alone (Table 3-15). Population density is relatively low, averaging about 40 people per mi^2, which is half of the national average of nearly 80 people per mi^2. Density ranges from about 1 person per mi^2 in Alaska to over 217 in California. Based on 2000 census data, population growth between 1990 and 2000 averaged over 16%, which was slightly higher than the national average. Many of the western states, however, exceeded the national average with growth rates of 20% or higher during this time period.

Within regions of the western states, mobility patterns of the population were evident. Population declined in rural areas with population increases in urban areas. Growth of the western states during this time occurred predominantly in WUI areas, due to expansion of urban population areas into previously rural areas.

The western U.S. contains a large percentage of the nation's minority populations, including over 60% of the nation's Hispanics and American Indians, and over 50% of the nation's Asian/Pacific Islanders. In particular, Arizona, California, New Mexico, and Texas contain large Hispanic populations, which comprise from 25% to over 40% of the total population in each of these states. Over 15% of Alaska's population is comprised of American Indians.

The age distribution of the population of the western U.S. is similar to that nationwide. Approximately 27% of the population is under 18 years of age, while about 11% is over 65. Alaska and Utah are slight exceptions, with a higher percentage of people under 18 (over 30%) and a lower percentage of people over 65 (5% and 8%, respectively).

Economic Environment

Employment

Between 1990 and 2000, employment growth in the western U.S. averaged 21%, which slightly exceeded the national average of about 18%. Nevada and Arizona had the most employment growth overall (60% and 42%, respectively) while California and Alaska had below-average employment growth of less than 15%. Most employment growth during this time occurred in the management, professional, and related occupations (26%) and in the service sector (15%), while negligible growth occurred in the manufacturing sector.

In July 2005, the nationwide unemployment rate was 5% (Table 3-16). Unemployment rates in the western U.S. exceeded the national average, with the greatest unemployment in Alaska (6.6%), Oregon (6.6%), and

New Mexico (6.0%). The unemployment rate was lowest in North Dakota (3.5%; U.S. Department of Labor Bureau of Labor Statistics 2005). Unemployment rates were generally higher for African Americans and Hispanics than other races.

Over 23% of the nation's employment opportunities, amounting to over 40 million jobs, are located in the western U.S. (Table 3-17). Employment in the trade and services industries accounts for over half of the total jobs. Industries related to natural resources, such as agriculture and mining, are important sources of employment and represent nearly one third of the nation's agricultural services, forestry, and fishing jobs. Employment in the government and military sector is higher in Alaska than in other states, accounting for 27% of total jobs versus about 17% overall in the western U.S.

Income

In 2000, the per capita income in the western U.S. was $20,215, which was similar to the national average of $21,690. Per capita income was greatest in Colorado, Washington, Alaska, and California, and lowest in Montana, Idaho, and Utah. In 1999, approximately 12% of the population of the western U.S. lived below the poverty level, which was consistent with the national average. The highest poverty rates occurred in Montana, California, and Arizona, while the lowest rates occurred in Alaska, Colorado, and Utah (U.S. Department of Commerce Bureau of the Census 2004).

In 1999, the highest mean annual income in the western U.S. was paid to individuals employed by the federal government ($63,048), followed by the mining ($57,458), transportation and public utilities ($50,397), and manufacturing ($50,201) sectors. The lowest average income was realized by those working in the agricultural services, forestry, and fishing ($18,845) and retail trade ($20,332) industries (U.S. Department of Commerce Bureau of the Census 2004).

Revenues Generated by BLM Lands

The BLM allows land use for authorized private commercial activities such as energy and mineral commodity extraction, timber harvesting, livestock grazing, recreation, and the development of ROW on public land. Income generated by public land is used to assist state and local governments, support the General Fund of the U.S. Treasury, and offset charges for program operations where certain fees collected can be retained by the BLM. During FY 2004, the BLM collected nearly $807 million from a variety of land uses in the western U.S. (Table 3-18). In addition, the value of oil and gas produced from public lands was close to $14 billion in 2004. A portion of oil and gas revenues are collected by the Minerals Management Service (USDI BLM 2005c, d).

Revenues from mineral leases and permits totaled $60 million in 2004. These receipts include rental collections from oil and gas ROWs, revenues from the developed lands within the Naval Oil Shale Reserve in Colorado, lease rentals and bonus bids from the National Petroleum Reserve in Alaska, and fees related to mining claims.

Woodland products are an important commodity and source of revenue generated on public lands. These products include timber; other wood products, such as fuelwood, posts, and poles; and non-wood forest products, such as Christmas trees, cactus, seed, yucca, pinyon nuts, mushrooms, and yew bark. During FY's 1997 to 2004, an average of approximately $35 million was generated annually from woodland products harvested from public lands, the majority of which came from timber sales. The average volume of timber harvested annually between 1997 and 2004 was approximately 30 million cubic feet. The revenue generated from timber sales has generally decreased over the past 7 years, from $83.6 million in 1997 to $23.4 million in 2004 (USDI BLM Public Land Statistics 1997-2004).

Ninety-five percent of income from the sale of timber and other vegetative materials is derived from Oregon and California and Coos Bay (Oregon) Wagon Road Grant Lands. Timber harvest levels on these lands are guided by the direction of the Northwest Forest Plan. Timber sales on other public lands include sales from salvage timber and forest health projects.

Grazing fees are derived using a formula established in the *Public Rangelands Improvement Act of 1978*, which is based on several index factors, including private land lease rates, beef cattle prices, and the cost of production. In 2004, the fee was $1.43 per AUM, up from $1.35 in 2003 (USDI BLM 2005c, d). Approximately $11.8 million was collected in grazing receipts in 2004. Half of the grazing fees are used by the BLM for rangeland improvements.

TABLE 3-15
Population, Age Distribution, and Race in the Western States and Alaska

State	Population 2000 (thousands)	Percent Change from 1990	Density (per mi^2)	Age Distribution: Percent Under 18	Age Distribution: Percent Over 65	Percent of Hispanic Origin	Percent of Both Hispanic and Non-Hispanic Origin: Caucasian	African American	American Indian	Asian/Pacific Islander	Other	More than 1 Race
Alaska	627	12.3	1.1	30.2	5.4	4.1	69.3	3.5	15.6	4.5	1.6	5.4
Arizona	5,131	28.6	45.2	26.5	12.6	25.3	75.5	3.1	5.0	1.9	11.6	2.9
California	33,877	12.1	217.2	27.2	10.1	32.4	59.5	6.7	1.0	11.2	16.8	4.7
Colorado	4,301	23.4	41.5	25.5	9.2	17.1	82.8	3.8	1.0	2.3	7.2	2.8
Idaho	1,294	22.2	15.6	28.4	10.7	7.9	91.0	0.4	1.4	1.0	4.2	2.0
Montana	902	11.4	6.2	25.3	12.5	2.0	90.6	0.3	6.2	0.6	0.6	1.7
Nebraska	1,711	8.4	22.3	26.3	13.6	5.5	89.6	4.0	0.9	1.3	2.8	1.4
Nevada	1,998	39.9	18.2	25.5	10.6	19.7	75.2	6.8	1.3	4.9	8.0	3.8
New Mexico	1,819	16.7	15.0	27.8	11.2	42.1	66.8	1.9	9.5	1.2	17.0	3.6
North Dakota	642	0.5	9.3	24.9	13.5	1.2	92.4	0.6	4.9	0.6	0.4	1.2
Oklahoma	3,460	9.7	50.3	25.9	13.2	5.2	76.2	7.6	7.9	1.5	2.4	4.5
Oregon	3,421	16.9	35.6	24.6	12.2	8.0	86.6	4.6	1.3	3.2	4.2	3.1
South Dakota	755	7.8	9.9	26.5	13.1	1.4	88.7	0.6	8.3	0.6	0.5	1.3
Texas	20,852	22.8	79.6	28.2	9.9	32.0	71.0	11.5	0.6	2.8	11.7	2.5
Utah	2,233	22.9	27.2	32.0	8.2	9.0	89.2	0.8	1.3	2.4	4.2	2.1
Washington	5,894	17.4	88.6	25.6	10.6	7.5	81.8	3.2	1.6	5.9	3.9	3.6
Wyoming	494	8.1	5.1	25.9	11.0	6.4	92.1	0.8	2.3	0.7	2.5	1.8
United States	281,422	11.6	76.6	25.6	11.7	12.5	75.1	12.3	0.9	3.7	5.5	2.4
Western States	89,406	16.5	40.5	27.1	10.5	24.9	70.7	6.5	1.9	6.0	11.4	3.6
Percentage of Total U.S.	31.8	-	-	33.7	28.5	63.2	29.9	16.7	68.3	50.3	66.3	46.7

Source: U.S. Bureau of the Census (2002).

TABLE 3-16
Percent Unemployment for Western U.S. and Alaska

State	Year		
	1990	2000	July 2005
Alaska	7.0	6.6	6.6
Arizona	5.5	3.9	4.9
California	5.8	4.9	5.1
Colorado	5.0	2.7	5.2
Idaho	5.9	4.9	4.2
Montana	6.0	4.9	4.4
Nebraska	2.2	3.0	4.0
Nevada	4.9	4.1	4.2
New Mexico	6.5	4.9	6.0
North Dakota	4.0	3.0	3.5
Oklahoma	5.7	3.1	4.3
Oregon	5.6	4.9	6.6
South Dakota	3.9	2.3	4.0
Texas	6.3	4.2	5.0
Utah	4.3	3.2	4.7
Washington	4.9	5.2	5.7
Wyoming	5.5	3.9	4.1
United States	5.6	4.0	5.0

Source: U.S. Department of Labor Bureau of Labor Statistics (2005).

Fees are charged at many public recreation sites to provide for maintenance and improvement, and include access fees for Entrance Permits, Special Area Permits, Daily Use Permits, Commercial, Competitive, and Group Permits, Leases, and Passports. At other locations, generally those without public facilities, no fees are charged. In FY 2004, about 77% of recreational use on public lands, in terms of visitor days, occurred in non-fee areas (USDI BLM 2005d). The BLM also issues special recreation permit to qualified commercial companies and organized groups such as outfitters, guides, vendors, and commercial competitive event organizers who conduct activities on both fee and non-fee lands. Nearly $13.3 million were collected in recreation fees in 2004 (USDI BLM 2005c).

In FY 2004, sales of public land and material, including receipts from the sale of public land, and the sale of vegetative and mineral materials, totaled nearly $571 million, of which nearly $561 million were from the sale of certain public lands in Clark County, Nevada, near the city of Las Vegas, under the *Southern Nevada Public Land Management Act.*

In addition to providing revenue for the BLM, all of the major public land activity categories generate economic benefits to the communities and states in which they occur. For example, there are nearly 18,000 grazing leases in force on public lands, supporting over 12 million AUMs (Table 3-6). Alaska and Texas have no grazing permits in force. The value of these grazing permits and the acreage they entail vary widely depending on the location, soil characteristics, and precipitation. The availability of public land grazing leases is highly beneficial, if not crucial, to some ranching operations, however, and consequently is very important to many rural communities throughout the west.

Similarly, mineral development is an economic mainstay of many western communities. Table 3-17 illustrates the relative importance to the employment base of mineral extraction, particularly in Arizona, Wyoming and Nevada. Each of these states, plus Alaska, has a much higher percentage of employment in mining/natural resource industry than the average for the west as a whole. This industry sector includes oil and gas, coal, aggregates, and hard rock minerals such as gold and copper. Alaska's oil industry not only supports on-going employment, it contributes toward minimizing taxes for all state residents and has provided a substantial cash rebate to residents over the years.

The BLM estimated the benefits to local economies from public lands from recreation. These estimates serve as one example of the economic activity that depends on the public land base. Recreational activity provides revenue for local economies through expenditures associated with activities such as hunting, fishing, and wildlife viewing (Table 3-19). In FY 2004, an estimated $2.9 billion was injected into local economies through these recreation-associated expenditures (USDI BLM 2005d). These activities produce indirect financial benefits to community businesses providing food, lodging, equipment sales, transportation, and other services. State fish and wildlife management agencies also benefit from spending associated with these activities from sources such as state tax revenue and state administered fishing and hunting license programs.

Expenditures by the BLM

The budget for the BLM was $1.72 billion in FY 2005, and is projected to be $1.79 billion in FY 2006 (USDI BLM 2005c). In 2005, $855 million was allocated to management of lands and resources (Table 3-20). These expenditures included integrated management of public land, renewable and cultural resources, fish and wildlife, threatened and endangered species, recreation, and energy and minerals.

TABLE 3-17
Percent Employment by Industry in 2004

State	Agriculture	Mining and Natural Resources	Construction	Manufacturing	Transportation and Public Utilities	Trade (Wholesale and Retail)	Finance, Insurance, and Real Estate	Services	Government	Other	Total Number (thousands)
Alaska	0.3	3.5	6.5	3.5	20.6	13.8	4.8	7.7	27.4	3.6	301
Arizona	2.7	8.6	8.4	7.2	19.0	15.8	6.8	14.0	17.6	3.7	2,379
California	3.1	0.2	5.8	10.5	18.9	15.5	0.6	15.1	16.4	3.4	14,633
Colorado	2.0	0.7	7.0	7.0	18.7	15.3	7.1	13.9	16.7	4.0	2,186
Idaho	6.5	0.8	7.3	10.3	19.8	16.5	4.6	12.9	19.7	3.1	600
Montana	6.5	1.7	6.5	4.6	20.8	17.0	5.2	8.4	21.4	4.0	410
Nebraska	6.9	0.1	5.3	11.0	21.6	16.1	6.9	10.3	17.8	3.8	917
Nevada	1.4	7.8	10.2	4.0	17.0	14.1	5.4	8.1	14.0	3.0	1,165
New Mexico	2.5	1.9	6.4	4.6	17.3	14.4	4.4	11.4	25.3	3.6	799
North Dakota	8.8	1.1	5.4	7.0	21.3	17.4	5.6	7.1	23.0	4.6	341
Oklahoma	3.3	2.2	4.3	9.7	18.8	15.2	5.7	10.8	20.5	5.0	1,472
Oregon	4.3	0.6	5.3	12.6	19.9	16.4	6.1	11.1	17.0	3.6	1,624
South Dakota	9.2	0.2	5.4	9.9	20.3	17.2	7.2	6.2	19.7	4.2	385
Texas	2.9	1.6	5.9	9.3	20.6	16.4	6.2	11.3	17.7	3.8	9,519
Utah	2.4	0.7	6.8	10.3	19.8	15.7	5.8	12.6	18.0	2.9	1,119
Washington	2.9	0.3	6.3	9.6	19.2	15.8	5.8	11.2	19.3	3.7	2,752
Wyoming	5.5	8.1	8.2	3.8	19.1	14.4	4.1	6.0	25.4	3.7	259
Western U.S.	3.2	0.8	5.8	9.3	19.5	15.8	6.1	12.8	17.6	3.6	40,861

Source: U.S. Department of Labor Bureau of Labor Statistics (2004a).

Wildland Fire Management

While the amount budgeted for wildland fire management may be relatively consistent from year to year, the cost of fighting fires has varied substantially. The USDI allocated $756 million to wildland fire management for FY 2006 for all USDI fire efforts.

Table 3-21 shows the BLM's fire suppression expenditures for recent years. The variability often results from changing weather, but terrain, vegetation, and proximity to populated areas all contribute to the cost of fighting a fire.

The cost of fire suppression also depends on the number and size of fires. Approximately 95% of wildland fires are controlled in the initial attack, when they are relatively small and haven't gotten seriously out of control. Table 3-22 illustrates the acreage lost to large (greater than 10,000 acres) fires in recent years. Notably, there were relatively few large fires in 2001 and 2003, which likely contributed to reduced suppression expenditures in those years. 2004 was an anomaly in that costs remained relatively low despite an extremely large acreage lost to fire. This is most likely explained by the fact that nearly all of the large fires that year were in Alaska and several were sufficiently remote, or in such rugged terrain, that they were allowed to burn without a major effort to control them.

Hazardous Fuels Reduction

Reducing the hazardous fuels available to sustain a wildland fire can be costly. The USDI treated 490,010 acres in the WUI during 2004 at an average cost of $235 per acre. Treatment can cost up to $5,000 per acre for labor-intensive, small mechanical treatments in forested WUI areas. During that same year, the USDI treated 770,797 acres in non-WUI areas at a cost of about $104 per acre (USDI BLM 2005c).

TABLE 3-18
Revenues Generated from Public Lands by Source for Fiscal Year 2004

State	Mineral Leases	Timber Sales	Land and Material Sales	Grazing Fees	Recreation Fees	Other[1]	Total
Alaska	$5,348,662	$(1,530)[2]	$136,818	$0	$252,671	$337,241	$6,073,862
Arizona	35,182	12,674	2,664,359	494,329	1,239,369	1,526,781	5,982,694
California	160,170	19,532	1,114,438	223,607	3,234,725	2,353,324	7,105,694
Colorado	9,153,896	77,015	663,987	492,033	490,758	530,892	11,408,581
Idaho	32,231	295,270	156,001	1,388,965	542,224	774,024	3,188,715
Montana	2,008,862	445,554	77,395	1,728,153	291,673	173,683	4,725,320
Nebraska	0	0	0	1,328	0	0	1,328
Nevada	235,980	5,982	560,990,421	1,869,075	2,493,804	3,055,193	568,650,455
New Mexico	801,434	7	2,209,706	1,622,651	341,118	699,983	5,714,899
North Dakota	1,055	0	1,680	15,841	0	5,695	24,241
Oklahoma	31,095	0	0	137	0	0	31,232
Oregon	9,046	23,312,257	511,576	1,115,107	2,089,131	1,393,626	27,430,743
South Dakota	625	64,927	15	134,870	0	4,028	204,528
Texas	620	0	0	0	0	0	620
Utah	88,354	71	383,358	838,948	2,082,940	657,101	4,050,772
Washington	374	134,013	447	44,735	0	22,483	202,052
Wyoming	620,749	3,391	1,947,602	1,820,466	180,722	926,491	5,499,471
Other	41,479,669[3]	0	0	0	0	0	41,479,669
Total	60,008,004	23,369,163	570,864,571	11,840,245	13,250,363	12,472,082	691,803,998

[1] Includes fees and commissions, ROW rents, rent of land, and other sources.
[2] This represents a negative amount.
[3] Includes mining claim and holding fees and non-operating revenue.
Source: BLM Public Land Statistics (2005d).

TABLE 3-19
Estimated Benefits to Local Economies by Recreation on Public Lands in FY 2004

State[1]	Fishing Expenditures	Hunting Expenditures	Wildlife Viewing Expenditures	Total
Alaska	$111,908,036	$21,298,347	$77,254,514	$210,460,897
Arizona	16,582,133	43,567,963	148,101,814	208,251,910
California	52,688,519	79,168,020	395,785,163	527,641,702
Colorado	71,232,385	148,425,214	94,721,554	314,379,153
Idaho	42,564,807	69,924,115	64,208,416	176,697,338
Montana	12,858,156	22,718,487	32,364,018	67,940,661
Nevada	42,267,134	97,412,143	186,136,882	325,816,159
New Mexico	20,956,274	26,162,787	102,276,338	149,395,399
Oregon	58,593,145	135,470,796	210,581,452	404,645,393
Utah	44,415,131	88,827,222	235,888,696	369,131,049
Washington	1,803,726	1,964,794	5,069,450	8,837,970
Wyoming	10,054,058	38,397,246	82,081,610	130,532,914
Total	4985,923,504	773,337,134	1,634,469,907	2,893,730,545

[1] Estimates include only states with more than 75,000 acres of public lands. No estimates were made for Nebraska, North Dakota, Oklahoma, South Dakota, and Texas.
Source: BLM Public Lands Statistics (USDI BLM 2005d).

TABLE 3-20
Summary of BLM Jobs and Expenditures for the Management of Lands and Resources Program by Activity and Subactivity (dollars in thousands)

Activity/Subactivity	2004		2005	
	FTE[1]	Amount	FTE[1]	Amount
Management of Lands and Resources	6,441	$855,271	6,440	$836,826
Land Resources	1,538	183,135	1,541	188,014
Soil, Water, Air	255	36,038	253	34,738
Range Management	712	72,459	700	69,183
Forest Management	75	8,093	81	8,895
Riparian Management	199	22,015	199	21,228
Cultural Resources	137	15,479	136	14,925
Wild Horse and Burros	160	29,051	172	39,045
Wildlife and Fisheries	279	34,098	299	36,947
Wildlife Management	185	22,387	204	25,063
Fisheries Management	94	11,711	95	11,884
Threatened and Endangered Species	182	21,940	180	21,144
Recreation	597	62,276	588	60,589
Wilderness Management	166	17,673	158	16,431
Recreation Resource Management	430	44,603	430	44,158
Resource Protection	530	81,290	541	81,501
Energy and Minerals	1,037	107,879	1,032	106,631
Realty and Ownership	739	93,246	736	92,624
Transportation Facilities and Maintenance	428	81,533	430	77,813
Workforce Organization and Support	651	137,065	651	142,161
Alaska Minerals	17	2,453	19	3,944
Other[2]	136	50,356	423	42,249

[1] Full Time Equivalent.
[2] Includes Communications Sites Management, Mining Law Administration, Land Resources Information Systems, Challenge Cost Share, and Reimbursable programs.

Weed Management

Herbicides and manual and mechanical methods are employed to control invasive plant species, which have caused a variety of problems on public lands. The Vegetation section of this chapter addresses several major types of weed infestations on public lands. As Duncan et al. (2005) noted, "The economic impact of most (weed) species is poorly documented. This is generally due to the lack of quantitative information on ecosystem impacts and the challenge of assessing non-market cost such as those to society and the environment (e.g., changes in fire frequency, wildlife habitat, aesthetics, loss of biodiversity)."

Expenditures for herbicides used on BLM land are a relatively small part of the agency's budget, accounting for only a little more than $2.9 million in 2003 (Table 3-23). Table 3-23 includes only the cost of the chemicals; labor and equipment costs for herbicide application would be in addition to the costs shown. The cost of herbicides can vary dramatically, depending on the type selected and the method of application. Costs can also vary significantly in different parts of the country, from different vendors, from use of generic versus branded chemicals, and on the size and terrain of the application target area. The Forest Service estimated the average cost per acre for application at $100 for ground application and $25 for aerial application (USDA Forest Service 2005). The BLM's range of estimated application costs is even broader. For ground applications, BLM's estimates range from $50 to $300 per acre for backpack or ATV applications and $25 to $75 per acre for boom sprayer applications. Aerial applications are estimated at $6 to $40 per acre for fixed-wing aircraft and $25 to $200 per acre for helicopter applications.

It is estimated that downy brome infests over 56 million acres in the 17 western states and that the infestation is growing at 14% per year (Duncan 2005). Table 3-5 indicates more than 24 million acres of public lands are infested with downy brome. Downy brome can increase the frequency and intensity of wildfire and destroy the structure of the native plant communities, particularly sagebrush habitats. Because of its widespread dominance, downy brome has become the most important forage grass in the western U.S. However, it is highly unreliable as a forage base for both cattle and wildlife because it can exhibit "tenfold differences (300-3,500 lbs/acre) from year to year" in productivity, depending on precipitation.

TABLE 3-21
BLM Wildland Fire Suppression Expenditures FY 1998 through FY 2004

Fiscal Year	Expenditure	Percent Change from Prior Year
1998	$63,470,000	NA
1999	85,724,000	35.1
2000	228,394,000	166.4
2001	192,115,000	-15.9
2002	204,666,000	6.5
2003	151,994,000	-25.8
2004	158,626,000	4.4
NA = Not applicable		

Once a treatment is accomplished, it is then costly to rehabilitate the land. Cost per acre to stabilize and rehabilitate disturbed land is estimated at $17. During 1991, however, it cost $100,000 to rehabilitate the 1,700 acres burned in the Snake River Birds of Prey Area, Idaho, or almost $59 per acre. During 2004, it cost the BLM $1,640 per acre to restore 12,000 acres of forestland and woodlands. The unit cost ranged from $295 per acre in New Mexico to $2,730 per acre in Oregon (USDI BLM 2005c).

TABLE 3-22
BLM Action Fires Larger Than 10,000 Acres[1] during 1999 to 2004

Calendar Year	Number of Fires	Average Size (Acres)	Total Acreage
1999	64	44,990	2,879,351
2000	66	34,851	2,300,187
2001	28	40,524	1,134,662
2002	46	55,484	2,552,265
2003	23	55,940	1,286,612
2004	51	122,805	6,263,059
Total	278	59,051	16,416,136
[1] Fire Type 1 - All protection types.			

Payments to State and Local Governments

Where the federal government maintains federal public land, the federal government makes payments to state and local governments for a variety of purposes. Receipts from coal leases and bonus payments, for example, are shared. Payments in lieu of taxes help address the loss of potential local tax income that could have been generated from those public lands if they were in private ownership. Payments in lieu of taxes, as well as other forms of transfer payments, are generally set by law and provided according to a formula. Payments in lieu of taxes, for example, are computed based on the number of acres of public lands within each county and multiplied by a dollar amount per acre. Over $2 billion in payments have been made since 1976. Table 3-24 shows the BLM payments to states and local governments for FY 2004.

Human Health and Safety

Background Health Risks

This section discusses background information on human health risks of injuries, and cancer and other diseases for people living in the states in which the BLM is planning to implement vegetation treatments. People living in these states are exposed to a variety of risks common to the U.S. as a whole, including automobile accidents and other injuries; contaminants in the air, water, soil, and food; and various diseases. Risks to workers may differ from those facing the general public, depending on the nature of a person's work. Some of these risks may be quantified, but a lack of data allows for only a qualitative description of certain risks. Where data are only available for the U.S. as a whole, it is assumed that these data apply to the treatment states. Information for this section was obtained from the Centers for Disease Control and Prevention (CDC), the National Center for Injury Prevention and Control (NCIPC), the National Center for Health Statistics (NCHS), the National Institute for Occupational Safety and Health (NIOSH), and the Bureau of Labor Statistics.

Risks from Diseases

Disease Incidence

Despite the difficulties in establishing correlations between work conditions and disease, certain illnesses have been linked to occupational hazards. For example, asbestosis and lung cancer among insulation and

TABLE 3-23
Herbicide Uses and Costs for Vegetation Treatments on Public Lands during 2003

Herbicide	Type of Application	Acres Treated[1]	Total Herbicide Expenditure[2]	Cost per Acre for Herbicide[2]
2,4-D	Aerial Ground	543 41,015	$3,237 200,829	$5.96 4.90
Bromacil	Aerial Ground	0 629	0 111,263	NA 176.89
Chlorsulfuron	Aerial Ground	338 1,977	49,443 169,100	146.28 85.53
Clopyralid	Aerial Ground	6,375 7,401	211,310 241,192	33.15 32.59
Dicamba	Aerial Ground	0 5,505	0 294,656	NA 53.53
Diuron	Aerial Ground	0 952	0 16,110	NA 16.92
Fosamine	Aerial Ground	0 16	0 1,431	NA 89.44
Glyphosate	Aerial Ground	28,802 9,442	85,116 43,048	2.96 4.56
Hexazinone	Aerial Ground	0 255	0 1,804	NA 7.07
Imazapyr	Aerial Ground	512 1,314	71,400 113,260	139.45 86.19
Metsulfuron methyl	Aerial Ground	1,773 7,579	46,561 176,795	26.26 23.33
Picloram	Aerial Ground	4,598 27,492	80,048 810,371	17.41 29.48
Sulfometuron methyl	Aerial Ground	0 139	0 2,621	NA 18.86
Tebuthiuron	Aerial Ground	52,083 362	53,925 310	1.04 0.86
Triclopyr	Aerial Ground	5,058 4,292	30,044 91,438	5.94 21.30

[1] Acres treated do not take into account whether the aerial application was by helicopter or airplane. They also do no distinguish between ground application methods. Costs would vary depending upon the application method.
[2] Total herbicide expenditure and cost per acre does not include costs for labor, equipment, and application, and represent an average cost for use throughout the BLM.
NA = Not available or not applicable.

shipyard workers has been linked to their exposure to asbestos (NIOSH 2002). Pneumoconiosis among coal miners has been correlated with the inhalation of coal dust. Occupational exposures to some metals, dusts, and trace elements, as well as CO, carbon disulfide, halogenated hydrocarbons, nitroglycerin, and nitrates, can result in increased incidence of cardiovascular disease. Neurotoxic disorders can arise from exposure to a wide range of chemicals, including some pesticides. Dermatological conditions like contact dermatitis, infection, trauma, cancer, vitiligo, uticaria, and chloracne have a high occurrence in the agricultural, forestry, and fishing industries.

Disease Mortality

Mortality rates for states in the BLM treatment area are listed in Table 3-25. The five most common causes of death in the U.S., as well as in the treatment states, are heart disease, cancer, stroke, respiratory disease, and accidents (Minino et al. 2002). Counties in the western U.S. that have the highest mortality rates are located in central Nevada, north and south-central California, and western Montana. Mortality rates are generally lowest in counties in western Utah, central Idaho, and northwest Wyoming (NCHS 2004). Mortality rates for males are nearly one and a half times as high as for

TABLE 3-24
BLM Payments to States and Local Governments during FY 2004

State	Payments in Lieu of Taxes	Mineral Leasing Act	Taylor Grazing Act[1]			Proceeds of Sales	Other	Total Payments
			Section 3	Section 15	Other			
Alaska	$15,638,222	$0	$0	$0	$0	$14,716	$2,530,586[2]	$18,183,524
Arizona	18,698,143	17,591	77,391	47,706	0	85,292	0	18,926,123
California	19,128,162	80,681	47,036	14,430	0	49,979	0	19,320,288
Colorado	17,600,933	112,877	25,716	51,706	37,964	23,790	0	17,852,986
Idaho	15,306,478	16,116	24,483	179,596	0	37,897	0	15,564,570
Montana	16,681,936	14,115	101,412	122,082	0	4,956	666,406[3]	17,590,907
Nebraska	654,262	0	397	0	0	0	0	654,659
Nevada	13,495,376	117,062	2,807	217,491	0	118,728	56,376,615[4]	70,328,079
New Mexico	21,999,459	381,315	138,740	198,989	13	62,632	9,053[3]	22,790,201
North Dakota	1,005,087	528	7,482	0	0	115	0	1,013,212
Oklahoma	1,500,526	477	89	0	0	0	0	1,501,092
Oregon	6,245,153	4,046	21,110	138,396	0	42,496	111,884,403[5]	118,335,604
South Dakota	2,506,524	313	67,457	0	0	1,197	0	2,575,491
Texas	2,593,311	310	0	0	0	0	0	2,593,621
Utah	19,136,869	44,477	0	91,166	0	24,981	0	19,297,493
Washington	5,879,878	187	21,217	0	0	6,378	0	5,907,660
Wyoming	14,627,836	304,085	314,924	140,807	10,231	51,108	0	15,448,991
Western States	192,698,161	1,094,180	850,261	1,202,369	48,208	524,265	171,467,063	367,884,501
All States	224,223,895	1,094,180	850,261	1,202,369	48,208	525,168	171,467,063	399,411,144

[1] Including payments for FY 2003 that were processed in FY 2004.
[2] National Petroleum Reserve – Alaska lands.
[3] Land utilization lands under the Bankhead-Jones Farm Tenant Act (7 U.S.C. 1012).
[4] Land utilization sales under the Southern Nevada Public Land Management Act resulted in direct payments at the time of sale totaling $56,294,902. Calendar year payments to Clark County and the State of Nevada under the Santini-Burton Act totaled $81,713.
[5] For FY 2004, a total of $8,572,365 of the $111,884,403 was returned to the BLM for Title II projects.
Source: USDI BLM (2004c).

females and nearly one and a half times for African Americans than for Caucasians (NCHS 2004).

Risks from Injuries

Injury Incidence

In 2003, more than 29.2 million nonfatal injuries were reported in the United States, 4.5 million of which were transportation related (CDC 2005). Injuries accounted for 37% of emergency department visits during the years 2001 and 2002 (NCHS 2004). The rate of hospitalizations for injury is significantly higher among elderly persons than among all other age groups (CDC 2005). The NIOSH estimates that approximately 10 million traumatic work-related injuries occur annually. Some chronic injuries may be directly linked to the nature of the work performed. For example, vibration syndrome affects a large proportion of workers using chippers, grinders, chainsaws, jackhammers, or other handheld power tools, causing blanching and reduced sensitivity in the fingers. The Bureau of Labor Statistics reported that in 1995, an estimated 62% of all work-related illness cases were due to musculoskeletal disorders associated with repeated trauma, such as that associated with the use of power tools (NIOSH 1997). Noise-induced hearing loss may also affect production workers who are exposed to noise levels of 80 decibels or more on a daily basis.

Acute trauma at work remains a leading cause of death and disability among U.S. workers. During the period from 1980 through 1995, at least 93,338 workers in the U.S. died as a result of trauma suffered on the job, with an average of about 16 deaths per day (NIOSH 2001). The *Census of Fatal Occupational Injuries Summary* by the BLS (U.S. Department of Labor Bureau of Labor Statistics 2004) identified 5,559 workplace deaths from acute traumatic injury in 2003. Occupational fatalities resulted from a number of causes, including motor vehicle accidents, machines, falls, homicide, electrocution, and being struck by falling objects (NIOSH 2002).

TABLE 3-25
Mortality Rates (per 100,000 Population) and Causes of Death by State

State	Cause of Death				
	All[1]	Diseases		Cancer	Accidents
		Cerebrovascular and Cardiovascular Disease	Chronic Respiratory Disease		
Alaska	825.8[2]	245.1	23.2	108.7	54.4
Arizona	787.4	252.7	47.1	172.3	46.6
California	775.1	291.6	37.5	155.8	23.5
Colorado	787.8	234.9	41.4	138.7	38.8
Idaho	798.0	269.8	44.0	158.5	43.3
Montana	840.3	255.5	64.4	216.0	51.7
Nebraska	793.5	298.6	51.3	197.0	36.8
Nevada	922.6	312.2	54.2	181.9	35.2
New Mexico	825.4	253.0	42.3	158.4	55.7
North Dakota	775.9	271.3	48.4	218.5	37.4
Oklahoma	959.7	363.7	55.4	213.6	49.0
Oregon	825.6	261.1	49.7	203.2	37.8
South Dakota	784.8	270.6	51.2	212.7	47.1
Texas	877.8	318.9	23.0	101.5	28.2
Utah	776.8	241.6	49.8	203.8	37.5
Washington	792.9	268.4	70.7	260.1	46.3
Wyoming	851.7	265.6	54.7	186.9	55.1
United States	864.8	305.7	43.2	194.4	35.7

[1] Based on 2002 data: all other columns are based on 2001 data.
[2] Age-adjusted death rate per 100,000 population, which accounts for changes in the age distribution of the population.
Source: NCHS (2004).

The occupational fatality rate in 2003 was approximately 4.0 fatalities per 100,000 employed. Fatality rates were highest for the agriculture, forestry, fishing, and hunting; mining; transportation; and construction industries. The fatality rate for the agriculture, forestry, fishing, and hunting sector was the highest, at 31.2 fatal industries per 100,000 workers. The mining sector had the second highest rate, at 26.9 fatalities per 100,000 employed. In the transportation and construction industries the rates were 17.5 and 11.7 fatalities per 100,000 employed, respectively. The largest number of fatal work injuries resulted from transportation incidents, which accounting for 42% of workplace fatalities in 2003 (U.S. Department of Labor Bureau of Labor Statistics 2004).

Injury Mortality

Over 161,000 Americans died from injuries nationwide in 2002. About 30% of these resulted from motor vehicle accidents, while other accidental deaths occurred from unintentional falls, drowning, and poisoning (CDC 2005). Injury is the leading cause of death and disability among children and young adults.

Risks from Cancer

Cancer Incidence

Nationwide, the chance of developing some form of cancer during one's lifetime is estimated to be about one in four (Calabrese and Dorsey 1984). There are many causes of cancer development, including occupational exposure to carcinogens, environmental contaminants, and substances in food. In the U.S., one-third of all cancers are attributed to tobacco smoking (Chu and Kamely 1988). Work-related cancers are estimated to account for 4 to 20% of all malignancies. It is difficult to quantify the information because of the long time intervals between exposure and diagnosis, personal behavior patterns, job changes, and exposure to other carcinogens. The NIOSH has reported that approximately 20,000 cancer deaths and 40,000 new cases of cancer each year in the U.S. are attributable to occupational hazards. Millions of U.S. workers are exposed to substances that have tested as carcinogens in animal studies (NIOSH 2002).

Cancer Mortality. Based on the data shown in Table 3-25, cancer accounted for between 13 and 33% of all deaths in the treatment states in 2001. Nationwide, cancer account for approximately 23% of all fatalities (National Center for Health Statistics 2004). Cancer mortality rates are generally highest in counties in western and southern Nevada and northern California and lowest in counties in Utah, central Colorado, and northern New Mexico (Devesa et al. 1999), and differ depending on race and sex. Generally, males have higher rates of cancer mortality than females, and African Americans have higher rates than Caucasians.

Risk from Using Herbicides on Public Lands

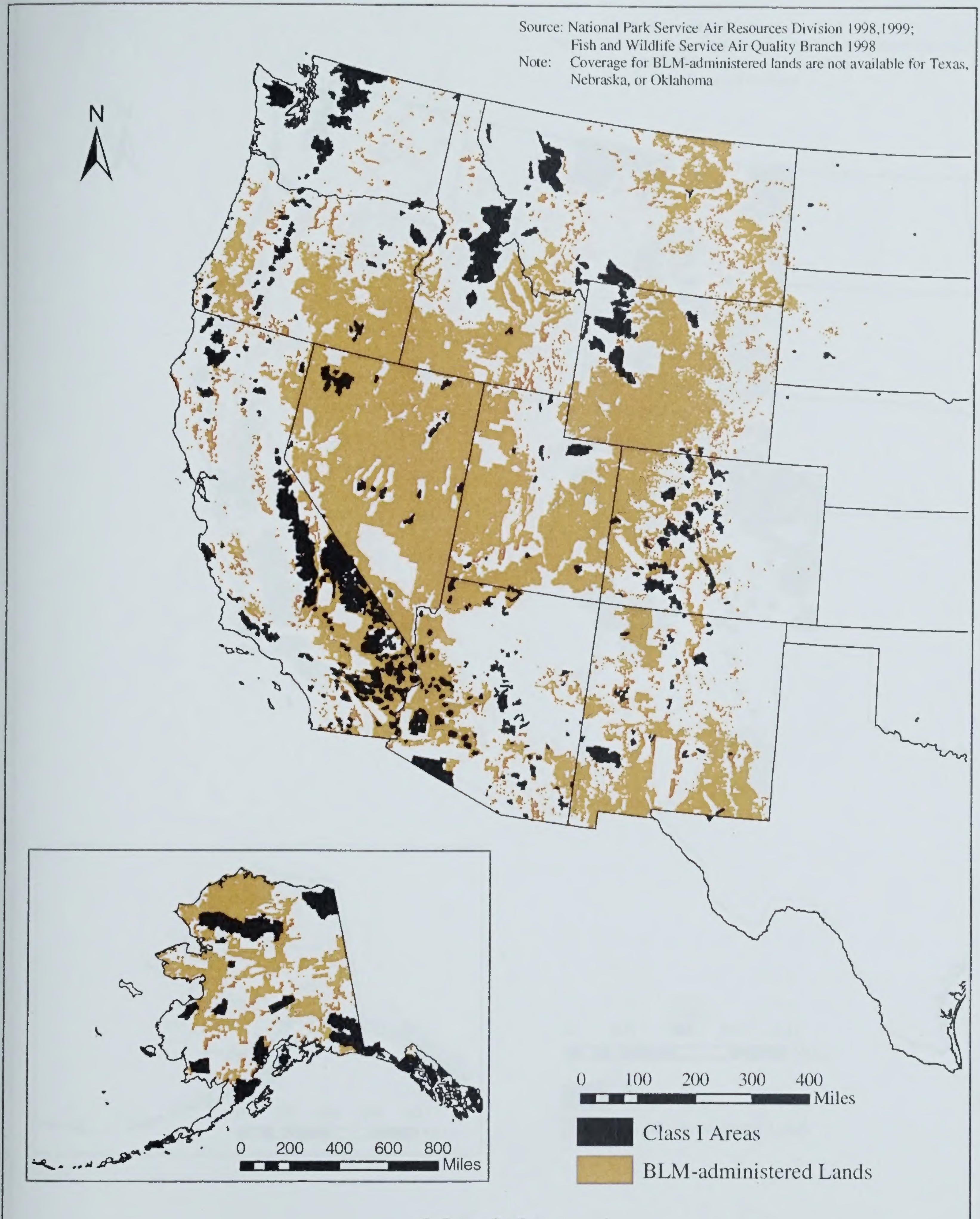
Based on the BLM's injury breakout report (USDI BLM 2005), only one minor injury from use of herbicides was recorded during FY 2005.

Risk from Wildfire Control on Public Lands

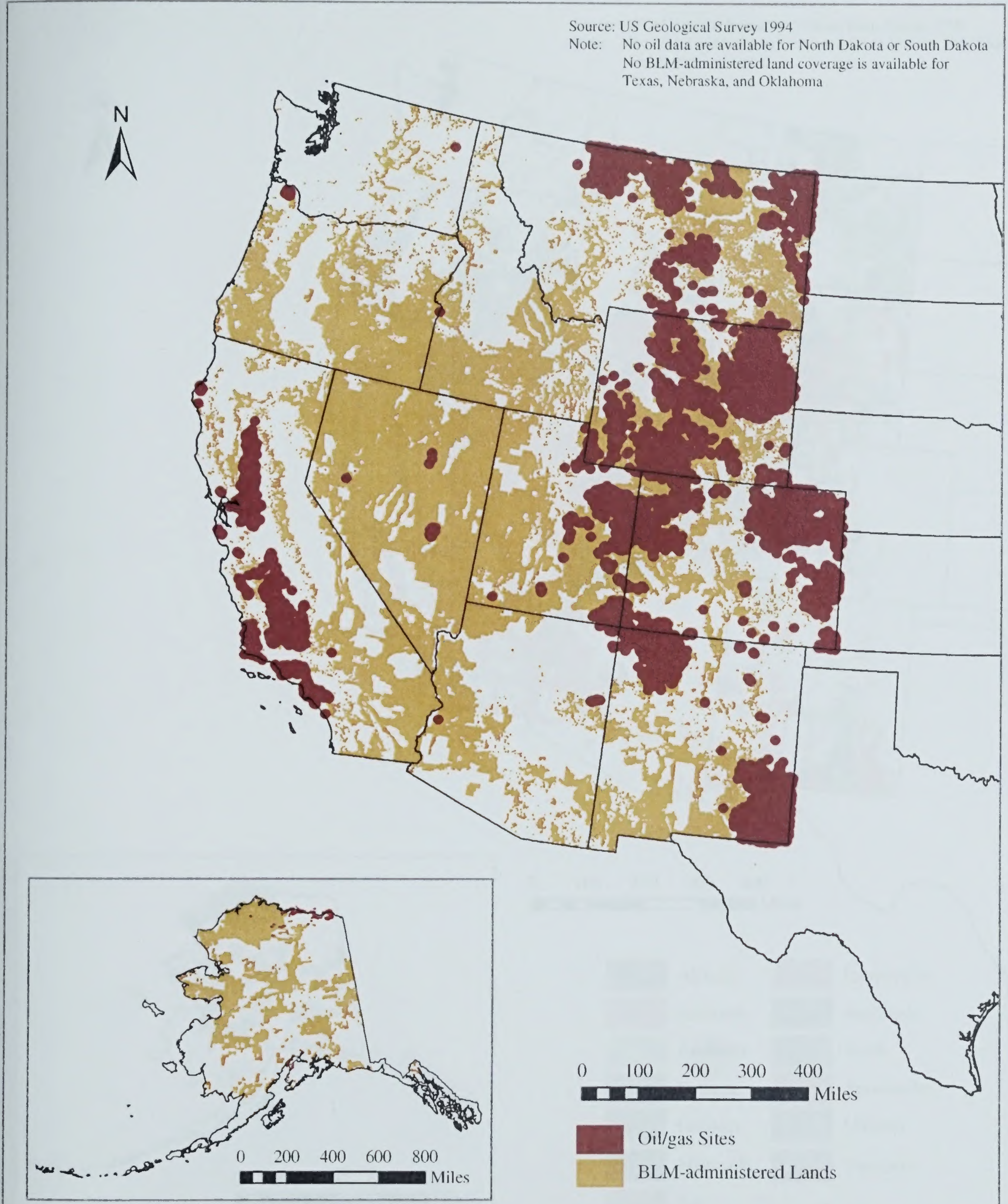
During FY 2004, 2,651 fires totaling 1,716,099 acres were suppressed on public lands. Two out of every three fires were caused by lightning, while the remainder were caused by humans. Approximately 60% of fires occurred on forestlands, the remainder on rangelands and other land types.

Wildfires cause the loss of life and property. According to the National Interagency Fire Center (2005), 20 people died from wildland fire accidents in 2004. During 2000 to 2003, 98 individuals died from wildland fire accidents. These included agency personnel, contractors, volunteers, and private individuals. The largest number of fatalities was associated with burnovers (47%), use of a vehicle or ground-based mechanical equipment (19%), or use of aircraft (13%). During FY 2002 to 2004, 49 BLM personnel were injured conducting fire operations. During 2004, wildland fires resulted in the loss of 314 primary structures on lands near BLM- or Forest Service-administered lands (USDI BLM 2005c).

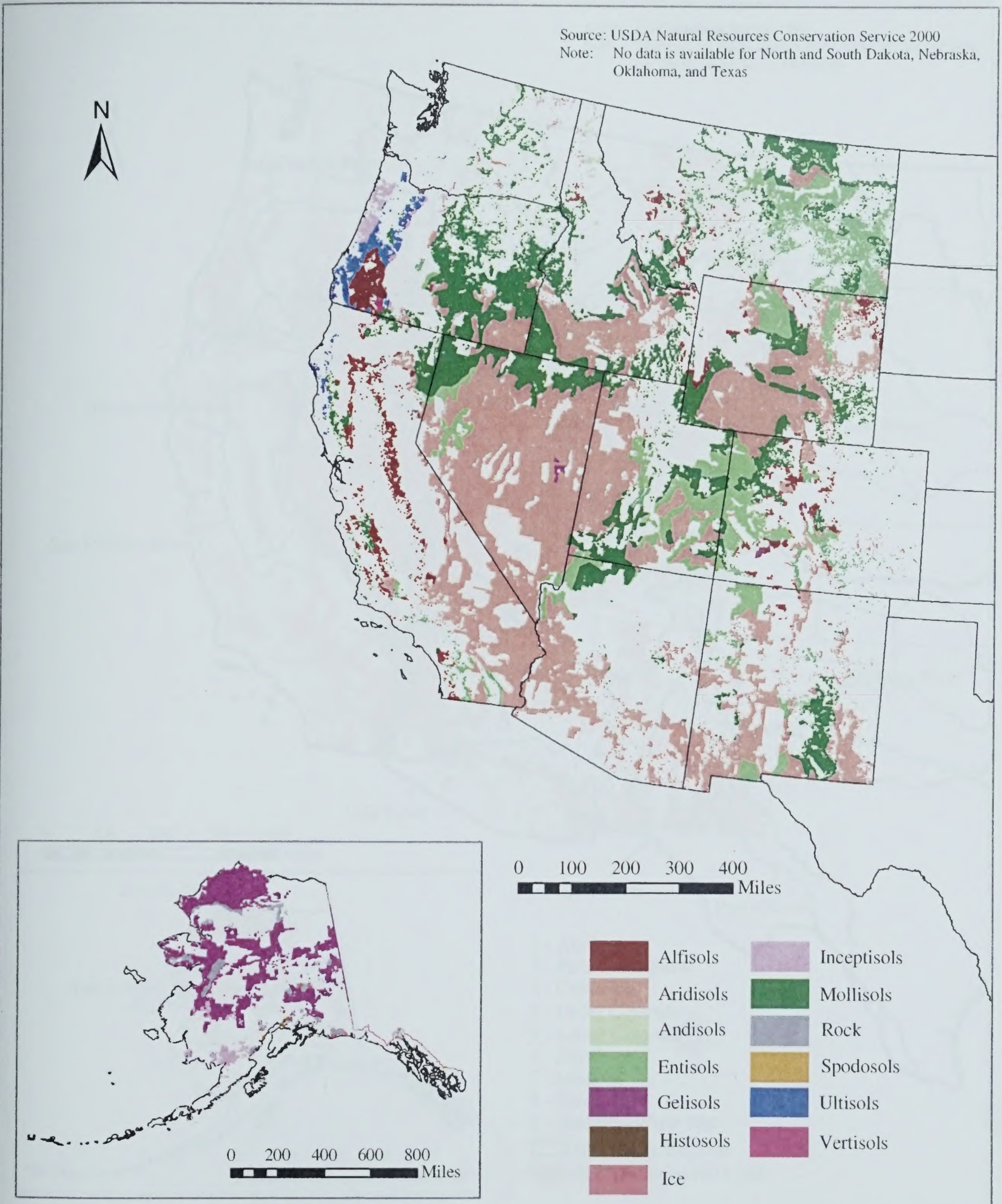
Map 3-1
Ecoregion Divisions



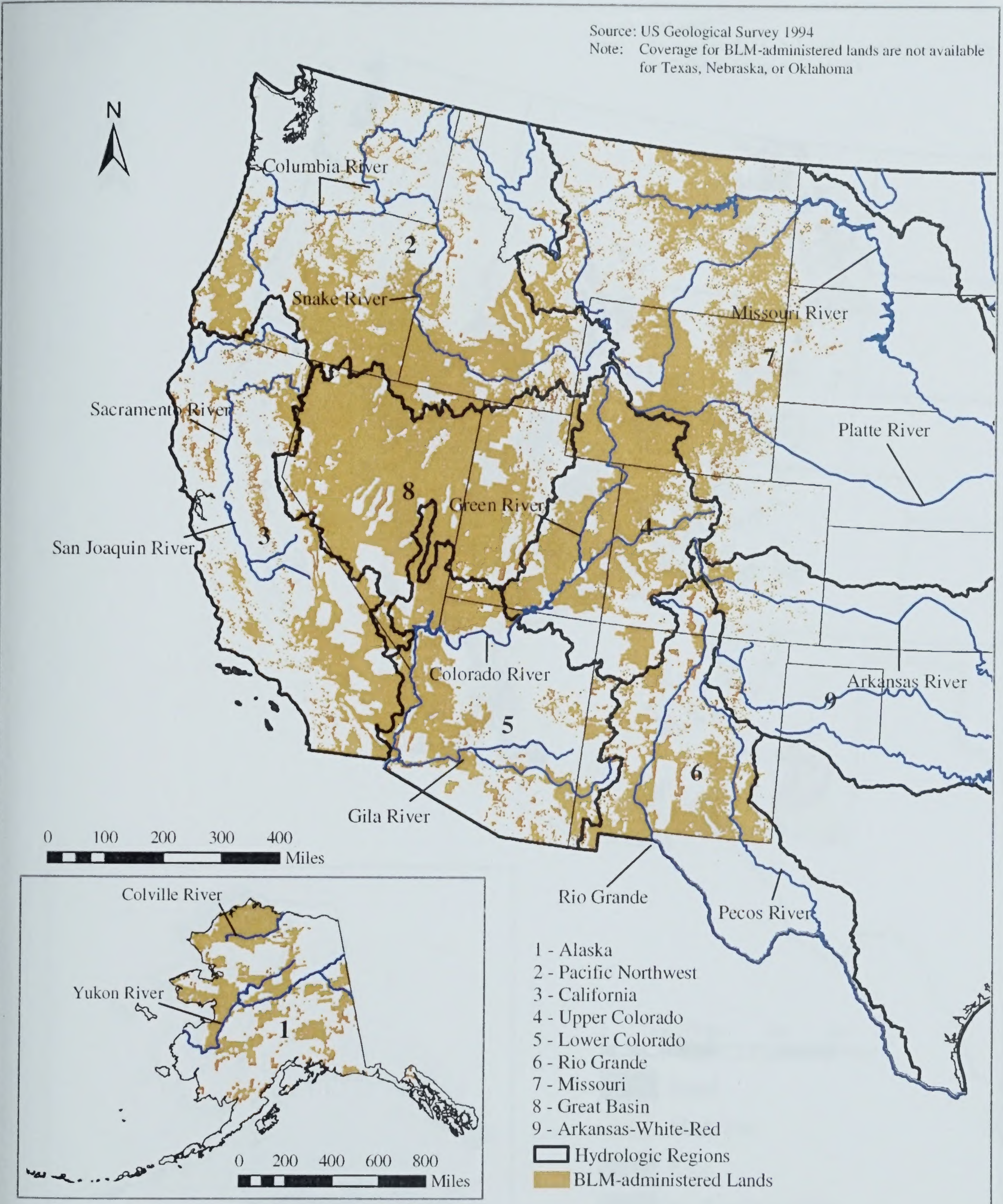
Map 3-2
Class I Areas



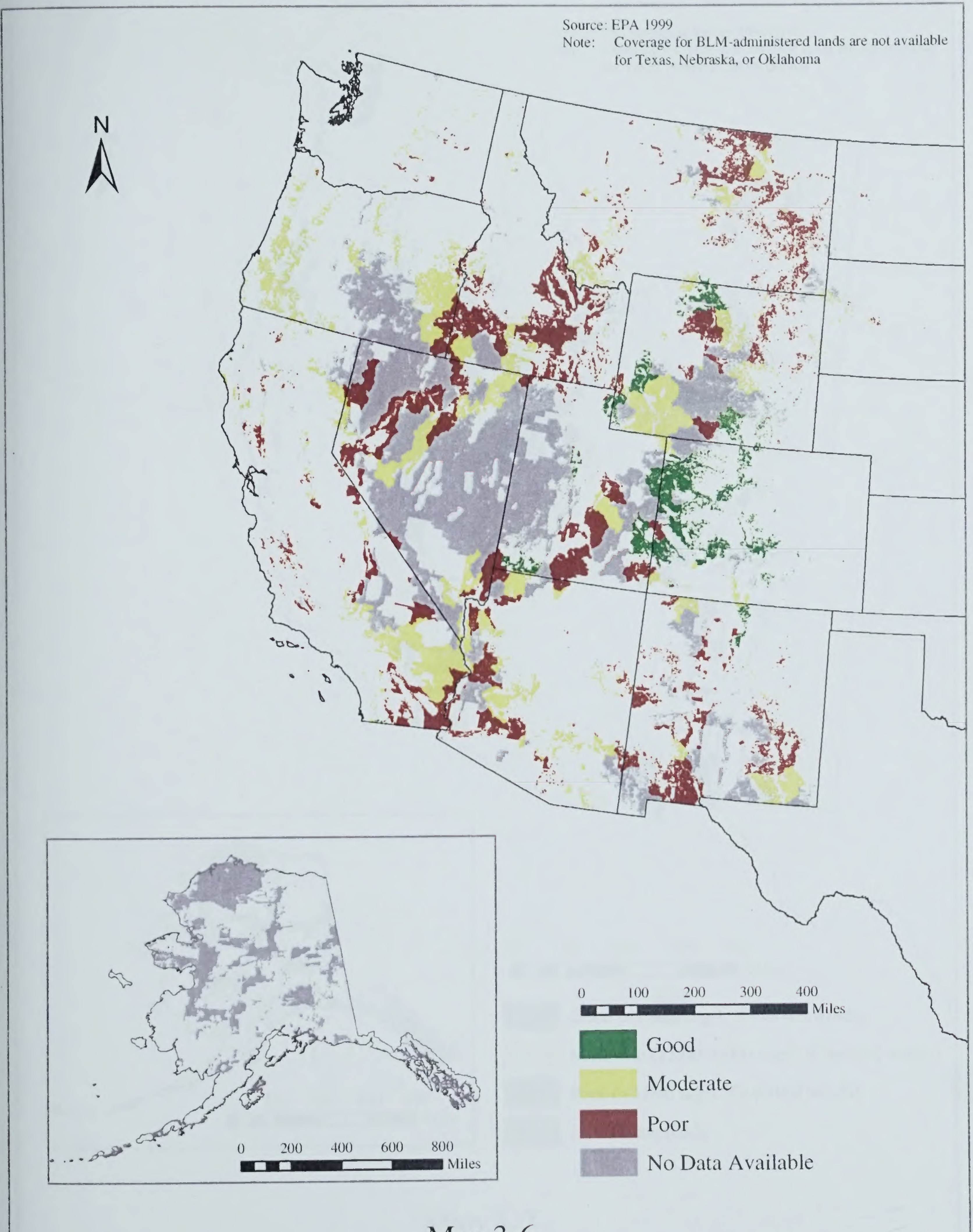
Map 3-3
Oil and Gas Resources



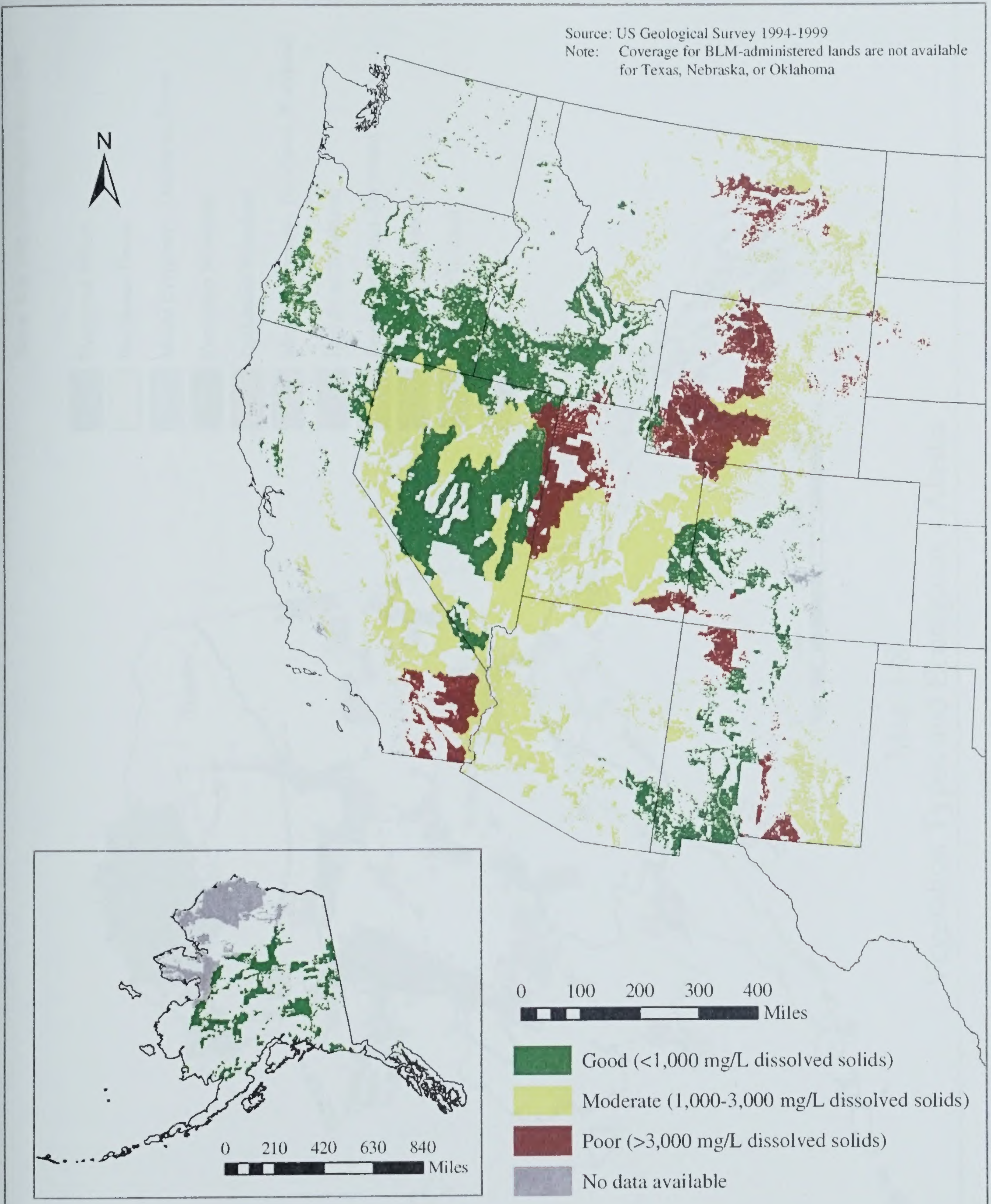
Map 3-4
Soil Orders



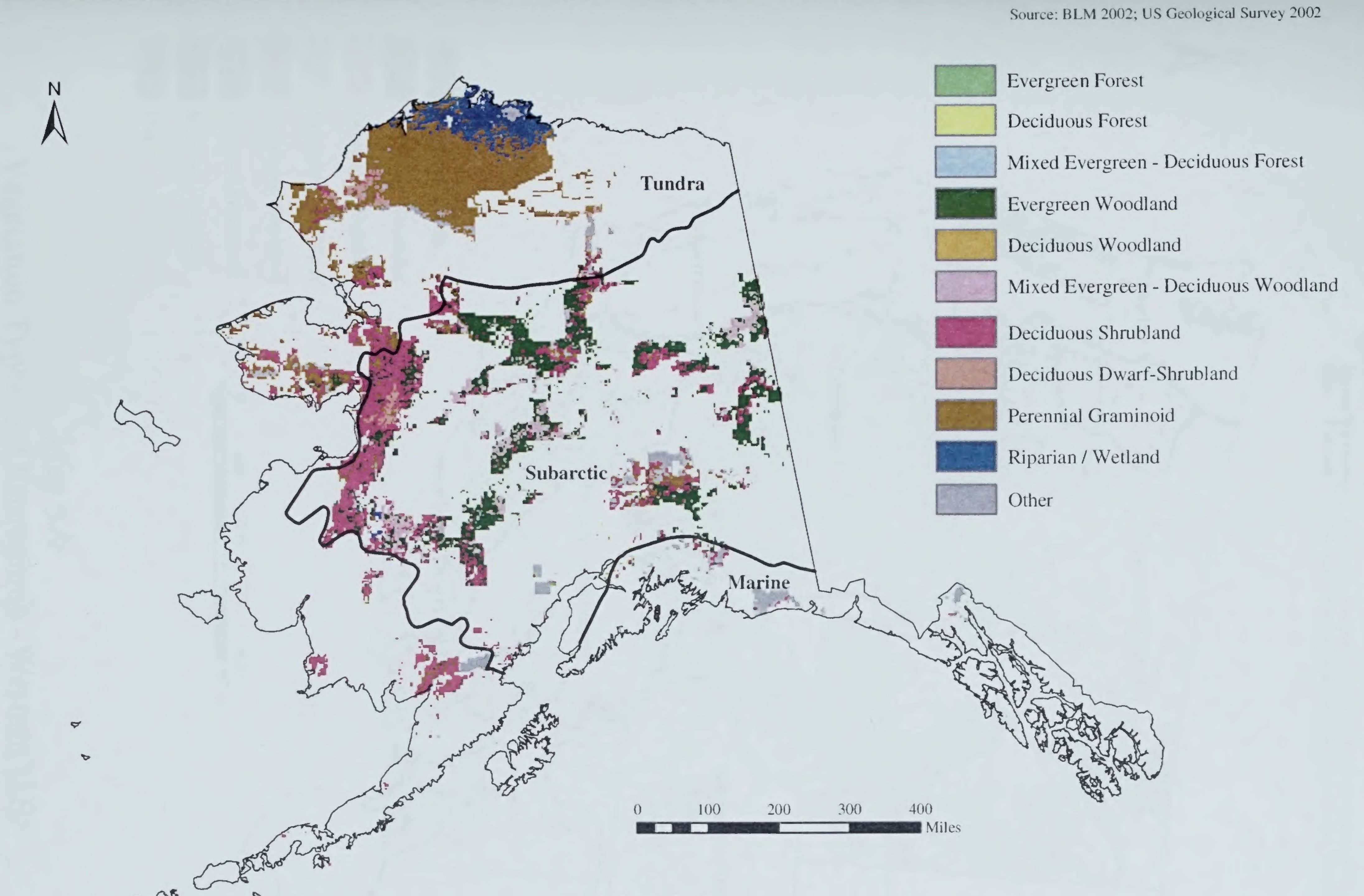
Map 3-5
Hydrologic Regions



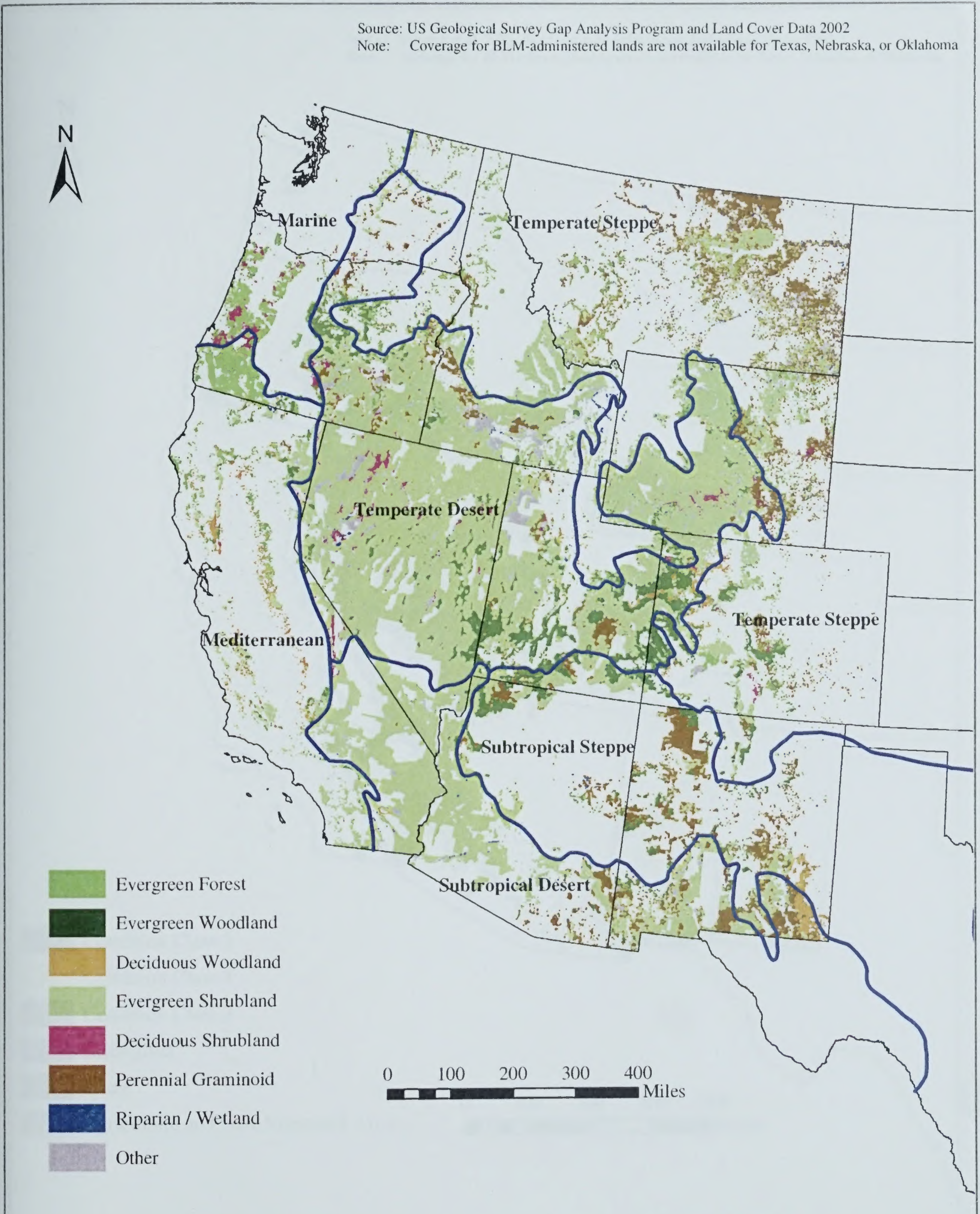
Map 3-6
Watershed Surface Water Quality



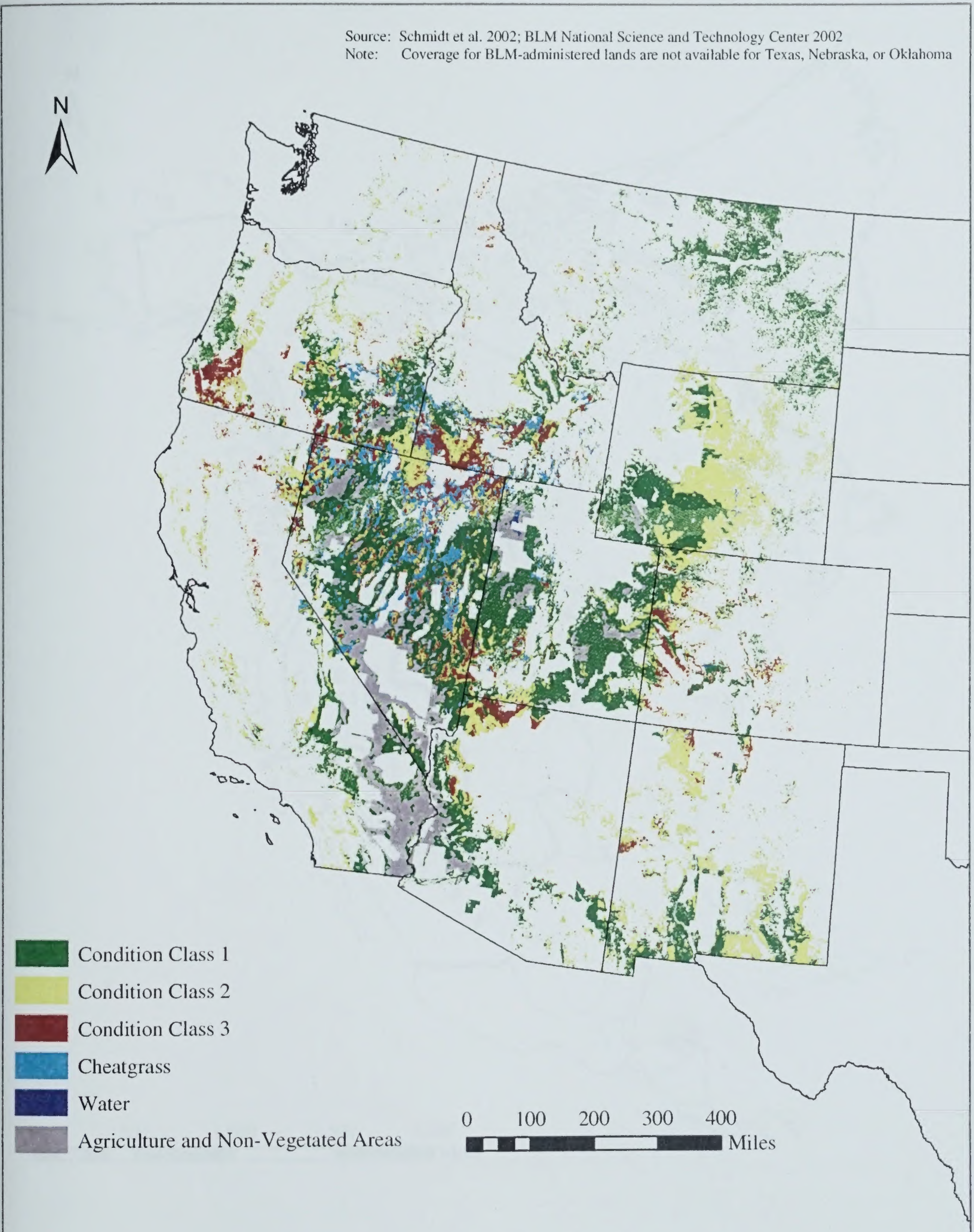
Map 3-7
General Groundwater Quality



Map 3-8
Vegetation Types and Ecoregions - Alaska

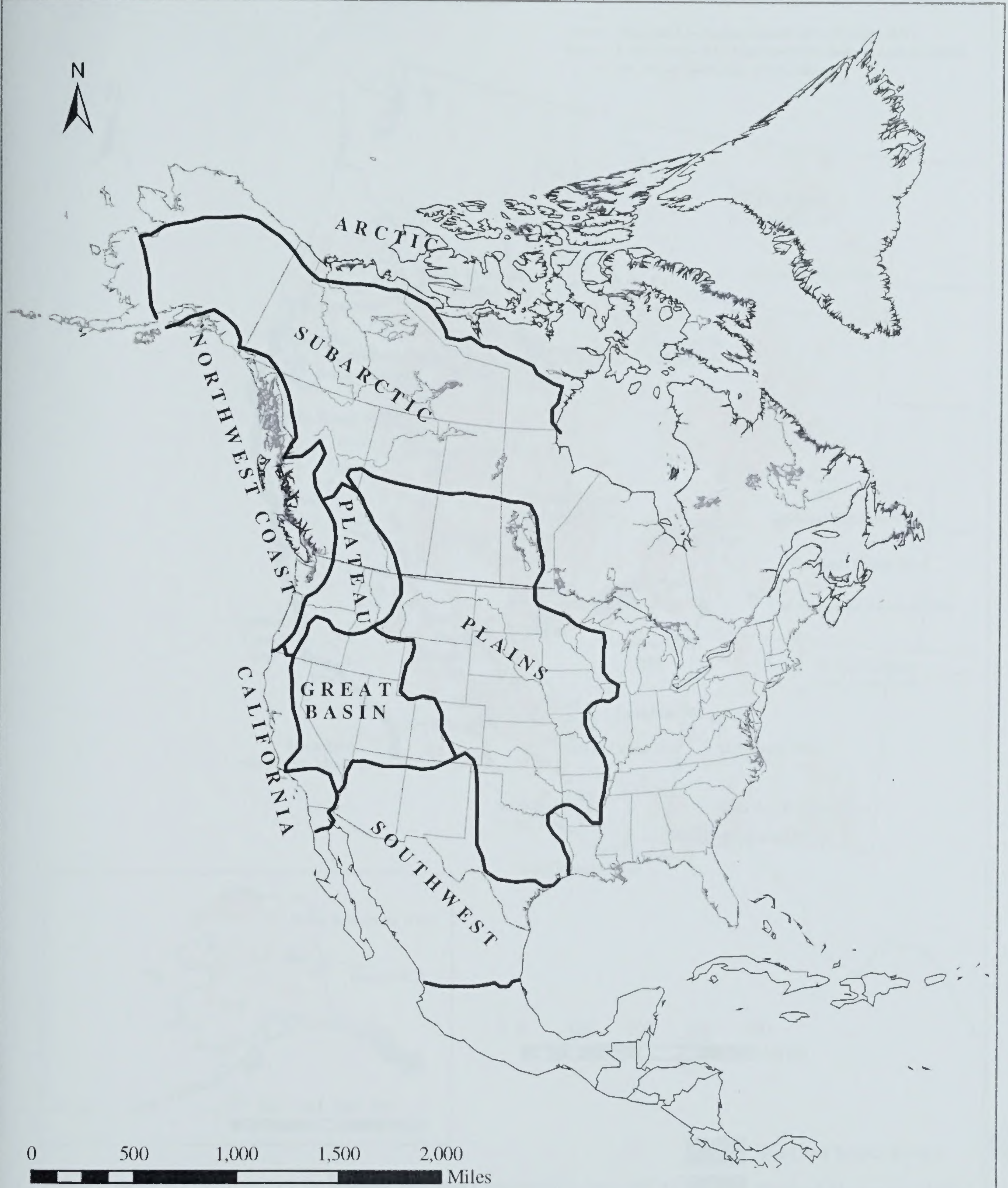


Map 3-9
Vegetation Types and Ecoregions - Western U.S.

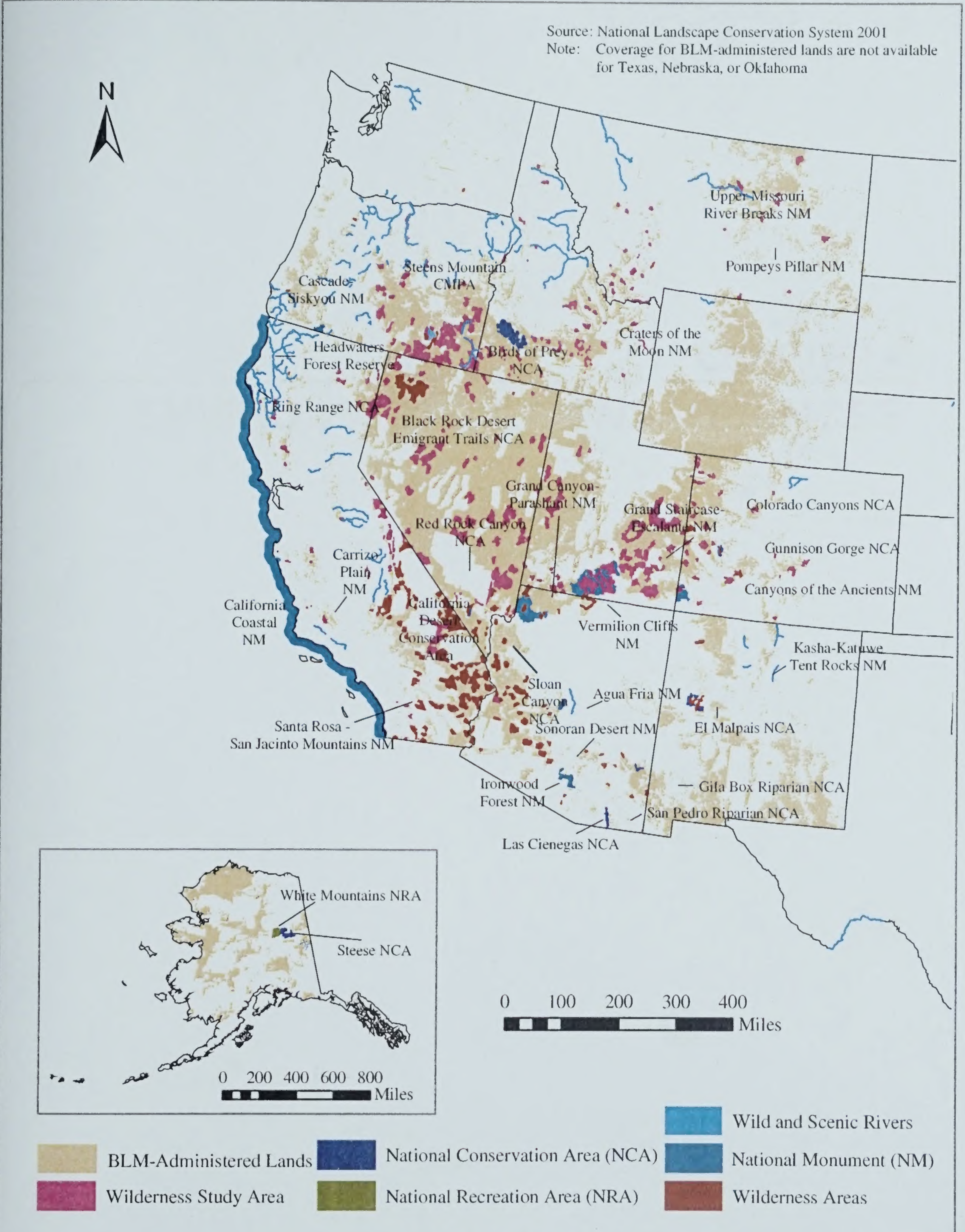


Map 3-10
Fire Condition Classes on Public Lands

Map 3-10
Fire Condition Classes on Public Lands



Map 3-11
Native Areas of Western North America



Map 3-12
National Monuments and National Conservation Areas

CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

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CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

Introduction and Effects

This chapter examines how vegetation treatment activities may affect natural, cultural, and socioeconomic resources on public lands. The focus of the analysis is on alternative proposals for treating public lands using herbicides; a summary of impacts associated with the use of other treatment methods is included in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States PER* (USDI BLM 2005a).

How the Effects of the Alternatives Were Estimated

Within each resource area, applicable direct and indirect effects are evaluated. Cumulative effects, unavoidable adverse effects, and those resource commitments that cannot be reversed or are lost are identified for all treatment activities in the PEIS. These impacts are defined as follows:

- Direct effects – Those effects that are caused by the action and occur at the same time and in the same general location as the action.
- Indirect effects – Those effects that occur at a different time or in a different location than the action to which the effects are related.
- Cumulative effects – Those effects that result from the incremental impact of the action when it is added to other past, present, and reasonably foreseeable future actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. For this PEIS, potential cumulative effects include those that could occur on other federal and non-federal lands.
- Unavoidable adverse commitments – Those effects that could occur as a result of implementing any of the action alternatives. Some of these effects would be short term, while others would be long term.
- Irreversible commitments – Those commitments that cannot be reversed, except perhaps in the extreme long term. This term applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity that are renewable only over long periods of time.
- Irretrievable commitments – Those commitments that are lost for a period of time. For example, timber production is lost while an area is mined. The production lost is irretrievable, but the action is not irreversible. If the site is reclaimed, it is possible to resume timber production.

This chapter should be read together with Chapter 2 (Alternatives), which explains the alternative proposals the BLM is considering for treating vegetation using herbicides, and Chapter 3 (Affected Environment), which describes the important resources and their occurrence and status on public lands. The analyses of environmental consequences in this chapter build upon and relate to information presented in these earlier chapters to identify which resources may be impacted and how and where impacts might occur.

This analysis addresses large, regional-scale trends and issues that require integrated management across broad landscapes. It also addresses regional-scale trends and changes in the social and economic needs of people. This analysis does not identify site-specific effects, in part, because of the level of specificity in broad-scale management direction, and because site-specific information is not essential to determining broad-scale management direction. As discussed in Chapter 1, Proposed Action and Purpose and Need, site-specific issues would be addressed through NEPA compliance for resource management activities and other land use plans prepared at the state, district, or field office level.

The analysis of impacts assumes that SOPs would be followed by the BLM under all alternatives to ensure that risks to human health and the environment from herbicide treatment actions were kept to a minimum (see Table 2-6). The analysis assumes that the BLM would comply with federal, state, tribal, and local regulations that govern activities on public lands. In addition, mitigation measures have been identified for most resource areas that could apply to one or more alternatives to further reduce impacts associated with herbicide treatments.

Incomplete and Unavailable Information

As discussed in Chapter 1, not all information that is available was used in the analysis of reasonably foreseeable significant adverse effects in the PEIS. According to the Council on Environmental Quality regulations for implementing the procedural provisions of NEPA (40 CFR 1502.22), if the information is essential to a reasoned choice among alternatives and the cost of gathering it is not excessive, it must be included or addressed in the PEIS.

Knowledge is, and always will be, incomplete regarding many aspects of terrestrial and aquatic species, forestland, rangelands, the economy, and society. However, central ecological, economic, and social relationships are well established, and a substantial amount of credible information about ecosystems in the project area is known. The alternatives were evaluated using the best available information.

As noted in Chapter 1, the primary issue of controversy identified through scoping, and which required NEPA review, was the BLM's continuing and proposed increase in the use of herbicides in vegetation treatment programs needed to implement the *National Fire Plan* and related initiatives. The use of herbicides has been affirmed as a central issue for analysis in all past EISs considered in this document.

To address issues related to the use of herbicides, the BLM prepared human health and ecological risk assessments for 10 herbicides/formulations currently-available to the BLM (bromacil, chlorsulfuron, diuron, sulfometuron methyl, and tebuthiuron), or proposed for future use (diflufenzopyr, diquat, fluridone, imazapic, and Overdrive® [diflufenzopyr in a formulation with dicamba]). The BLM also consulted risk assessments prepared by the Forest Service for nine other herbicides used by the BLM (2,4-D, clopyralid, dicamba, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, and triclopyr). For the remaining six herbicides (2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine), the BLM consulted earlier EISs prepared by the BLM, and the literature developed since 1991, to evaluate the risks from using these six herbicides. These six herbicides would not be used by the BLM under the Preferred Alternative and Alternatives D and E, but could be used if the No Action Alternative was selected.

These risk assessments were developed in cooperation with the USEPA, USFWS, and NOAA Fisheries, and are considered state-of-the-art. As such, they address many of the risks that would be faced by humans, plants, and animals, including TES species, from the use of these herbicides, and supercede risk assessments prepared by the BLM for the previous vegetation treatment EISs.

To assess risks to other resources from the use of herbicides, the BLM consulted information in the risk assessments and supporting documentation (see Appendices B and C and supporting Human Health and Ecological Risk Assessment reports); state, federal, and local databases, Geographic Information System (GIS) themes, and contract reports; subject experts within and outside of the BLM; and the current literature.

While additional information may add precision to estimates or better specify relationships, more information is unlikely to significantly change the understanding of relationships that form the basis of the evaluation of effects.

Subsequent Analysis before Projects

Before site-specific actions are implemented and an irreversible commitment of resources made, information essential to those fine-scale decisions will be obtained by the local land managers. Localized data and information will be used to supplement or refine regional-level data and identify methods and procedures best suited to local conditions in order to achieve the objectives in this PEIS. Further analysis may be necessary to deal with site-specific conditions and processes. For example, mitigation measures identified in the following sections would be appropriate for protection under the wide range of conditions that must be considered at the programmatic level of analysis. However, by considering more site-specific parameters, such as soil and vegetation type and amount of rainfall, the BLM may be able to use less restrictive mitigation measures and still ensure adequate protection of the resource. This subsequent analysis will be used to bridge the gap between broad-scale direction and site-specific decisions. This "step-down" analysis is described in Chapter 1 and shown in Figure 1-1.

Land Use

As discussed in Chapter 1, several federal laws, regulations, and policies guide BLM management activities on public lands. These include the *FLPMA of 1976* that directs the BLM to manage public lands "in a manner that will protect the quality of scientific, scenic, historic, ecological, environmental, air and atmospheric, water resources and archeological values" and to develop resource management plans consistent with those of state and local governments to the extent that BLM programs also comply with federal laws and regulations. The *Taylor Grazing Act of 1934* introduced federal protection and management of public lands by regulating grazing on public lands. The *Oregon and California Grant Lands Act of 1937* provides for the management of the revested Oregon and California and reconveyed Coos Bay Wagon Road grant lands for permanent forest production under the principle of sustained yield and for leasing of lands for grazing.

Management actions on public lands are guided by LUPs. Land use plan decisions establish goals and objectives for resource management, the measures needed to achieve these goals and objectives, and parameters for using public lands (USDI BLM 2000g). As discussed in Chapter 1, land use planning occurs at several levels. Planning at multiple levels allows the BLM to tailor decisions to specific needs and circumstances. The broadest level, which this PEIS represents, is a national-level programmatic study. This level of study contains broad regional descriptions of resources, provides a broad environmental impact analysis, including cumulative impacts, focuses on general policies, and provides Bureau-wide decisions on herbicide use and other available tools for vegetation management. Additionally, it provides an umbrella ESA Section 7 consultation for the broad range of activities described in the PEIS.

At the national level, this PEIS and the PER identify broad management goals and evaluate resource issues of national interest. This PEIS assumes that vegetation treatments would occur on approximately 6 million acres annually, that treatments would focus on areas with high levels of hazardous fuels and unwanted vegetation, that land uses would comply with the intent of Congress as stated in the FLPMA (43 U.S.C. 1701 *et seq.)*, and that future land uses would be similar to those that currently occur on public lands. Based on these evaluations, modifications to existing land uses could occur at lower levels, primarily the field office level, based on recommendations in the PEIS and PER.

Air Quality

Air quality is the measure of the atmospheric concentration of defined pollutants in a specific area. Air quality is affected by pollutant emissions sources, as well as the movement of pollutants in the air via wind and other weather patterns. Air quality standards have been designated in the U.S. to prevent significant human health and welfare impacts caused by pollutants in the air. The Clean Air Act, as amended in 1990, establishes a mandate to reduce emissions of specific pollutants via uniform federal standards. As the agency responsible for implementing the Act, the USEPA established the NAAQS for six pollutants to protect public health and welfare. These criteria pollutants are SO_2, NO_2, CO, O_3, lead, PM_{10}, and $PM_{2.5}$. In addition, PSD regulations, implemented as part of the New Source Review program, guide permitting officials in limiting potential air quality impacts above legally defined baseline levels (USEPA 2004). In essence, established facilities with new major pollutant sources that were previously in attainment of the NAAQS (or were unclassifiable with respect to these standards) are still considered to have acceptable emissions levels if the potential cumulative impacts do not exceed these guideline PSD significance levels. Prevention of Significant Deterioration levels are used in this analysis as criteria to indicate whether the herbicide use alternatives would significantly affect air quality.

The majority of the area covered by this PEIS meets existing air quality standards; however, there are several counties (or portions of counties) where air pollutants exceed maximum levels of one or more of the NAAQS (see Table 3-2). In addition, the Clean Air Act stipulates that the air quality of most areas should not significantly deteriorate; therefore, this PEIS considers the contribution of proposed herbicide treatment alternatives to levels of the above mentioned criteria pollutants.

Scoping Comments and Other Issues Evaluated in the Assessment

In line with scoping comments, this section assesses the effects of herbicide treatments on air pollutants and consequent effects on visibility and NAAQS. Most scoping comments were related to the impacts of smoke from prescribed burning treatments on air quality. Specifically, comments called for an evaluation of the cumulative effects of smoke and an evaluation of the human health effects of smoke, particularly on asthmatics and in non-attainment zones (areas with levels of one or more criteria pollutants greater than the NAAQS). The impacts of prescribed burning on air quality are discussed in the PER (USDI BLM 2005b).

Emissions Sources

The potential impacts of herbicide use on air quality originate primarily from ground vehicle (truck, all-terrain vehicle [ATV], and boat) and aircraft (plane and helicopter) emissions, as well as fugitive dust (dust created by vehicle travel on unpaved roads) resulting from herbicide transport and application. These impacts are discussed in this section. In addition, spray drift (movement of herbicide in the air to unintended locations) and volatilization (the evaporation of liquid to gas) of applied herbicides temporarily results in herbicide particles in the air, which can be inhaled and deposited on skin or plant surfaces and affect humans, wildlife, and non-target plants. Herbicide particles can be transported away from the target location, depending on weather conditions and the herbicide application method. Spray drift and other off-site herbicide transport processes (e.g., wind blown dust) are discussed briefly in this section and more specifically in the following sections related to risks to humans, wildlife, non-target plants, and other resources.

Methodology for Assessing Impacts to Air Quality

Vehicle Use Emissions

This analysis includes annual emissions for the proposed alternatives and treatments by state for the following compounds: CO, total suspended particles (TSP), PM_{10}, $PM_{2.5}$, NO_2, and VOCs. Lead and SO_2 emissions should not occur, or occur in trace amounts, as a result of herbicide treatments using vehicles and aircraft.

Exhaust emission factors were determined using vehicle data provided by the USDI BLM and the USEPA's Compilation of Air Pollutant Emission Factors (USEPA 1995a). Emission factors for the fugitive dust from the roads (assumed to be unpaved) were determined from trip mileage and soil properties provided by the BLM and the USEPA's Compilation of Air Pollutant Emission Factors (USEPA 2003a). All other emissions that would occur during herbicide treatments would be negligible, and are not included in the annual emissions computations for each treatment alternative.

To estimate the potential annual emissions that would result from herbicide treatment for each state, the amount of annual acres assumed to be treated by each of the five herbicide spraying methods (helicopter, fixed-wing plane, truck, ATV, and backpack) was first calculated by estimating the total number of chemical treatment acres for each state by alternative action (Table 4-1). The number of acres treated in each state is an approximation, based on field data compiled for this analysis. To calculate the annual number of events for each treatment method by state, the estimated annual number of acres treated was divided by the total acreage per single treatment event. The annual air pollutant emissions from herbicide treatments for each state were then predicted.

Exhaust Emissions from Transportation Vehicles

To predict the annual vehicle emissions from each treatment method, the exhaust emissions for a single event were multiplied by the annual number of events per state for each method. The amount of pollutant emissions due to exhaust from transportation vehicles was calculated using the procedures (e.g., regarding trip mileage, vehicle type) described in the *Annual Emissions Inventory for BLM Vegetation Treatment Alternatives (*ENSR 2005a).

Particulate Emissions from Unpaved Roads

To predict the particulate emissions from travel on unpaved roads, the emissions for a single event were multiplied by the annual number of events per state for each method. The amount of pollutant emissions due to exhaust from unpaved roads and vehicles was calculated using the procedures (e.g., soil properties) described in ENSR (2005a).

Total Annual Chemical Treatment Emissions

The annual pollutant emissions from vehicle exhaust and fugitive dust were combined for each method. The resulting annual emissions for each method were then summed, yielding the total predicted emission by state and alternative (Tables 4-2 to 4-5). Because the proposed number of acres to be treated by state and alternative is subject to change, so are the estimated annual emissions, as they are directly dependent on the number of acres treated. The total estimated emissions were then compared to the PSD emission source modeling threshold significance level. Under the PSD program, if potential emissions for a given source and pollutant are less than the designated PSD level of 250

TABLE 4-1
Estimated Acres Treated Annually for Each State under Each Treatment Alternative

State	Treatment Alternative				
	A	B	C	D	E
Alaska	0	0	0	0	0
Arizona	9,960	36,300	0	23,595	18,150
California	5,060	5,620	0	3,935	2,810
Colorado	7,770	20,960	0	13,625	10,480
Idaho	57,100	258,990	0	168,345	129,480
Montana	23,190	53,160	0	34,555	26,580
Nebraska	0	0	0	0	0
Nevada	24,970	206,560	0	82,625	103,270
New Mexico	96,620	88,600	0	35,440	44,295
North Dakota	10	10	0	10	5
Oklahoma	0	0	0	0	0
Oregon (Total)	20,960	70,280	0	26,000	35,135
Eastern	8,380	28,110	0	10,400	14,055
Western	12,570	42,170	0	15,600	21,080
South Dakota	1,030	1,600	0	640	800
Texas	0	11,830	0	7,100	5,915
Utah	21,660	20,480	0	15,360	10,240
Washington	1,940	4,640	0	3,015	2,320
Wyoming	35,130	152,820	0	114,615	76,400
Total	305,400	931,850	0	528,860	465,880

tpy, then these emissions are assumed to not be likely to significantly impact air quality. This is a conservative assumption given that PSD levels are designed to apply to a single facility or a group of facilities, whereas the total predicted pollutant emissions presented here would be spread throughout an entire state or region.

CALPUFF Modeling

The USEPA's guideline California Puff (CALPUFF) "lite" air pollutant dispersion model (referenced in Appendix W of 40 CFR Part 51) was also used to provide an example of potential PM (TSP, PM_{10}, and $PM_{2.5}$) impacts resulting from assumed herbicide application methods. Since most criteria pollutant emissions were so low, only example PM impacts were modeled. The total fugitive dust particulate emissions per truck spraying event (10 acres sprayed over 8 hours) were used to estimate maximum daily emission rates in the CALPUFF modeling analysis. Because vehicles traveling on unpaved roads emit the most PM (dust), and the truck spray scenario includes the most travel on dirt roads, this scenario was conservatively used so that modeling would predict the maximum potential impacts. Activities related to airplane and helicopter aerial spraying, ATV spraying, and backpack spraying would be less significant than truck spraying, and therefore are not included in the example modeling. Chemical treatment example modeling was conducted for five representative locations: Tucson International Airport (Arizona), Glasgow International Airport (Montana), Winnemucca Weather Service Office Airport (Nevada), Medford/Jackson County Airport (Oregon), and Lander/Hunt Field (Wyoming).

Total PM emissions were calculated for each treatment "event," and then divided by the number of days per event in order to determine daily TSP, PM_{10}, and $PM_{2.5}$ emissions. The daily emissions were modeled using CALPUFF "lite" based on a full year of meteorological conditions to predict the maximum air quality impacts likely to occur. The maximum potential impact period was defined as those consecutive days (excluding months when treatment activity is unlikely) during which the highest short-term impacts were predicted to occur. Once the period of maximum potential impact was established, CALPUFF "lite" was re-run, with daily emissions occurring only during that period, to determine both short-term and annual impacts (assuming one herbicide treatment event in each location per year). Because only one event was modeled per year, the results are provided as an example of the maximum emission concentrations resulting from a single annual herbicide treatment event.

TABLE 4-2
Annual Emissions Summary for Herbicide Treatments under Alternative A

State	Pollutant (tons per year)					
	CO	NO_X	TSP	PM_{10}	$PM_{2.5}$	VOCs
Alaska	0.00	0.00	0.00	0.00	0.00	0.00
Arizona	0.93	0.11	4.02	0.85	0.12	0.07
California	0.49	0.06	2.14	0.45	0.06	0.03
Colorado	0.76	0.09	1.81	0.40	0.05	0.07
Idaho	5.34	0.64	13.30	2.91	0.37	0.38
Montana	2.17	0.26	5.05	1.13	0.14	0.15
Nebraska	0.00	0.00	0.00	0.00	0.00	0.00
Nevada	1.31	0.15	5.76	1.23	0.17	0.09
New Mexico	5.29	0.59	19.33	4.33	0.59	0.44
North Dakota	0.00	0.00	0.00	0.00	0.00	0.00
Oklahoma	0.00	0.00	0.00	0.00	0.00	0.00
Oregon (Total)	1.97	0.22	10.37	2.47	0.35	0.14
Eastern	0.81	0.10	2.55	0.56	0.07	0.06
Western	1.15	0.13	7.82	1.91	0.27	0.08
South Dakota	0.05	0.01	0.13	0.03	0.01	0.00
Texas	0.00	0.00	0.00	0.00	0.00	0.00
Utah	2.57	0.30	9.05	1.99	0.27	0.22
Washington	0.18	0.02	0.42	0.09	0.01	0.01
Wyoming	2.57	0.30	6.02	1.31	0.17	0.22
Total	23.63	2.75	77.40	17.19	2.31	1.82

Comparison to Air Quality Standards

The short-term air quality impacts, as predicted using CALPUFF "lite," were compared to the applicable NAAQS as a threshold of significance (Table 4-6). Potential direct air quality impacts for TSP, PM_{10}, and $PM_{2.5}$ predicted using CALPUFF "lite" were added to a representative rural background concentration, and then compared to the NAAQS to determine if the example treatment method scenarios would be likely to exceed any NAAQS due to a single herbicide spraying event. No such exceedances of the applicable threshold values were predicted.

Spray Drift and Volatilization

Spray drift from various herbicide application methods is assessed using the model AgDRIFT® Version 2.0.05 (SDTF 2002), a product of a Cooperative Research and Development Agreement between the USEPA's Office of Research and Development and the Spray Drift Task Force (SDTF, a coalition of pesticide registrants). Maximum herbicide concentrations by particle size were predicted at increasing distances from the point of application 24 hours after treatment. These concentrations were modeled for the five representative locations described above, and averaged to present the potential effects of spray drift. Toxic risks to humans, wildlife, and non-target plants and other resources potentially affected by drift are presented in the relevant sections of this chapter.

Standard Operating Procedures

The BLM has developed several management practices to minimize the potential adverse effects of herbicide use on air quality. These management practices are based on direction in BLM air quality, chemical pest control, and weed management manuals (e.g., manuals 7000 and 9011) and handbooks (e.g., H-9011-1; USDI BLM 1988e). Most of this guidance is related to the effects of spray drift or other forms of wind transport of herbicides. For example, guidance on spray particle size, wind velocity and direction, height of spray boom, herbicide formulation, and drift control spray systems is presented with respect to their effects on spray drift and non-target species. The following SOPs have been developed to guide herbicide applications to minimize the effects on air quality:

- Consider the effects of wind, humidity, temperature inversions, and heavy rainfall on herbicide effectiveness and risks.

TABLE 4-3
Annual Emissions Summary for Herbicide Treatments under Alternative B

State	Pollutant (tons per year)					
	CO	NO_X	TSP	PM_{10}	$PM_{2.5}$	VOCs
Alaska	0.00	0.00	0.00	0.00	0.00	0.00
Arizona	3.40	0.41	14.66	3.09	0.42	0.24
California	0.54	0.06	2.37	0.50	0.07	0.04
Colorado	2.06	0.24	4.88	1.07	0.14	0.18
Idaho	24.22	2.92	60.35	13.18	1.67	1.71
Montana	4.97	0.60	11.58	2.58	0.32	0.35
Nebraska	0.00	0.00	0.00	0.00	0.00	0.00
Nevada	10.81	1.26	47.63	10.18	1.39	0.75
New Mexico	4.85	0.54	17.73	3.97	0.54	0.40
North Dakota	0.00	0.00	0.00	0.00	0.00	0.00
Oklahoma	0.00	0.00	0.00	0.00	0.00	0.00
Oregon (Total)	5.00	0.57	28.77	6.97	0.99	0.34
Eastern	1.31	0.15	2.55	0.56	0.07	0.09
Western	3.87	0.43	26.22	6.40	0.91	0.26
South Dakota	0.08	0.01	0.20	0.05	0.01	0.01
Texas	1.07	0.13	2.46	0.55	0.07	0.08
Utah	2.42	0.28	8.56	1.88	0.25	0.21
Washington	0.43	0.05	1.01	0.23	0.03	0.03
Wyoming	2.42	0.28	5.69	1.24	0.16	0.21
Total	62.27	7.35	205.89	45.49	6.06	4.55

- Apply herbicides in favorable weather conditions to minimize drift. For example, do not treat when winds exceed 10 mph (6 mph for aerial applications) or rainfall is imminent.
- Use drift reduction agents, as appropriate, to reduce the drift hazard.
- Select proper application equipment (e.g., spray equipment that produces 200- to 800-micron diameter droplets [spray droplets of 100 microns and less are most prone to drift]).
- Select proper application methods (e.g., set maximum spray heights, use appropriate buffer distances between spray sites and non-target resources).

The analysis of potential air quality impacts assumes that guidance provided in BLM manuals, handbooks, and SOP's would be followed during herbicide treatment activities.

Impacts by Alternative

Impacts Common to All Alternatives

The potential impacts from herbicide applications on local and regional air quality would be minor for each treatment alternative. None of the predicted annual emissions by pollutant, state, or herbicide treatment alternatives (A, B, D, and E) would exceed PSD annual emission significance thresholds. Furthermore, the total emissions from all the states, for each pollutant under each alternative, are less than 25% of the PSD threshold (250 tons per year) for a single facility. Comparing the total emissions produced by all the states to the PSD threshold is especially conservative because the PSD threshold is designed to apply to one facility or a group of facilities and not entire states. For each treatment alternative, potential emissions would be highest in states with higher treatment acres for each alternative. In addition, all PM concentrations resulting from a single example herbicide spraying event modeled using CALPUFF "lite" are substantially lower than NAAQS thresholds at the five representative locations, and predicted concentrations are at least four orders of magnitude smaller than assumed background

TABLE 4-4
Annual Emissions Summary for Herbicide Treatments under Alternative D

State	Pollutant (tons)					
	CO	NO_X	TSP	PM_{10}	$PM_{2.5}$	VOCs
Alaska	0.00	0.00	0.00	0.00	0.00	0.00
Arizona	1.75	0.14	14.45	3.05	0.42	0.10
California	0.56	0.07	2.41	0.51	0.07	0.04
Colorado	2.49	0.24	5.74	1.21	0.15	0.18
Idaho	25.63	3.63	63.68	13.86	1.76	1.95
Montana	5.15	0.61	11.88	2.63	0.33	0.36
Nebraska	0.00	0.00	0.00	0.00	0.00	0.00
Nevada	13.46	2.16	57.73	12.08	1.64	1.09
New Mexico	6.37	1.05	21.26	4.70	0.63	0.78
North Dakota	0.00	0.00	0.003	0.00	0.00	0.00
Oklahoma	0.00	0.00	0.00	0.00	0.00	0.00
Oregon (Total)	3.89	0.40	20.55	4.81	0.67	0.26
Eastern	1.39	0.15	4.26	0.93	0.12	0.09
Western	2.50	0.25	16.29	3.88	0.55	0.16
South Dakota	0.10	0.01	0.23	0.05	0.01	0.01
Texas	1.11	0.13	2.54	0.56	0.07	0.78
Utah	2.63	0.29	9.17	1.98	0.27	0.22
Washington	0.50	0.05	1.13	0.25	0.03	0.03
Wyoming	19.84	2.07	46.05	9.80	1.23	1.55
Total	83.48	108.50	256.82	55.49	7.28	7.35

concentrations (Table 4-6). Concentrations will vary by alternative based on the number of treatment events.

Under the proposed alternatives, atmospheric concentrations of herbicides (predicted by particle size) resulting from spray drift from aerial, ground vehicle, and hand application would be temporary in nature (most predominant at the time and location of treatment) and are not predicted to significantly impact air quality. Maximum average modeled herbicide concentrations from all five example modeling locations, 24 hours after treatment, were modeled presented at various distances from the point of application. Herbicide concentrations in the air tend to increase up to 1.5 kilometers (km; 0.93 mi) from the point of application (concentrations may double between 0.6 and 1.5 km (0.37 and 0.93 mi) from the application site), but then these concentrations tend to decrease slowly at greater distances.

Chemical volatilization is also temporary in nature, and none of the herbicides proposed for use are likely to result in substantial volatilization from soils. Chemical vapor pressure (the pressure exerted by a vapor in equilibrium with its solid or liquid phase) largely affects the potential for volatilization of applied herbicides. Based on their vapor pressures, bromacil, diflufenzopyr (Lyman et al. 1990; National Library of Medicine 2002), diquat (National Library of Medicine 2003), diuron (Lyman et al. 1990; Mackay et al. 1997), sulfometuron methyl (Lyman et al. 1990; National Library of Medicine 2003), and tebuthiuron (Tomlin 1994) are not expected to volatilize from dry or wet soil surfaces. Vapor pressure values are not available for imazapic; however, according to Tu et al. (2001), volatilization of imazapic from terrestrial systems is insignificant. Fluridone might volatilize slowly from wet soil surfaces, but volatilization from dry soils would not be expected (Lyman et al. 1990; Mackay et al. 1997; National Library of Medicine 2002). In addition, dicamba may volatilize from soil surfaces, but this is not considered likely unless it has been exposed at the soil surface under hot and dry conditions for several weeks (USDI BLM 1988e). Therefore, application of the evaluated herbicides would not impact air quality through volatilization.

TABLE 4-5
Annual Emissions Summary for Herbicide Treatments under Alternative E

State	Pollutant (tons)					
	CO	NO_X	TSP	PM_{10}	$PM_{2.5}$	VOCs
Alaska	0.00	0.00	0.00	0.00	0.00	0.00
Arizona	1.70	0.20	7.33	1.54	0.21	0.12
California	0.27	0.03	1.18	0.25	0.03	0.02
Colorado	1.03	0.12	2.44	0.53	0.07	0.09
Idaho	12.12	1.46	30.17	6.59	0.84	0.86
Montana	2.49	0.30	5.79	1.29	0.16	0.18
Nebraska	0.00	0.00	0.00	0.00	0.00	0.00
Nevada	5.41	0.63	23.81	5.09	0.70	0.38
New Mexico	2.43	0.27	8.86	1.98	0.27	0.20
North Dakota	0.00	0.00	0.00	0.00	0.00	0.00
Oklahoma	0.00	0.00	0.00	0.00	0.00	0.00
Oregon (Total)	3.32	0.38	17.48	4.17	0.58	0.23
Eastern	1.39	0.16	4.36	0.97	0.13	0.10
Western	1.94	0.21	13.11	3.20	0.46	0.13
South Dakota	0.04	0.00	0.10	0.02	0.00	0.00
Texas	0.53	0.07	1.23	0.27	0.03	0.04
Utah	1.21	0.14	4.28	0.94	0.13	0.10
Washington	0.22	0.03	0.51	0.11	0.01	0.02
Wyoming	1.21	0.14	2.85	0.62	0.08	0.10
Total	31.98	3.77	106.03	23.40	3.11	2.34

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, following the current vegetation management program, approximately 305,000 acres would be treated with herbicides each year (Table 2-5). This is the lowest acreage of all treatment alternatives and would result in approximately 77 tpy of TSP, 24 tpy of CO, and 17 tpy of PM_{10} emissions, with all other pollutants having emissions totaling less than 3 tpy (Table 4-2). These emissions are lower than all other alternatives. In general, emissions would be greatest in states where more acres are treated (e.g., Idaho, New Mexico, Utah, and Wyoming).

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Under the Preferred Alternative, an estimated 932,000 acres would be treated using herbicides annually. As this is the alternative with the highest number of acres treated, it also results in the highest pollutant emissions (206 tpy TSP, 62 tpy CO, and 45 tpy PM_{10}; Table 4-3)—over 2 times the expected emissions of the No Action Alternative. Again, these emissions would dominate in states with the highest number of acres treated. Herbicide treatments in Idaho and Nevada account for half of the acreage of proposed herbicide treatments under the Preferred Alternative, and they result in over half of the predicted annual emissions.

Alternative C – No Use of Herbicides

Under Alternative C, herbicides would not be used for vegetation management. There would be no emissions associated with this alternative and this alternative would not impact air quality. As with all alternatives, other treatment methods (fire use and mechanical, manual, and biological control methods) would also emit pollutants as discussed in the PER.

Alternative D – No Aerial Applications

Under Alternative D, about 529,000 acres would be treated annually using ground application methods alone. Although about 40% fewer acres would be treated under this alternative than under the Preferred Alternative, Alternative D would generate the greater amount of pollutant emissions (Table 4-4). Alternative D would result in approximately 257 tpy TSP, 83 tpy of CO emissions, and 55 tpy of PM_{10} emissions, which are more than 20% greater than the pollutant emissions

TABLE 4-6
Example NAAQS Compliance Analysis for Chemical Treatment

Location	Pollutant	Averaging Period	CALPUFF Concentration (μg/m³)	Background Concentration[1] (μg/m³)	Total Concentration (μg/m³)	NAAQS Standard[2] (μg/m³)
Tucson, Arizona	TSP	24-hour	2.79E-04	40	40	NA
		Annual	7.65E-07	11	11	NA
	PM_{10}	24-hour	5.47E-04	30	30	150
		Annual	1.50E-06	8	8	50
	$PM_{2.5}$	24-hour	7.21E-05	30	30	65
		Annual	1.97E-07	8	8	15
Glasgow, Montana	TSP	24-hour	1.06E-04	40	40	NA
		Annual	2.90E-07	11	11	NA
	PM_{10}	24-hour	2.36E-04	30	30	150
		Annual	6.48E-07	8	8	50
	$PM_{2.5}$	24-hour	2.82E-05	30	30	65
		Annual	7.74E-08	8	8	15
Winnemucca, Nevada	TSP	24-hour	1.36E-04	40	40	NA
		Annual	3.72E-07	11	11	NA
	PM_{10}	24-hour	2.72E-04	30	30	150
		Annual	7.44E-07	8	8	50
	$PM_{2.5}$	24-hour	3.60E-05	30	30	65
		Annual	9.85E-08	8	8	15
Medford, Oregon	TSP	24-hour	3.75E-03	40	40	NA
		Annual	1.04E-05	11	11	NA
	PM_{10}	24-hour	8.20E-03	30	30	150
		Annual	2.28E-05	8	8	50
	$PM_{2.5}$	24-hour	1.14E-03	30	30	65
		Annual	3.19E-06	8	8	15
Lander, Wyoming	TSP	24-hour	6.08E-05	40	40	NA
		Annual	1.67E-07	11	11	NA
	PM_{10}	24-hour	1.37E-04	30	30	150
		Annual	3.75E-07	8	8	50
	$PM_{2.5}$	24-hour	1.72E-05	30	30	65
		Annual	4.70E-08	8	8	15

[1] PM_{10} Data from Table 6.1 of the Montana Modeling Guideline for Air Quality Permits (November 2002; Montana Department of Environmental Quality [2002]). TSP concentrations calculated by multiplying PM_{10} data by 1.33. PM_{10} concentrations are also conservatively used as background concentrations for $PM_{2.5}$.
[2] None of the states analyzed have ambient air quality standards for TSP.
NA = Not applicable.

resulting from the Preferred Alternative. This increase would be due to greater engine emissions from ground vehicle use (in the absence of aerial spraying) and related increases in fugitive dust emissions from dirt roads. None of the states analyzed have ambient air quality standards for TSP, and all other emissions for this alternative (and for each state) would be below the PSD emission significance threshold of 250 tpy. However, because the potential for spray drift is usually highest in aerial applications, drift per acre of application would likely be lower for Alternative D than for alternatives A, B, and E (spray drift is also largely dependent on weather conditions such as wind speed, temperature, and precipitation). See the Vegetation, Fish and Other Aquatic Resources, Wildlife Resources, and Human Health and Safety sections for the potential toxic effects of spray drift on humans, non-target plants, and animals.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

Under Alternative E, approximately 466,000 acres would be treated annually using herbicides. Particulate emissions under Alternative E (106 tpy TSP, 32 tpy CO, and 23 tpy PM_{10}; Table 4-5) are about twice those under the current vegetation management program (No Action Alternative). Half of the acreage treated would be in Idaho and Nevada, which would experience slightly more than half (53%) of the emissions under Alternative E.

Mitigation for Herbicide Treatment Impacts

No mitigation measures are proposed for air quality.

Soil Resources

Introduction

Soil refers to the loose material composed of weathered rock and other minerals and partly decayed organic matter that covers large parts of land surfaces. Soil provides habitats for a great variety of organisms, functions as an essential component of terrestrial ecosystems, and is the essential medium for plant growth (Wild 1993). Healthy soil is fundamental to high functioning ecosystems and contains a diverse, thriving community of organisms adapted to life in the soil environment. In addition, soil functions to protect down-gradient ecosystems by functioning as a physical and biological filter of chemicals in the environment.

Noxious weeds and other invasive vegetation can impact soil function. The amount of moisture in the soil can be altered if infiltration is reduced and runoff increased on sites dominated by weeds (Lacey et al. 1989). Many noxious weeds have relatively sparse canopies, which allow for greater evaporation from the exposed soil than on sites with dense vegetative cover. Sites infested with weeds often have more extreme soil temperatures that can alter soil moisture regimes. Noxious weeds may alter soil nutrient availability for native species, and slow the rate of natural plant succession (Olson 1999). Some weeds also produce toxins or allelopathic compounds that can suppress growth and germination of other plants (Kelsye and Bedunah 1989).

Herbicide applications inevitably result in contact with soils, intentionally for systemic treatments, or unintentionally either as spills, overspray, spray drift, or windblown dust. In addition to direct application, transmission to soil may occur when an herbicide is transported through the plant from sprayed aboveground portions to roots, where it may be released into soil. Also, some herbicides remain active in plant tissue and can be released into the soil during plant decay and result in residual herbicide activity.

Scoping Comments and Other Issues Evaluated in the Assessment

Commentors encouraged the BLM to focus vegetation management within the structure of achieving long-term ecosystem sustainability and maintaining biological diversity. In a general sense, soil health is a keystone factor to maintaining ecosystem sustainability. Concerns were voiced for evaluating groundwater protection, and certain soil characteristics play a role in attenuating the risk of groundwater contamination.

There was considerable concern that the PEIS address herbicide fate and transport, such as runoff, overspray, drift, and drift of wind-eroded soil. One respondent recommended measuring organochlorine residues in soil. Other respondents felt that disturbances to biological soil crusts should be eliminated, sites where the crust species are locally extinct must be re-inoculated, and signs should be placed alongside trails to educate hikers about biological soil crusts.

Standard Operating Procedures

The BLM would implement several SOPs to reduce impacts to soil. These include procedures to 1) minimize treating areas where herbicide runoff is likely, such as steep slopes when heavy rainfall is expected; 2) minimize use of herbicides with high soil mobility, such as in areas where soil type would contribute to soil mobility; and 3) not apply granular herbicides on slopes of more than 15% where there is the possibility of runoff carrying the granules into non-target areas.

Factors that Influence the Fate, Transport, and Persistence of Herbicides in Soil

The fate and transport of herbicides in soil is a function of their interaction with the soil environment and is generally considered a complex process (Bovey 2001). Chemical, physical, and biological soil processes influence herbicide availability, phytotoxicity, and fate and transport (Anderson 1983). Herbicides dissipate from soils by transport with water or wind, through chemical or biological degradation processes, or by immobilization through adsorption onto soil surfaces.

Chemical Processes

Adsorption

Adsorption to soil surfaces is probably the most influential factor on the fate and transport of herbicides in soils (Chiou and Kile 2000). Adsorption in soils is the process whereby ions and molecules are bonded to the surface of soil colloids due to the electrical attraction between themselves and the colloidal particles. All soil-applied herbicides are adsorbed to some extent. Adsorption occurs onto clay particles and onto both the solid and dissolved form of organic matter. Adsorption affects herbicide mobility and availability to plants and other organisms, which in turn influences herbicide fate.

The organic carbon-water partitioning coefficient (K_{oc}), measures the affinity of a chemical to adsorb to soil organic carbon (a component of soil organic matter) relative to water (Table 4-7). For a given chemical, the greater the K_{oc} value, the less soluble the chemical is in water and the higher affinity the chemical has for soil organic carbon. For most chemicals, a higher affinity for soil organic carbon (greater K_{oc}) results in less mobility in soil. When herbicide active ingredients are very water- soluble (low K_{oc} values), the risk of leaching through soils and transport to surface water and groundwater increases.

Photochemical Decomposition and Chemical Reactions with Soil Constituents

Photodegradation and chemical reactions are common chemical degradation pathways in the environment. Herbicides may degrade in the presence of sunlight, converting to degradation products in a relatively short time. Chemical reactions, including hydrolysis, occur when chemical transformations replace or remove portions of the herbicide active ingredient chemical structure, rendering it inactive.

Physical Processes

Leaching

Leaching through soils is dependent on herbicide use patterns as well as soil texture, total organic carbon in soil, chemical half-life, amount and time of rainfall, and depth to water table. Fine-grained soils inhibit herbicide leaching because of either low vertical permeability through the soil or high soil surface area, both of which enhance adsorption to the solid phase. Coarse-grained soils with low total organic carbon do not adsorb herbicides as readily, and leaching is more likely.

Volatility

Volatilization is the process by which a substance passes from a solid or liquid state to a gaseous state. The volatilization of herbicides applied to soils is of concern when poor weed control occurs due to loss of the herbicides from the soil, or when non-target species injury occurs due to drip of the vapors of the herbicides. None of the herbicides proposed for use are likely to result in substantial volatilization from soils.

Herbicide movement in soil depends on concentration, as well as on the physical status of soil, especially soil moisture content, organic matter content, and temperature.

Generally, herbicides may be moved from the application area with water runoff, or be leached through soil by rainwater infiltration and potentially reach the groundwater. Herbicide transport in runoff is usually greatest in areas with poorly infiltrating soils, flooding, and steep slopes. Poorly infiltrating soil includes compacted soil, soil with a non-biological surface crust, and fine textured soil, such as clay and clay loam.

Transport with Water or Wind

Herbicide transport includes movement with water or wind.

Wind can transport herbicides that have adsorbed to particles. The potential for wind blown transport depends on the weather and condition of the soil. Fine sand or silty textured soils, low soil stability, soil disturbance, and dryness all increase the risk for wind erosion of herbicide-containing particles.

Biological Processes

For best results, herbicides must remain in soils in an active and available form until their purpose is accomplished. Herbicidal activity is desirable, however, only until the time that the herbicides have achieved their intended effect; longer persistence may pose a hazard to subsequent land use (Anderson 1983).

TABLE 4-7
Estimated Soil Half-life and Adsorption Affinity for Active Ingredients

Herbicide	Soil Half-life (days)	Soil Adsorption (K_{oc})
2,4-D	10	20 m/g (acid/salt), 100 mL/g (ester)
2,4-DP	10	1,000 mL/g
Asulam	7	40 mL/g
Atrazine	60	100 mL/g
Bromacil	60	32 mL/g
Chlorsulfuron	40	40 mL/g
Clopyralid	40	6 mL/g, ranges to 60 mL/g
Dicamba, sodium salt, or dimethylamine salt	14	2 mL/g
Diflufenzopyr, sodium salt	2 to 14	18 to 156 mL/g
Diquat	1,000	1,000,000 mL/g
Diuron	90	480 mL/g
Fluridone	21	1,000 mL/g
Fosamine	8	150 mL/g
Glyphosate	47	24,000 mL/g
Hexazinone	90	54 mL/g
Imazapic	120 to 140	206 mL/g
Imazapyr	25 to 141	1,000 mL/g
Mefluidide	4	200 mL/g
Metsulfuron methyl	30	35 mL/g
Picloram	90	16 mg/L
Simazine	60	130 mL/g
Sulfometuron methyl	20	78 mL/g
Tebuthiuron	360	80 mL/g
Triclopyr	46	20 mL/g (salt), 780 mL/g (ester)
Source: Vogue et al. (1994).		

The length of time that an herbicide remains active in soils is called soil persistence or soil residual life. The half-life is the time it takes for half of the mass of an herbicide to disappear. The half-life can vary widely in soil, with some times as short as a matter of days and others taking years (Table 4-7). Chemical characteristics of the herbicide, as well as soil characteristics, especially moisture, temperature, organic matter, and the type and activity of soil organisms influence herbicide half-lives.

Soil microorganisms can sometimes degrade herbicide active ingredients. Moderate temperatures, organic material, and adequate moisture result in biologically active soils with large populations of soil microorganisms usually including capabilities for biodegradation. In contrast, soils that are very dry or wet, very cold or hot, or have low organic matter generally have less biological activity and smaller populations of active soil microorganisms.

Impacts by Treatment

The following discusses impacts to soil from herbicides currently used by the BLM and from herbicides proposed for use. This assessment of impacts assumes that SOPs (see Table 2-6) are followed. SOPs are designed to reduce potential unintended impacts to soil. These procedures include using the lowest effective application rate; testing smaller areas for unintended consequences prior to treating larger areas; evaluating soil characteristics to determine the likelihood of herbicide transport by runoff, infiltration, or wind; limiting herbicide use on fine-textured and sandy soils, especially where soil can be transported onto adjacent areas potentially harming non-target vegetation; and carefully evaluating the use of herbicides on hot, dry, cold, wet, sodic (containing high levels of sodium), and saline (containing high levels of salts) soils.

Herbicides may indirectly affect soil through plant removal resulting in changes in physical and biological soil parameters. As vegetation is removed, there is less plant material to intercept rainfall and less to contribute organic material to the soil. Loss of plant material and soil organic matter can increase the risk of soil susceptibility to wind and water erosion. The risk for increased erosion would be temporary until vegetation was reestablished. If herbicide treatments lead to revegetation with native plants, soil stability may be improved relative to sites dominated by invasive plants.

There are few studies on herbicide effects on biological soil crusts. Therefore, caution should be used when applying these chemicals to soils supporting biological soil crusts (Belnap et al. 2001) or to areas where management goals include crust recovery.

Youtie et al. (1999) studied the effects of two glyphosate herbicide formulations (Roundup® and Accord®) on moss-dominated biological soil crusts in a native bunch grass community invaded by non-native grasses. Effects were measured by the change between pre- and post-treatment cover. They determined that herbicide treatment showed no short-term impacts on bryophyte (liverworts and moss) cover or species diversity. They also observed that biological crust cover was reduced where annual grass leaf litter accumulated, and that herbicide treatment reduced litter buildup, suggesting that herbicide treatment slowed the loss of crust cover from annual grass invasion. The authors cautioned that removal of annual grasses requires repeated applications of herbicides and that long-term effects were not known.

Gadkari (1988 *cited in* Belnap et al. 2001) observed that a photosynthesis-inhibiting herbicide (simazine) had a significant impact on *Nostoc* (an algal community constituent) growth and nitrogen fixation. Some herbicides appear to inhibit growth and reproduction of green algae when biological crust species are tested under lab conditions (Belnap et al. 2001). Both positive and negative effects have been observed depending on the compound and the species (Metting 1990). Peterson et al. (1994 *cited in* SERA 2004f) showed significant inhibition in growth of three species of cyanobacteria in laboratory exposures using metsulfuron methyl at a concentration of 0.003 mg a.i./L. Of the several common constituents of the crust community, the cyanobacteria, which generally are embedded in the soil, may be more resilient. In contrast, because lichen and moss constituents generally lay above the soil surface, they may be more susceptible to herbicide damage (Belnap 2005).

Impacts of BLM-Evaluated Herbicides

Bromacil

Bromacil can be used as a pre-emergent herbicide and residual soil activity is necessary for this herbicide to be effective. Bromacil is persistent and highly mobile in soil, with a half-life of 124 to 155 days (ENSR 2005b). There is limited research on the toxicity of bromacil to most soil organisms. It biodegrades in anaerobic soil, but biodegradation is slow in aerobic soil with an estimated biodegradation half-life of 275 to 350 days, suggesting possible toxicity for some soil organisms. One soil bacterial isolate has been identified which can biodegrade bromacil (Chaudhry and Cortez 1988).

Chlorsulfuron

Chlorsulfuron rapidly degrades in soil by chemical hydrolysis in acidic soils, but remains relatively stable in neutral soil (ENSR 2005c). The products of the chemical hydrolysis are then biodegraded in soil (Sarmah and Sabadie 2002). Chlorsulfuron soil biodegradation rates are negatively correlated with pH and positively correlated with temperature, soil moisture content, organic matter content, and microbial biomass (James et al. 1999).

Chlorsulfuron has been reported to remain active in soils for more than 1 year after application, especially at low temperatures and high pH (James et al. 1999). In a laboratory study in sandy soil, only 4% of added chlorsulfuron was transformed 126 days after application and high residual concentrations were found in the lower soil profile (Andersen et al. 2001). Sarmah et al. (1999) observed that the rate of chlorsulfuron degradation in alkaline subsoils was slow. They concluded that under conditions conducive to leaching in alkaline systems, prolonged persistence of chlorsulfuron in the soil profile is possible. It is likely that in some soils dissipation rates could be slower than the reported average, including arid soils with high pH and low organic matter.

Chlorsulfuron appears to be only mildly toxic to terrestrial microorganisms and effects are generally transient (SERA 2004a) even though bacteria have an enzyme that is functionally equivalent to the herbicide target enzyme in plants. Biodegradation of chlorsulfuron does occur in some soil systems. For example a bacterial strain (*Pseudomonas fluorescens* strain B2) isolated from soil was able to degrade 32% of added chlorsulfuron within 2 weeks (Zanardini et al. 2002). Rovesti and Desco (1990 *cited in* SERA 2004a) studied two soil nematode species in soil exposed to 312 to 10,000 ppm chlorsulfuron for 72 hours, and no effect was observed on reproduction, viability, and movement.

Diuron

Diuron is highly persistent and has low to moderate mobility in soil (ENSR 2005f). Despite its reported low to moderate soil mobility, diuron is frequently detected in groundwater (Spurlock et al. 2000). Sorption studies of diuron have shown that the proportion of organic matter in soil directly influences the amount of adsorbed diuron. Biodegradation is the major source of diuron attenuation and occurs either under aerobic or anaerobic conditions.

In one study, biodegradation in soil increased with increasing temperature and decreasing initial concentration, while pH had little effect on the degradation rates (ENSR 2005f). Biodegradation does not occur at freezing temperatures. 3,4-dichloraniline (3,4-DCA) is one breakdown product of diuron. 3,4-DCA is also persistent in soil and reportedly exhibits a higher toxicity to some receptors (Tixier et al. 2002; Skogerboe 2003; Giacomazzi and Cochet 2004). In soil, 3,4-DCA can exceed 5.0 μg/kilograms (kg) at typical application rates (Giacomazzi and Cochet 2004). Waterfleas are negatively affected by fairly low concentrations (1.0 μg/L) of 3,4-DCA in water, but it is unknown if effects to crustaceans occur in soil. Widehem et al. (2002) identified a common soil bacteria capable of transforming diuron to 3,4-DCA. In addition, 3,4-DCA was degraded by four fungal species (Tixier et al. 2002).

Diuron had adverse effects on bacterial community structure and on bacterial activity at a concentration of 25 mg/L (Giacomazzi and Cochet 2004). One study showed by molecular techniques that bacterial diversity seemed to decrease in soil treated by diuron or other phenylurea herbicides.

Dicamba

Dicamba is not adsorbed by most soils and is highly mobile. Dicamba is moderately persistent in soil. Biodegradation is its primary fate, with slower rates at lower temperatures and dry soil. It is likely to be more rapidly degraded in soils with high microbial populations, but dissipates more slowly in hardwood forest soils (Voos and Groffman 1997a, b). The slower dissipation in hardwood forest soils is probably attributable to adsorption of dicamba in acidic and highly organic soil horizons. One study reported that dicamba applied at 0.25 lb/ac dissipated from grassland soils in Texas in 4 weeks, and applied at 0.5 lb a.i./ac in 9 to 16 weeks (Bovey 2001). However, when dicamba granules were applied at rates of 1.5 or 1.86 lbs a.i./ac to sand in semiarid grassland, dicamba residues were detected up to 48 inches deep 53 weeks after application. The primary breakdown product of dicamba is 3,6-dichlorosalicylic acid, which adsorbs to soils strongly. Very little information is available on the toxicity of this breakdown product (USDA Forest Service 1999).

Dicamba caused a transient decrease in nitrification after incubation in sandy loam soil at an application rate of 10 mg/kg, but the decrease in nitrification was not substantial and was not observed after 3 weeks of incubation (Tu 1994). In the same study, dicamba did not affect ammonia formation or sulfur oxidation. Martens and Bremner (1993) showed that dicamba did not affect urea hydrolysis or nitrification in four soil types at an application rate of 1 mg/kg. Dicamba did decrease urea hydrolysis by 6% in one of the four soil types and inhibited nitrification in two of the soils at 7 and 14 days, but not at 21 days, after application at a rate of 50 mg a.i./kg soil. After herbicide applications for 24 years, there were no detectable residues of dicamba in soil at two long-term tillage sites and one long-term manured site, probably due to biodegradation and mobility (Miller et al. 1995).

Diflufenzopyr

Biodegradation, photodegradation, and hydrolysis are the primary mechanisms that remove diflufenzopyr from soil. K_{oc} values range from 18 to 156 ml/g. Soil biodegradation and photodegradation half-lives are 14 days or less (USEPA 1999a). Diflufenzopyr appears to be soluble enough that transport in surface runoff is possible, especially in neutral to alkaline soils (ENSR 2005d).

Diquat

Diquat readily adsorbs to soil surfaces, effectively immobilizing the chemical. The amount of diquat adsorbed depends on the type and amount of clay particles present, with soils high in clay adsorbing larger amounts than sandy soils. Sodic and saline soils adsorb reduced amounts (Kookana and Aylmore 1993). Diquat is resistant to anaerobic and aerobic biodegradation, possibly in part because it adsorbs so well to soil particles. There is some evidence that the more loosely bound fraction of diquat may be subject to slow biodegradation (Howard 1991). The half-life of diquat is 3 years or longer (ENSR 2005e).

Fluridone

Fluridone applications target unwanted aquatic vegetation, especially submerged vegetation. Fluridone adsorption to soil increases with clay content, organic matter content, cation exchange capacity, surface area, and decreasing pH (Weber et al. 1986 and Reinert 1989 *cited in* ENSR 2005g). The half-life for fluridone ranges from 44 to 365 days when it is applied on sandy loam, sandy clay loam, and peaty loam soils (10 °C and 18 to 24 °C; Howard 1991). Longer half-lives tend to be associated with dry soils (Malik and Drennan 1990 *cited in* ENSR 2005g). Fluridone can volatilize slowly from wet soil surfaces, but volatilization from dry soils would not be expected (ENSR 2005g).

The toxicity of fluridone to earthworms has been measured and no mortality was seen in direct exposures up to 103 mg/L (103 ppm; ENSR 2005g); this concentration is approximately 1,000 times greater than the expected soil concentration in a typical use application.

Imazapic

Imazapic is moderately persistent in soils and has not been found to move laterally with surface water. Imazapic has a half-life of 120 to 140 days in soil (Tu et al. 2001), with most imazapic lost through biodegradation. Sorption to soil increases with decreasing pH and increasing organic matter and clay content. Little is known concerning the effects of imazapic on soil organisms or processes (ENSR 2005h).

In the risk assessment for imazapic (SERA 2004d), Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) modeling estimated the proportion of the applied imazapic lost by runoff for clay, loam, and sand at rainfall rates ranging from 5 to 250 inches per year. Runoff would be negligible in relatively arid environments as well as sandy or loam soils. In clay soils, which have the highest runoff potential, off-site loss may reach up to 3.5% of the applied amount in regions with very high rainfall rates. The model showed that as rainfall rate increased, maximum soil concentrations were reduced because of imazapic losses from soil through percolation or runoff. Modeling also showed that longer-term concentrations in soil varied substantially with rainfall rates, ranging from about 1 to 2 mg a.i./kg soil in very arid soils to about 0.01 mg a.i./kg soil in regions with high rainfall.

Sulfometuron Methyl

Sulfometuron methyl is hydrolyzed in acidic soil, but is stable in neutral soil. Hydrolysis and biodegradation appear to be important degradation pathways in soil (Sarmah and Sabadie 2002). The degradation rate for sulfometuron methyl was found to increase with increasing soil temperature and moisture content and the half-life ranged from 2 to 5 weeks. Sulfometuron methyl moves readily through conductive, coarse-textured soils such as sand and sandy loams (ENSR 2005j).

Effects of sulfometuron methyl to soil organisms are not well studied. A study on the response of ectomycorrhizal symbiotic formation to sulfometuron methyl applications showed that the herbicide did not result in a reduction of the symbiont on tree seedlings (Busse et al. 2004).

Tebuthiuron

In soil, tebuthiuron is resistant to abiotic degradation and biodegradation. Field half-life ranges from 2 weeks to over 33 months (ENSR 2005k). It has a low adsorption affinity to soil with some adsorption occurring as organic matter and clay content increase. It is mobile in soil and has been detected in groundwater (USEPA 1994).

The amount of tebuthiuron recovered from application sites in northcentral Arizona declined from 55% of that applied after 1 year to 5% after 8 years, but then increased during the remaining 3 years of the study. The increase may have been due to release of the soil-adsorbed fraction. No metabolites were found, suggesting little or no degradation in soil (National Library of Medicine 2002). Montgomery (1997) reported that 38% of tebuthiuron applied to rangeland at a rate of 0.84 kg/ha tebuthiuron remained after 21 months.

In an evaluation of brush control and reseeding in a post oak forest using tebuthiuron applied at a rate of 2.2 kg /ha, Gay et al. (1997) determined that total soil nitrogen was unchanged after treatment regardless of the reseeding method, possibly indicating few changes to nitrogen cycling from treatment methods. Tebuthiuron applied at the rate of 1.01 kg/ha in pellet form to sagebrush semi-desert in Utah showed that soft brome had both reduced persistent mycorrhizal root infection and reduced mycorrhizal spore density in its rhizosphere (Allen and West 1993). The herbicide did not appear to affect germination of mycorrhizal spores collected 6 months after herbicide application. Mostafa and Helling (2003) isolated three tebuthiuron-degrading bacteria from soil. Shelton et al. (1996) demonstrated that a *Streptomyces* strain degraded tebuthiuron in vitro.

Impacts of Forest Service-evaluated Herbicides

2,4-D

It is generally accepted that 2,4-D is rapidly inactivated in moist soil (Bovey 2001). However, the fate is of 2,4-D is largely dependent on pH (Aly and Faust 1964 *cited in* Tu et al. 2001). In alkaline soil, 2,4-D is rapidly converted to the anion form (negatively charged), which is more susceptible to photodegradation and biodegradation and less likely to adsorb to soil particles. In acidic soil, degradation is inhibited and 2,4-D may adsorb to soil particles (Tu et al. 2001).

The half-life of 2,4-D averages 10 days in moist soils, but can be longer in cold or dry soils, or where the microbial community is not present to facilitate degradation (Tu et al. 2001). Warm and moist soil conditions that enhance microbial populations facilitate 2,4-D degradation (Foster and McKercher 1973 *cited in* Tu et al. 2001). In addition, 2,4-D has been shown to dissipate more rapidly in soils previously treated with 2,4-D, presumably because there was an increase in 2,4-D degrading bacteria after the first application (Oh and Tuovinen 1991, Smith and Aubin 1994, and Shaw and Burns 1998 *cited in* Tu et al. 2001).

Studies have generally shown that at typical application rates, no effect from 2,4-D can be detected on soil macroorganisms (Eijsackers and Van Der Drift 1976). Furthermore, most studies of the effects of 2,4-D on microorganisms concluded that the quantity of 2,4-D reaching the soil from applications would probably not have a serious negative effect on most soil microorganisms (Bovey 2001).

Clopyralid

Clopyralid is unstable in soil and field dissipation half-life ranges from 10 to 161 days (SERA 2004b). Clopyralid does not appear to bind tightly to soil and will leach under favorable conditions; however, the potential for leaching or runoff is attenuated by the apparently rapid biodegradation of clopyralid in soil. Clopyralid can be persistent in plants, and can result in soil activity when plants containing clopyralid die and biodegrade releasing clopyralid to the soil where it can again be taken up by plants.

Hassan et al. (1994 *cited in* SERA 2004b) summarized the effects of clopyralid on potential biocontrol agents. Exposures to clopyralid resulted in less than 30% mortality to 14 out of 17 insects and predatory mites in contact bioassays. Higher mortality rates (25 to 50%) were observed with clopyralid exposures to three insects: a beetle species, a pirate bug, and a green lacewing. A laboratory study on spiders reported an acute (96-hour) lethality of less than 10% following a direct application of clopyralid (as Lontrel EC, an emulsifiable concentrate of clopyralid) at the recommended application rate (Pekar 2002).

At concentrations of 1 or 10 mg a.i./kg soil, clopyralid had no effect on nitrification, nitrogen fixation, or degradation of carbonaceous material (Hassan et al. 1994 *cited in* SERA 2004b). Applications of Lontrel EC at 0.26 lb/ac had no substantial effect on spore germination in a fungal bioherbicide for round-leaved mallow (Grant et al. 1990 *cited in* SERA 2004b).

Glyphosate

Glyphosate is a polar compound that is inactivated by soil adsorption. Adsorption is controlled by soil pH to a large degree (Gimsing et al. 2004). Glyphosate is water-soluble, but it has a high affinity to bind to soil particles (SERA 2003b). Adsorption of glyphosate increases with increasing clay content and cation exchange capacity, and decreasing soil pH and phosphorous content (Sprankle et al. 1975, Hance 1976, Nomura and Hilton 1977, and Rueppel et al. 1977 *cited in* Tu et al. 2001).

Glyphosate is biodegraded by soil organisms, and many species of soil microorganisms can use glyphosate as a carbon source (SERA 2003b). Glyphosate exposure results in the inhibition of respiration and nucleic acid synthesis in plants and in microorganisms. There is little information, however, to suggest that glyphosate is harmful to soil microorganisms under field conditions; some studies suggest glyphosate may benefit some soil microorganisms.

In a study on the direct and indirect effects of long-term glyphosate applications in ponderosa pine plantations in California, Busse et al. (2004) determined that both direct and indirect soil microbial characteristics in the top 4 inches of soil were generally unchanged after 9 to 13 years of continuous vegetation control by glyphosate. Single or repeated applications of glyphosate at the recommended field concentration had little effect on microbial communities.

Hexazinone

Hexazinone has a relatively low affinity for soil particles and dissolves in soil water. Biodegradation is an importation fate and the half-life in soil averages about 90 days, although hexazinone has been reported in the soil at low concentrations for up to 3 years after application. Soil organic matter content does not affect adsorption.

One field study that was designed to detect effects on non-target species suggests that hexazinone may have an effect on the behavior of soil mites. At an application rate of 0.9 lb/ac, soil mites tended to migrate deeper into the soil than mites from untreated plots. However, it is not known whether the behavior was related to toxicity, avoidance, or some other unidentified factor (Badejo and Adejuyigbe 1994). When testing pure strains of ectomycorrhizal fungi in a laboratory assessment, Diaz et al. (2003) determined that hexazinone had little or no adverse effect on fungi, and even stimulated the growth of one strain.

Hexazinone did not adversely affect the nitrogen cycle or soil respiration in acidic plant soils when applied at the recommended application rate (Vienneau et al. 2004). Busse et al. (2004) found that hexazinone did not alter soil respiration and the capability of mycorrhizal fungi to infect conifer seedling roots, even at concentrations detrimental to seedling growth.

Imazapyr

Imazapyr is water soluble, potentially mobile, and has a long half-life (SERA 2004e). Imazapyr does not readily bind to mineral soils, but is likely to bind relatively strongly to organic soil. In a study of the fate of imazapyr applied to a railroad ROW, most imazapyr was found in the upper 12 inches of the soil and degraded with a half-life in the range of 67 to 144 days (Borjesson et al. 2004).

Imazapyr may persist in soil for a prolonged period in relatively arid regions, and will not bind tightly to alkaline soils with low organic matter. Thus, the potential for longer-term effects on soil organisms and down gradient systems exists (SERA 2004e). When imazapyr is applied at maximum application rates directly to the soil, it can remain active throughout the growing season (Tu et al. 2001).

Effects on soil microorganisms appear to be highly species specific, with variations in sensitivity among species of up to a factor of 100 (SERA 2004e). Imazapyr can affect some sensitive microorganisms and potentially shift soil microbial community composition toward imazapyr tolerant species. Imazapyr can inhibit rates of cellulose decomposition and carboxymethyl cellulase activity in peat soil with 59% organic carbon (Ismail and Wong 1994 *cited in* SERA 2004e).

Metsulfuron Methyl

The principal modes of degradation of metsulfuron methyl are hydrolysis and microbial degradation, with the latter being the only major pathway in alkaline soils (Sarmah et al. 1998). Degradation rates are affected by soil temperature, moisture content, and soil pH. Half-lives in acidic or neutral soils varied from 5 to 190 days (Sarmah and Sabadie 2002, SERA 2004f). In acidic soils, adsorption of metsulfuron methyl is influenced by soil temperature, clay content, and organic matter content. In alkaline soils, adsorption is very low and leaching potential is high. This is likely to result in increased persistence in alkaline subsoils that often lack in organic matter and biological activity (Sarmah et al. 1998).

An application rate of 5 mg a.i./kg soil decreased levels of amylase, urease, and protease activity in loamy sand and clay loam soil (Ismail et al. 1998). At surface application rates of 0.04 to 0.067 lb/ac, decreases in soil bacteria were apparent for 3 days but reversed completely after 9 days. Biodegradation of metsulfuron methyl increased as soil moisture increased from 20% to 80% of field capacity, and half-life increased when temperature was raised from 20 to 30°C (Ismail and Azlizan 2002). Peterson et al. (1994 *cited in* SERA 2004f) showed significant inhibition in growth of three species of cyanobacteria using metsulfuron methyl at a concentration of 0.003 mg a.i./L.

Picloram

Photolysis and biodegradation are primary mechanisms of dissipation of picloram (USDA Forest Service 2000a). Picloram adsorbs to clay particles and organic matter, but if the soil contains little clay or organic matter, picloram is easily moved by water. Picloram has been reported to remain active in soil at levels toxic to plants for more than 1 year at typical application rates (SERA 2003c). The half-life of picloram in soil is reported to vary from 1 month under favorable environmental conditions to more than 4 years in arid regions (USDA Forest Service 2000a). Picloram can be persistent in plants, resulting in soil activity when plant parts containing picloram degrade and release picloram to the soil where it can be taken up by plants.

The persistence of picloram in soil is dependant on soil moisture and temperature. Picloram dissipates more slowly when soils are alkaline, fine textured, and low in organic matter. Picloram degrades more rapidly under anaerobic than aerobic conditions and at lower application rates (USDA Forest Service 2000a).

Higher soil concentrations of picloram result in longer persistence of the compound. With high application rates, picloram may inhibit microbial activity (Krzyszowska et al. 1994). There does not appear to be a defined threshold for picloram toxicity to soil microorganisms (SERA 2003c). Concentrations of picloram in the soil as low as 0.025 mg a.i./kg soil appear to result in an increase in the persistence of picloram, and this may be attributable to negative effects on microbial populations.

Triclopyr

There are two formulations of triclopyr—a triethyamine salt (TEA) and a butoxyethyl ester (BEE). Both formulations degrade to triclopyr acid in soil. Degradation occurs primarily through microbial metabolism, but photolysis and hydrolysis can be important. The average half-life of triclopyr acid in soil is 30 days (Tu et al. 2001). Triclopyr can be persistent in plants, resulting in soil activity when plants containing triclopyr die and biodegrade releasing triclopyr to the soil where it can be taken up by plants.

Microbial metabolism accounts for a significant percentage of triclopyr degradation in soils (SERA 2003d). In general, warm moist soils with a high organic content will support the highest rates of herbicide metabolism (Newton et al. 1990 *cited in* Tu et al. 2001). Johnson et al. (1995) found that microbial degradation of triclopyr was significantly higher in moist versus dry soils and at 30°C than at 15°C. They also found that sunlight plays a role in the rate of microbial metabolism of triclopyr, as microbial metabolism slowed when soil was deprived of light.

Triclopyr inhibited growth of four types of ectomycorrhizal fungi associated with conifer roots at concentrations of 1,000 ppm and higher (Estok et al. 1989). Some evidence of inhibition of fungal growth was detected in bioassays with as little as 100 ppm triclopyr. Typical usage in forest plantations, however, results in triclopyr residues of only 4 to 18 ppm on the forest floor.

Impacts of Other Herbicides Currently Available for Use

Asulam, atrazine, fosamine, mefluidide, simazine and 2,4-DP (also known as dichlorprop) have been previously approved for use on public lands in many western states (see Table 2-1) and risk assessments were provided in earlier BLM vegetation treatment EISs. The use of these herbicides by the BLM has been quite limited, with only fosamine used in the last 7 years. Table 2-2 provides information on areas where use of these herbicides is appropriate.

Atrazine, simazine, and 2,4-DP, are persistent in soil, do not adsorb well, and are generally considered mobile. Persistence in soil is extended under dry and or cold conditions. Asulam does not adsorb well; however, it is readily biodegraded and metabolites of asulam will adsorb to the soil (Vogue et al. 1994; Information Ventures, Inc. 1995a, b, c; Mahler et al. 1998).

Mefluidide is not strongly adsorbed to the soil and has a half-life from 1 to 2 weeks. It does not cause adverse effects in soil microorganisms (Information Ventures, Inc. 1995d). Because fosamine is rapidly metabolized by soil microbes, it does not persist in soils and reported half-lives range from 1 to 6 weeks (Han 1979 *cited in* Tu et al. 2001).

Impacts by Alternative

The BLM proposes use of herbicides to treat vegetation to improve ecosystem function and health, and in turn, soil health. However, herbicide treatments can also affect soil fertility and function and kill or harm soil organisms. The following discusses the benefits and risks to soil under each alternative.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue current vegetation treatment programs in 14 western states and would treat an estimated 305,000 acres per year using both ground-based and aerial methods. Public lands in Alaska, Texas, or Nebraska are not included under this alternative.

Under this alternative, the BLM would be able to use the 20 herbicides previously approved in earlier EISs. However, based on the recent pattern of BLM herbicide use, it is likely that approximately three fourths of the area treated would involve the use of only four herbicides: 2,4-D, glyphosate, picloram, and tebuthiuron (Table 2-4). It is also likely that asulam, 2,4-DP, atrazine, mefluidide, and simazine would not be used at all because they have not been used in the last 7 years, and fosamine use would likely be less than 50 acres annually.

Of the herbicides most often used by the BLM, picloram and tebuthiuron are persistent in soil for a year or more, while glyphosate and 2,4-D are relatively non-persistent in soil. None of these herbicides appears to result in severe adverse impacts to soil. Of these, glyphosate has been shown to have little or no impact on biological crust cover after 1 year, while impacts from the other commonly-used herbicides are less known. 2,4-D, glyphosate, picloram, tebuthiuron, and other herbicides used by the BLM could benefit soil by removing invasive species and other unwanted vegetation and allowing restoration of native vegetation.

Fewer acres would be treated under this alternative than other alternatives. Negative effects to soils could be greater because fewer acres with invasive species would be treated and soil characteristics are often negatively affected by invasive species. Generally, invasive plants can increase the potential for wind or water erosion by altering fire frequency or producing chemicals that directly effect soil quality or organisms. These negative effects include increased sediment deposition and erosion, and alterations in soil nutrient cycling (Bossard et al. 2000). For example, millions of acres of grassland in the Great Basin have been taken over by downy brome. A study that compared soil organisms in native grasslands after invasion by soft brome found that the soft brome caused negative changes in most levels of the soil food web (Belnap and Phillips 2001). Soft brome invasion also appears to change soil physical characteristics and alter the cycling of carbon and nitrogen (Norton et al. 2004).

In areas with saltcedar invasions, salt accumulates in the soil as salt-accumulated leaves decompose. Scotch broom and gorse can increase the nitrogen content in soil, potentially giving an advantage to non-native species that thrive in a nitrogen-rich soil (Bossard et al. 2000). Studies in Montana have shown that sedimentation and erosion rates were 50 to 200% greater on sampling plots dominated by spotted knapweed than on plots dominated by native bunchgrasses (Lacey et al. 1989). In a few instances, invasive plants can positively affect soil through enrichment of certain nutrients and by providing erosion control.

Under this alternative, the BLM would not be able to eliminate unwanted vegetation using herbicides when it occurs on BLM lands in Texas (11,833 acres), Nebraska (6,354 acres) and Alaska (86.7 million acres). Invasive species are common on Texas and Nebraska public lands. In Alaska, there are only small, scattered outbreaks of invasive species and the focus of invasive species treatments is to control these outbreaks before they become much larger. There is concern in Alaska regarding the use of herbicides in sensitive environments, including on tundra and in boreal forests, but herbicide use may be appropriate where impacts to soil and other resources would be negligible, and where other treatment methods may not provide adequate vegetation control (Hebert 2001).

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Under the Preferred Alternative, the BLM would be able to use four new herbicides in addition to 14 previously-approved herbicides to treat approximately 932,000 acres annually across 17 western states.

As discussed under the No Action Alternative, the use of herbicides would have both beneficial and adverse effects to soil. The area treated under this alternative would be approximately 3 times greater than under the No Action Alternative, thus effects would be approximately 3 times greater. By treating a larger area than under the No Action Alternative, the BLM would have a greater likelihood of reducing the number of acres covered by weeds and other invasive vegetation and restoring ecosystem function, to the benefit of soil resources.

Based on BLM patterns of use, 2,4-D, glyphosate, picloram, and tebuthiuron would comprise about 70% of the currently-used herbicides that would be used under this alternative. The risks and benefits of using these herbicides are discussed under the No Action Alternative. Approximately 10% of all treatment acres would be treated with the new herbicides, and of these, approximately 8% of the acres would be treated using imazapic. Imazapic would be used to control downy brome, hoary cress, perennial pepperweed, and several other invasive species that are known to alter soil characteristics, and alter wildfire intensity and frequency, and increase soil erosion. Effects to soil and soil organisms from the new herbicides appear to be minor.

In addition to providing for the use of four new herbicides, the BLM would be able to use herbicides in Alaska, Nebraska, and Texas. Although little or no herbicide treatments are planned for Alaska under this alternative, being able to use herbicides in Nebraska and Texas would allow for a more comprehensive weed management program that should reduce the negative effects of invasive species on soil.

If new herbicides are developed in the future that provide control of unwanted vegetation superior to that of currently-used or proposed herbicides and with fewer risks to soil and other resources, the BLM would be able to use these herbicides to the benefit of soil resources upon completion of appropriate risk assessments and associated NEPA analysis.

Alternative C – No Use of Herbicides

Under Alternative C, no herbicides would be used in the BLM vegetation management program in 17 western states. Some areas would not be treated by any method, while other areas would be treated by mechanical, manual, biological, or fire methods (USDI BLM 2005a).

Without the use of herbicides, it is likely that invasive plants would continue to rapidly spread, resulting in dramatic and potentially irreversible effects on soil quality through changes in organic matter content, diversity and abundance of soil organisms, and nutrient and water availability. As discussed above, weeds and other undesirable vegetation can out-compete native vegetation and lead to widespread incidence of fire and other conditions that can result in increased rates of soil erosion and loss of soil productivity. Other treatment methods, including use of fire, machinery, and livestock can remove vegetation, but also disturb soil, leading to soil erosion and loss of soil quality (see PER). In many situations, herbicides are the only, or the most effective method for controlling invasive vegetation. For example, mechanical and manual methods are not appropriate for large-scale treatments (hundreds to thousands of acres), and for treatments in remote areas that are difficult to access and would require construction of roads and other soil disturbance activities to allow access by mechanical equipment. The effects of these other treatments on soil are discussed in the PER.

Alternative D – No Aerial Applications

Under Alternative D, the BLM would be able to use 14 previously-approved and four newly-approved herbicides in 17 states, but would not be able to apply herbicides from aircraft. This alternative would result in reduced risk of inadvertent applications that result from off-site drift and subsequently there could be less risk to non-target soils.

Ground-based treatments could be used to replace aerial treatments for some locations. However, areas where ground-based treatments are ineffective or too costly to implement include remote areas, areas with difficult terrain, and large expanses of woodland and forest. Other areas where ground-based treatments would be ineffective include areas with extensive coverage of invasive species (such as downy brome in the Great Basin). If treated by ground-based methods, coverage may not be comprehensive and re-invasion would require re-treating the same area, thus using more herbicide (USDI BLM 1991a).

Non-herbicide methods of vegetation control may be substituted in areas unsuitable for ground-based herbicide treatment. For example, where there is sufficient fuel to carry a fire, prescribed fire could be used to control large areas of invasive vegetation. Currently, vegetation management best practices use herbicide applications following fire to avoid reinvasion and promote native vegetation. For many areas, this would be impractical without the use of aerial application. Also, mechanical and/or biological treatments may also be substituted, but the amount of area that could be treated by these methods would be substantially less, and these treatments would disturb more soil than aerial treatments (see PER).

Under this alternative, the BLM would likely use substantially less imazapic than under the Preferred Alternative, as imazapic is proposed for both large- and small-scale treatments of downy brome and other invasive vegetation.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

Under this alternative, the BLM would not be able to use ALS-inhibiting herbicides. This group of herbicides has been shown to damage off-site native and crop species and several weed species can develop resistance to these herbicides, making them less effective. Under this alternative, four currently-approved herbicides (metsulfuron methyl, sulfometuron methyl, chlorsulfuron, and imazapyr) and one proposed herbicide (imazapic) would not be used. Approximately one-half as many acres would be treated under this alternative as compared to the Preferred Alternative. In addition, aerial herbicide treatments, and herbicide treatments in wetland, riparian, wilderness, and cultural resource areas, would be discouraged, while more passive treatment methods would be promoted.

The impacts associated with reducing the area treated are discussed under Alternative C, and impacts associated with restrictions on aerial application are discussed under Alternative D. The impacts to soils associated with the use of herbicides in wetland and riparian areas is discussed in the Wetland and Riparian section of this chapter. Use of herbicides in areas with cultural resources in discussed in the Cultural Resources section.

This alternative would discourage other activities that are known to impact soils and lead to invasive species establishment, such as OHV use and livestock grazing. However, OHV use and livestock grazing could only be restricted to levels consistent with adopted BLM LUPs. Restrictions on grazing and OHV use would benefit soils, but in areas with extensive infestations of weeds and other invasive vegetation, the full benefits of restricting grazing, OHV, and other ground-disturbing activities might not be fully realized until invasive species are controlled and sites are restored with native vegetation.

An extensive knowledge of ALS-inhibiting chemical behavior in soil appears to be lacking, including toxicity of residues, remnants of degradation products, presence and release of bound residues, and potential for groundwater pollution (Sarmah and Sabadie 2002). At this time, ALS-inhibiting herbicides have not been found to be more or less toxic to soil organisms or to demonstrate other soil effects notably different from the other herbicides.

Under this alternative, the BLM would not be able to use imazapic, which is proposed for extensive control of downy brome. This would reduce the number of acres of downy brome treated in the Great Basin and elsewhere, and could increase adverse effects to soil.

Mitigation for Herbicide Treatment Impacts

No mitigation measures are proposed for soil resources.

Water Resources and Quality

Introduction

The proposed herbicide treatments have the potential to affect water resources on or near public lands by altering water flows, surface water and groundwater and quality, and rates of groundwater recharge. Surface water provides an important source of drinking water, provides habitat for fish and wildlife, and is used for recreation. Groundwater, and especially potable groundwater, provides drinking water for more than 97% of the rural population without access to public water supplies, and between 30 to 40% of the water used for agriculture (Alley et al. 1999).

Groundwater studies have shown some water supplies to be contaminated with herbicides and other contaminants (total dissolved solids, metals, etc). Generally, shallow groundwater aquifers are at greater risk of contamination than deeper sources. Water quality data for the surface and groundwater resources of the western states are available from several data sources, as discussed in Chapter 3 under Water Resources and Quality. These sources were used to develop a general assessment of water quality in the hydrologic regions of the western states, including Alaska, where the BLM has substantial land management responsibility. Data from the USEPA's Index of Watershed Indicators characterizes the condition and vulnerability of each of the 2,262 subbasins in the U.S. (Map 3-6). Information on general groundwater quality (based on concentration of TDS) was compiled from the USEPA's National Water Quality Inventory (USEPA 2000; Map 3-7). Based on these assessments, watershed and groundwater water quality is poor to moderate over many areas in the west (based on concentration of TDS for groundwater), primarily in areas associated with agricultural activities. Thus, actions that further deteriorate water quality or watershed health need to be carefully evaluated before being implemented on public lands.

Scoping Comments and Other Issues Evaluated in the Assessment

Commentors during scoping encouraged the BLM to evaluate the effects of herbicides on watersheds and watershed sustainability; water supply (yield); infiltration, runoff, and other hydrologic processes; and surface and groundwater quality and quantity protection, including conservation and pollution. A number of commentors pointed out the potential impacts associated with herbicide runoff, overspray, and drift. Commentors suggested that concerns regarding the effects of herbicide metabolites in water should also be addressed. Specific concerns regarding the impacts of herbicides on water quality degradation and the accumulation of herbicides in surface water and groundwater were raised. Commentors also expressed concern about the effects of invasive species (in particular, saltcedar) on water quality and quantity, and on riparian habitats.

Standard Operating Procedures

The following discusses impacts from herbicides currently available for use by the BLM and from herbicides proposed for use. This assessment of impacts assumes that SOPs (Table 2-6) designed to reduce potential unintended impacts to water are used. The following SOPs are recommended to reduce potential unintended impacts to water quality and quantity from the application of herbicides:

- Select herbicide products to minimize impacts to water. This is especially important for application scenarios that predict risk from active ingredients in a particular herbicide.
- Review and understand the "Environmental Hazards" section on the herbicide label. This section warns of known pesticide risks to the environment and provides practical ways to avoid harm to organisms or to the environment.
- Use local historical weather data to choose the month of treatment. Based on the phenology of the target species, schedule treatments based on the condition of the water body and existing water quality conditions.
- Plan to treat between weather fronts (calms) and at appropriate time of day to avoid high winds that increase water movements, and to avoid potential stormwater runoff and water turbidity.

- When possible, plan to treat shallow areas, which are easier to control.
- Apply the smallest effective amount of herbicide to reduce the risk of contamination from runoff and leaching.
- Buffer widths should be developed based on herbicide- and site-specific criteria to minimize impacts to water bodies.
- Because fine textured and sandy soils present the most risk to adjacent aquatic systems from unintended leaching and/or runoff, soil type in treatment areas should be considered when developing an herbicide treatment program.
- Minimize the potential effects to surface water quality and quantity by stabilizing terrestrial areas as quickly as possible following treatment.

Impacts by Treatment

Aquatic Vegetation Control Using Herbicides

Water Quality

The BLM currently uses four herbicides in riparian and aquatic habitats—2,4-D, glyphosate, imazapyr, and triclopyr—and is proposing to use diquat and fluridone in these areas, as well. The remaining herbicides available to the BLM, or proposed for use, are registered for use on terrestrial sites.

Herbicides applied to streams, ponds, and lakes for aquatic vegetation control could impact surface water quality if applied at concentrations that exceed label requirements. Based on the HHRA (see the Human Health and Safety section in this chapter and Appendix B), there would be low risk to drinking water in areas treated with diquat, fluridone, glyphosate, or imazapyr, even if these herbicides were accidentally spilled in streams, ponds, or lakes used by humans. However, risk is moderate to high for drinking water if treated with 2,4-D or triclopyr.

Aquatic plant control can cause a high rate of plant decomposition and may cause rapid oxygen loss from water that can seriously degrade water quality. The magnitude of this effect depends on water temperature, lake or pond stratification, and the amount and rate of plant decomposition. The effects can persist from few weeks to an entire growing season, but are generally not permanent.

The proliferation of invasive and unwanted aquatic vegetation in surface waters can affect water quality, resulting in water quality degradation. Blooms of weedy vegetation can result in reduced drinking water quality, potentially limit recreation opportunities, and lead to depletion of oxygen in water, which can degrade fish and wildlife habitat. Infestations can block channels or culverts, causing flooding. Use of aquatic herbicides to remove weedy and invasive aquatic vegetation could reverse such infestations and greatly improve water quality and enhance fish and wildlife habitat and recreational opportunities.

Water quality degradation could result from removal of riparian vegetation and a reduction in shade. With the loss of shade, the resulting increase in surface-water temperature fluctuations may drive water temperature beyond tolerable limits for temperature sensitive fish and other aquatic species.

Water Quantity

Applications of herbicides to aquatic systems would not directly modify water quantity. Indirect impacts to water quantity could occur if treatments that removed unwanted aquatic vegetation reduced plant uptake of water, increasing the amount of available water.

Terrestrial Vegetation Control Using Herbicides

Water Quality

The four primary means of offsite movement of herbicides are runoff, drift, misapplication/spills, and leaching. Surface water could be affected by any of these means, while groundwater potentially would be affected only by leaching. Site conditions and application technique are other factors that can influence the affects of an herbicide on water quality.

Runoff and Leaching. There are three physical properties that, when combined with climate, geology, and topography determine the runoff and leaching potential of an herbicide. They are 1) persistence, which is the time a chemical stays active; 2) soil adsorption, which is the tendency of a chemical to bind to soil particles; and 3) solubility, which is the tendency of a chemical to dissolve in water (BPA 2000).

Herbicides have to be relatively persistent in order to have either leach or runoff potential (non-persistent herbicides do not stay active long enough to create a risk). If an herbicide has a high soil adsorption, it is more likely to run off with soil movement. Soils high in organic content or clay tend to be the most adsorptive, while sandy soils low in organic content are typically the least adsorptive (USDI BLM 1991a). If an herbicide has low soil adsorption, it is likely to leach down through the soil. If an herbicide is highly soluble in water, it is likely to leach; with low solubility, it is likely to run off. Tables 4-8 and 4-9 list the factors associated with herbicide movement to groundwater, and physical properties and off-site movement potentials (leaching and runoff) for each currently available and proposed herbicide.

Even if an herbicide has runoff or leaching potential, the likelihood of it reaching a water body also depends on site characteristics. For example, if a persistent herbicide with a high potential for leaching to groundwater was used at a site with low annual precipitation, and the depth to groundwater was over 100 feet, the overall potential for that herbicide to reach groundwater before degrading would be quite low. Conversely, the same herbicide, applied at a site with high annual rainfall, coarse underlying soils, and groundwater depths less than 100 feet would have a higher relative potential of reaching groundwater. Herbicides that are highly water soluble, relatively persistent, and not readily adsorbed by soil particles have the greatest potential for movement into the groundwater. Sandy soils low in organic content are the most susceptible to groundwater contamination (USDI BLM 1991a).

Drift. Herbicide drift can degrade surface water quality. Herbicides can reach water through drift, the airborne movement of herbicides beyond the treatment area. Three factors that contribute to drift are: 1) application technique; 2) weather conditions; and 3) applicator error. Aerial and broadcast applications are most likely to reach water through drift, because the herbicide is sprayed from a helicopter/plane or through a boom and must settle through the air to reach the treatment area. Spot and localized applications are less likely to result in drift because these applications are targeted to specific plants, and less herbicide is applied. Wind speed and air temperature, and their effect on herbicide evaporation, affect the potential for drift. During application when winds are over 5 mph and temperatures are warm, the potential for drift is greater (BPA 2000). Peak concentrations from aerial spraying of fine droplets with 50- to 70 feet buffer zones commonly range from 0.130 to 0.148 ppm (USDA 1988). Well-vegetated buffers can intercept herbicides and reduce the potential for herbicides to reach surface water. The BLM typically uses nozzles that produce large droplets, and requires 100-foot or wider buffers, to minimize the risk of herbicides drifting into surface waters (USDI BLM 1991a). Still, buffer widths up to 1,500 feet may be required for some herbicides to protect sensitive aquatic species from exposure to aerial drift (Appendix C).

The potential for spray drift to impact perennial and intermittent streams would be low because of minimum10-foot (ground-hand application), 25-foot (ground-vehicle), or 100-foot buffers would be provided between treatment areas and water bodies (Note: The BLM would use information in the ERAs to develop more precise buffer distances based on soil, precipitation, vegetation, and treatment characteristics; also see Appendix C). Herbicides applied near water bodies would have to move through the buffers, and would likely be mixed and diluted. The potential for spray drift to impact ephemeral streams would be greatest because they are no proposed buffers for these streams. Herbicides applied near these streams are often liberated during storm surges (USDI BLM 1991a; Appendix C).

Misapplications and Spills. Herbicides registered for use in terrestrial habitats may affect surface water and groundwater as a result of unintentional spills or movement of herbicides from the upland sites into aquatic systems. Pollution results from herbicide concentrations that are elevated enough to impair water quality and the beneficial use of that water (USDI BLM 1991a). The potential for upland herbicide applications to reach water is affected by the herbicide's physical properties, the application method and rate, and site conditions (Bonneville Power Administration [BPA] 2000).

Most experts agree that misapplications and spills are the leading cause of impacts on non-target resources. Misapplications and spills are caused by failure to follow label instructions and restrictions and by applicator carelessness. The impacts of spills depend on the persistence and mobility of the spill, as well as how quickly and thoroughly the spill is cleaned up.

Site Conditions. Site conditions that determine the potential for an herbicide to intercept water include proximity of the treatment area to water and buffer width. The type of water body determines the potential for contamination, should an herbicide reach the water body. Small, still water bodies, such as ponds and small wetlands, are the most likely to be affected; these water bodies move small volumes of water that are necessary to disperse or dilute contaminants. By contrast, large

TABLE 4-8
Factors Associated with Herbicide Movement to Groundwater

Category	Properties Increasing Likelihood of Groundwater Detection
Herbicide properties	Greater mobility (lower adsorption) Greater pesticide persistence (lower reactivity)
Agricultural management practices	Higher pesticide use Increasing proximity to pesticide application areas Reductions in depth or frequency of tillage
Well characteristics	Decreasing well depth Dug or driven (versus drilled) wells Poorer integrity of surficial or annular well seals
Hydrogeologic and edaphic factors	Unconsolidated aquifer materials (versus bedrock) Decreasing depth of upper surface of aquifer Decreasing thickness or absence of confining layers Higher hydraulic conductivity Higher soil permeability Increased recharge (from precipitation or irrigation) Younger groundwater age
Source: Barbash et al. (1999).	

fast-moving rivers would be least likely to be affected because the volume and turbulence of the water would help dilute the herbicide quickly (BPA 2000).

Rainfall is another factor affecting the potential for herbicides to contaminate water bodies after treatment. Herbicides, particularly granular formulations, are likely to be washed from treatment areas toward water bodies.

The vegetation, ground cover, or soil type between a treatment area and a water body can influence whether herbicides will reach water. Thick vegetation might block drift or absorb an herbicide moving through water or ground before it reaches a water body. In comparison, where little to no vegetation is present, the herbicide would encounter less resistance when washing toward the water body.

Additional effects to water quality that could occur from herbicide treatments include increased nutrient loads to surface water and groundwater. Soluble nutrients can enter surface water or groundwater. Nutrients adsorbed to particles may be moved to water bodies by wind and water erosion. Nutrient enrichment of aquatic systems can lead to algal blooms and eutrophication (mineral and organic nutrient loading and subsequent proliferation of plant life), resulting in decreased dissolved oxygen contents. The extent and duration of effects would be dependent on the geographic location, and on the extent of vegetation removal, as well as on revegetation management practices. If large amounts of vegetation are removed along streams, this could lead to higher water temperatures to the detriment of fish and other aquatic organisms.

In contrast to the negative effects to water that could result from herbicide treatments, herbicide use can benefit water quality if vegetation removal resulted in reduced fire risk and reduced risk of post-fire sedimentation. Treatment of upland areas could reduce hazardous fuels and contribute to long-term benefits to surface water quality by reducing the risk high-intensity wildfires. In addition, the use of herbicides to control invasive species in terrestrial and aquatic systems could provide long-term benefits to water quality with the return of more stable soils, attenuated nutrient cycling, and return to normal fire cycles.

Application Technique. Application technique can also have an impact on leaching and runoff potential. Applications over large areas (broadcast and aerial techniques) are more likely to result in deposition of herbicides in soils than spot or localized treatments, thus increasing the potential for runoff and leaching.

From a watershed perspective, the concentration and amount of the herbicide applied can influence the risk of water contamination. The ratio of treated to untreated surface area in any given watershed is usually sufficiently low to permit rapid dilution. This ratio is much lower than that for the concentrated

TABLE 4-9
Herbicide Physical Properties and Off-site Movement Potential

Herbicide	Physical Properties			Off-site Movement Potential	
	Persistence	Solubility (mg/l)	Adsorption (Koc)	Groundwater Leaching	Surface Water Runoff
Aquatic Use Herbicides					
2,4-D	Moderate	3.39×10^4	19-109	Moderate	Low
2,4-DP	Low	50	1,000	Low	Moderate
Diquat	High	700,000	690	Low	High
Fluridone	Low	10	1,000	Low	High
Glyphosate	Moderate	900,000	24,000	Low	High
Imazapyr	Moderate	>11,000	100	High	Low
Triclopyr TEA Triclopyr BEE	Moderate Moderate	2,100,000 23	20 780	High Low	Low High
Terrestrial Use Herbicides					
Asulam	Low	7	55,000	Moderate	Low
Atrazine	Moderate	33	100	High	Moderate
Bromacil	Moderate	700	32	High	Moderate
Chlorsulfuron	Moderate	7,000	400	High	Low
Clopyralid	Moderate	300,000	6	High	Low
Dicamba	Moderate	400,000	3	High	Low
Diflufenzopyr	Low	5,850	18-156	High	Moderate
Diuron	Moderate	42	480	Moderate	High
Fosamine ammonium	Low	Completely soluble	79	Low	Low
Hexazinone	High	33,000	40	High	Moderate
Imazapic	High	2,200	206	Low	Low
Mefluidide	Low	180	200	Low	Moderate
Metsulfuron methyl	Moderate	9,500	35	High	Moderate
Picloram	Moderate	200,000	16	High	Low
Simazine	Moderate	6	130	High	Moderate
Sulfometuron methyl	Low	70	78	Moderate	Moderate
Tebuthiuron	High	2,500	80	High	Low

Sources: USDI BLM (1991a), Vogue et al. (1994), Mahler et al. (1998), and BPA (2000).

areas or blocks of land typically targeted by the BLM for rangeland and forestry treatments. For example, aerial application of herbicides along a 100-foot wide ROW would result in about 2 to 3% of a 640-acre area (section) being treated. By contrast, treatment areas of 10 to 25% per section can occur in forestry practice, and areas greater than 75% per section are common in rangeland applications. Risk of direct application to streams along ROW would increase if the linear flight path of the applicator crosses several streams. No one factor can be used to anticipate the effect of herbicides on stream systems. By following label instructions and restrictions, and establishing buffers, applicators can reduce the potential for herbicides to reach water bodies.

Water Quantity

The use of herbicides to remove vegetation could affect water quantity by altering both the magnitude of base flows and the frequency and magnitude of peak flows. For some treatment areas, the removal of vegetation, especially in large quantities, could improve groundwater recharge by limiting the amount of water lost through sublimation or plant evapotranspiration. In this case, base flows, which are dependent on the quantity of groundwater discharge, would increase. These changes could be very minor or short-lived if the vegetation did not evapotranspirate or sublimate large proportions of precipitation, or if areas were revegetated quickly (Satterlund and Adams 1992).

In contrast to increasing base flow, vegetation removal could result in the reduction of groundwater discharge and reduced base flows as a function of reduced infiltration rates. Reduced infiltration rates result in more surface runoff reaching streams and lakes immediately after a rain event, thus increasing the velocity, frequency, and magnitude of peak stream flows. These changes in water quantity could alter the physical characteristics of stream channels and affect the speed of water movement. Any changes would last until the site was revegetated.

Impacts by Herbicide

Aquatic Vegetation Control

2,4-D

The salt formulation of 2,4-D is registered for use in aquatic systems. 2,4-D is a known groundwater contaminant; the USEPA has set a maximum concentration level of 0.07 mg/L as a permissible level for this herbicide for potable water.

Concentrations of up to 61 mg/L 2,4-D have been reported immediately following direct application to water. Based on label directions, treated water should not be used for irrigation if the water could be consumed by humans. Concentrations as low as 0.22 mg/L can damage sensitive plants (Tu et al. 2001).

There are conflicting conclusions regarding biodegradation of 2,4-D in aquatic systems (Que Hee and Sutherland 1981 and Wang et al. 1994 *cited in* Tu et al. 2001). Biodegradation can take place in bottom sediments if the appropriate microbial population is present and the pH level is sufficiently high, but it is not likely to occur in the water column. Under acidic conditions, when microbial activity is inhibited (Sandmann et al. 1988 *cited in* Tu et al. 2001), biodegradation may not occur. Differences in reported half-lives of 2,4-D may arise from differences in the microbial populations in treatment areas and the influence of plants on soil biological and chemical properties (Tu et al. 2001; Boucard et al. 2005).

2,4-D will change form and function with changes in pH (Que Hee and Sutherland 1981 *cited in* Tu et al. 2001). In alkaline waters, 2,4-D takes a negatively-charged form that is water-soluble and remains in the water column. In water of a lower pH, 2,4-D will remain in a neutral molecular form, increasing its potential for adsorption to organic particles in water and increasing its persistence. 2,4-D is predicted to adsorb to suspended particles in muddy waters with a fine silt load, but little adsorption has been observed in the field (Tu et al. 2001).

In terrestrial applications, most formulations of 2,4-D do not bind tightly with soils and, therefore, have moderate potential to leach into the soil column and to move off site in surface or subsurface water flows (Tu et al. 2001). In a study on groundwater expressed as spring flow, 2,4-D was detected in 7% of the samples (Wood and Anthony 1997).

Diquat

Diquat would be applied to remove emergent, floating, or submerged aquatic vegetation. In aquatic systems, diquat (ionic) adsorbs to sediment, suspended solids, and aquatic vegetation, and becomes immobilized (Simsiman and Chesters 1976). Thus, diquat is ineffective in turbid waters. Loss of diquat from aquatic systems, both through photolysis and biodegradation, is possible, but only when the herbicide is not adsorbed to solid surfaces. When adsorbed, the herbicide is protected from biodegradation and photolysis (Howard 1991). Aquatic half-lives of 1 to 2 days have been reported for diquat, as a result of sorption onto particulates and sediments (National Library of Medicine 2002). Diquat is a known groundwater contaminant, and the USEPA has set a maximum concentration level of 20 µg/L for potable water. It has a moderate potential to leach into the groundwater and a high potential to be transported in surface water runoff.

Fluridone

Fluridone would be applied to ponds, lakes, canals, and reservoirs, but has limited use in flowing water because this herbicide works through contact maintained over several weeks. Water quality is not degraded when fluridone is used at a concentration of less than 20 ppb, and it is generally considered safe to use in areas where swimming or fishing occur (Washington Department of Ecology 2002). Whole-lake treatments using fluridone are possible because the herbicide does not result in a rapid plant kill, which could result in oxygen-depleted water and reduced water quality.

Photodegradation in aquatic systems is an important loss pathway for fluridone (British Crop Protection Council and The Royal Society of Chemistry 1994). Fluridone is stable to hydrolysis, volatilizes slowly from water, and adsorbs to suspended solids and sediments (USEPA 1986; Lyman et al. 1990; Tomlin 1994; Mackay et al. 1997; ENSR 2005g). Desorption from sediments followed by photolysis is reported to be a loss pathway (ENSR 2005g). Biodegradation can also remove fluridone from aquatic systems. Aquatic dissipation half-lives from 4 days to 9 months (anaerobic sediments) have been reported. Fluridone has low potential to leach to groundwater and is not known to contaminate groundwater. It does have high potential to be transported in stormwater runoff.

Glyphosate

Glyphosate, which is registered for aquatic use, would be applied to wetland and emergent aquatic vegetation (Tu et al. 2001). Glyphosate dissipates rapidly from surface water through adsorption to organic substances and inorganic clays and by biodegradation (Folmar et al. 1979; Feng et al. 1990; Zaranyika and Nydandoro 1993; Paveglio 1996 *cited in* Tu et al. 2001). It does not photodegrade, and in water has an estimated half-life of 12 days to 10 weeks. It is generally considered immobile because of its adsorption characteristics; however, it is a known groundwater contaminant. The USEPA has set a maximum concentration limit of 0.7 mg/L as a permissible level for glyphosate in potable water.

Strong adsorption to particles slows microbial degradation allowing glyphosate to persist in aquatic environments. Glyphosate can be inactivated by adsorption if mixed with muddy water (Tu et al. 2001). Residues adsorbed to suspended particles are precipitated into bottom sediments where they can persist until biodegraded or be released into water (Goldsborough and Brown 1993 and Extension Toxicology Network 1996a *cited in* Tu et al. 2001).

Glyphosate is unlikely to enter waters through surface runoff or subsurface flow because it binds strongly to soils, except when the soil itself is washed away by runoff; even then, it remains bound to soil particles and generally unavailable (Rueppel et al. 1977 and Malik et al. 1989 *cited in* Tu et al. 2001). More recent studies found solution-phase glyphosate in 36% of 154 stream samples, while its degradation product, aminomethylphosphonic acid was detected in 69% of the samples. The highest measured concentration of glyphosate was 8.7 µg/L, well below the USEPA's maximum concentration limit of 700 µg/L.

Glyphosate may stimulate algal growth at low concentration; Austin et al. (1991) have suggested that this could contribute to eutrophication of waterways. An increase in periphyton concentrations in artificial streams has been reported by Austin et al. (1991), and Wong (2000) reported an increase in chlorophyll-a synthesis by a green microalgae (*Scenedesmus quadricauda*) at a concentration of 0.02 mg/L (*cited in* SERA 2003b).

Imazapyr

Imazapyr is registered for use in aquatic systems, including brackish and coastal waters, to control emergent, floating, and/or riparian and wetland plants. Imazapyr is a water soluble and potentially mobile herbicide (SERA 2004e). Imazapyr is rapidly degraded by sunlight in aquatic solutions with a half-life of approximately 2 days that decreases with increasing pH (Mallipudi et al. 1991 and Mangels 1991 *cited in* Tu et al. 2001). Imazapyr does not appear to degrade in anaerobic systems, such as wetland soil or lake or pond sentiments, and will bind strongly to peat (American Cyanamid 1986 *cited in* Tu et al. 2001).

Tu et al. (2001) found no reports of imazapyr contamination in water despite its potential for mobility. It is not known to be a groundwater contaminant. Battaglin et al. (2000) stated that little is known about its occurrence, fate, or transport in surface water or groundwater. In one study, imazapyr (from terrestrial applications) was detected in 4% of the 133 samples taken from streams, but was not detected in reservoirs or groundwater.

Triclopyr

The two formulations of triclopyr, a triethyamine salt and a BEE, behave very differently in water. Both formulations are used to control woody riparian vegetation. However, only the triethylamine salt formulation of triclopyr (known as Garlon 3A®, now marketed as Renovate 3®), is registered for use for selective control of submersed aquatic plants. Both formulations will readily degrade to the acid form, which is the active form in plants.

The triethyamine salt formulation of triclopyr is soluble in water and will photodegrade in several hours with adequate sunlight. Field studies have shown triclopyr (salt formulation) and its metabolites dissipated from water, with half-lives ranging from 0.5 to 10 days and sediment dissipation half-lives ranged from 3 to 13 days (Petty et al. 2003). Johnson et al. (1995) found triclopyr acid in water had a half-life due to photolysis of 1 to 12 hours (*cited in* Tu et al. 2001). The rate of degradation in water is generally dependent on water temperature, pH, and sediment content.

No adverse effects on water quality were found following triclopyr triethyamine salt applications in two studies of whole-pond applications in closed systems (no water exchange; Petty et al. 2001). Results of these studies were comparable to those of triclopyr dissipation studies conducted in reservoirs, lakes, and river systems, and indicated that the degradation and dissipation of triclopyr and its metabolites are similar in representative systems throughout the U.S. (Petty et al. 2001).

The BEE formulation (terrestrial use only, not registered for aquatic application) is not water-soluble and can partition into organic materials and be transported to sediments, where it is persistent. Alternatively, bound ester forms can degrade through hydrolysis or photolysis to triclopyr acid, which will diffuse into the water column and continue to degrade (Tu et al. 2001). The fate and effects of triclopyr BEE were investigated in a first-order forest stream (Thompson et al. 1995). Measurements of triclopyr in stream samples indicated the ester form was rapidly converted to the acid, and that partition to organic materials occurred as chemical pulses moved downstream.

Assessment of Impacts of Herbicides Used for Terrestrial Vegetation Control

Bromacil

Bromacil is mobile in soil and can reach groundwater and surface water. It can be persistent in most aquatic environments because it is stable to hydrolysis, and photodegradation occurs rapidly only under alkaline conditions (ENSR 2005b). Bromacil is a known groundwater contaminant, and the USEPA standard for drinking water is 90 µg/L. The environmental hazards section of current product labels includes a groundwater advisory warning users not to apply bromacil in areas with permeable soils in order to protect water quality. Biodegradation is a major loss mechanism in aerobic and anaerobic aquatic systems. Bromacil is not expected to partition to suspended particles or sediments in aquatic systems, but will remain dissolved in the water column and has a high potential to leach into the groundwater.

Chlorsulfuron

Chlorsulfuron is persistent and mobile in some soils. In aquatic environments, the environmental fate of chlorsulfuron is related to pH and temperature. Hydrolysis rates are fastest in acidic waters and slower in more alkaline systems (Sarmah and Sabadie 2002). As hydrolysis rates drop, biodegradation becomes the mechanism affecting the breakdown of chlorsulfuron. Photodegradation is not an important loss mechanism in natural systems; although photodegradation has been observed under laboratory conditions. Aquatic dissipation half-lives from 24 days to greater than 365 days have been reported (ENSR 2005c), with a shorter time reported for flooded soil (47 to 86 days) than anaerobic aquatic systems (109 to 263 days; SERA 2004a). Chlorsulfuron is not known to be a groundwater contaminant, but has a high potential to leach into the groundwater. Chlorsulfuron has low potential to be transported in surface water; in a large study of surface water, chlorsulfuron was detected in only 1% of the 133 samples taken from Midwest streams (Battaglin et al. 2000).

Clopyralid

Clopyralid does not appear to bind tightly to soil and will leach under favorable conditions (SERA 2004b). However, leaching and subsequent contamination of groundwater appear to be minimal, which is consistent with a short-term monitoring study of clopyralid in surface water after an aerial application (Rice et al. 1997 *cited in* SERA 2004b). Clopyralid is not known to be a common groundwater contaminant, and no major offsite movement has been documented. Clopyralid will not bind with suspended particles in water; biodegradation in aquatic sediments is the main pathway for dissipation. The half-life of clopyralid in water ranges from 8 to 40 days (Tu et al. 2001).

Dicamba

Because it is mobile in soil, terrestrial application of dicamba can result in groundwater and surface water contamination under conditions that favor such activities. Biodegradation is the major mechanism for dicamba degradation in water. Although photodegradation occurs, it is not the major loss process. Hydrolysis and sediment adsorption are not significant loss mechanisms (Howard 1991). Dicamba is a known groundwater contaminant, and has a high potential to leach into groundwater. The USEPA has set health advisory concentration levels for dicamba (e.g. 300 µg/L for 1-day exposures), but has not set maximum concentration limits for potable water. Dicamba is registered for use on ditch banks, but should not be applied directly to water.

Following herbicide applications for 1 to 24 years, there were no detectable residues of dicamba in groundwater at two long-term tillage sites and one long-term manured site in Alberta (Miller et al. 1995). However, a regional study of pesticides in shallow groundwater in Delaware, Maryland, and Virginia detected dicamba in groundwater at low concentrations, generally less than 3 µg/L (Koterba et al. 1993).

Diflufenzopyr

Diflufenzopyr appears to be soluble with transportation from surface runoff following application, particularly when diflufenzopyr is applied on soils with neutral to alkaline pHs. However, based upon proposed uses, fate characteristics, and model predictions, the USEPA does not include diflufenzopyr among constituents that occur in significant quantities in drinking water (USEPA 1999a). Diflufenzopyr is not a known groundwater contaminant.

Biodegradation, photolysis, and hydrolysis are important mechanisms in removing diflufenzopyr from aquatic systems. Its half-life is less than 1 month, with hydrolysis and photolysis rates higher in acidic environments. The aquatic dissipation half-life for diflufenzopyr is 25 to 26 days in aerobic and 20 days in anaerobic conditions. Diflufenzopyr's expected half-life in small ponds is estimated at 24 days. These factors suggest that diflufenzopyr would be removed from an aquatic environment relatively rapidly if contamination occurred (USEPA 1999a).

Diuron

Diuron is a known surface and groundwater contaminant. The USGS NAWQA Program analyzed pesticide occurrence and concentrations for major aquifers and shallow groundwater in agricultural areas and found diuron in 71% of 2,608 samples. The maximum concentration of diuron was 0.34 ppb. The USEPA recently (February 2005) placed diuron on the drinking water contaminant candidate list. Diuron is currently labeled for use on ditch banks, but should not be applied directly to water.

In aquatic systems, biodegradation and photodegradation appear to be the primary loss mechanisms for diuron. An aquatic biodegradation half-life of 33 days has been reported for aerobic systems. Aquatic dissipation half-lives have been reported ranging from 3 to 10 days in anaerobic pond sediment to 177 days in a drainage ditch. Diuron is stable to hydrolysis and is unlikely to volatilize from aquatic systems (USEPA 2001a). Diuron is expected to adsorb to suspended solids and sediments (National Library of Medicine 2002).

The principal product of biodegradation is 3,4-dichloraniline (3,4-DCA), which also persists and exhibits higher toxicity than diuron (Tixier et al. 2002; Giacomazzi and Cochet 2004). In areas where diuron is used for crop production, monitoring has shown high concentrations of 3,4-DCA in small streams. 3,4-DCA was detected year-round in surface water (333 detections, 13 non-detections), with a range from 0.05 ppb (detection limit) to 26 ppb; the majority of the sample detections were less than 1 ppb (USEPA 2001a). At a poorly drained field site along an intermittent stream in Oregon, diuron and its transformation product, DCPMU (3-(3,4-dichlorophenyl)-1-methyl-urea), were detected in the stream at a maximum of 28 µg/L, and were detected in shallow groundwater immediately adjacent to a tributary stream at 2 to 13 µg/L. Movement through soil transported the herbicide and its metabolite to the stream, while surface runoff removed less than 1% of the applied herbicide (Field et al. 2003).

Hexazinone

Hexazinone and its degradates persist, are highly mobile, and are readily washed into surface waters. Hexazinone has been identified as a groundwater contaminant in Hawaii, Minnesota, Georgia, Arkansas, Florida, Maine, and North Carolina. The USEPA Office of Water has issued a lifetime health advisory, which sets a maximum concentration level of 0.21 mg/L for hexazinone in drinking water (USEPA 1994). In addition, the USEPA requires a groundwater advisory on all product labels stating that hexazinone not be used on permeable soils. In areas where irrigation water is contaminated with hexazinone or where groundwater discharges to surface water, hexazinone residues in water could pose a threat to plants. Hexazinone is labeled for use on ditch banks, but should not be applied directly to water.

In surface water, photodegradation is a primary fate of hexazinone. Hexazinone does not adsorb to particulates or sediments. Biodegradation in surface water is slow, but can be increased by the presence of organic matter. Hexazinone contamination has been detected in small waterbodies in episodic, low-level pulses that were rapidly diluted with increased flow (Tu et al. 2001). Hexazinone was detected in streams near terrestrial application sites up to 30 days after treatment, and reported in runoff up to 6 months post-treatment in a forestry dissipation study (Neary and Michael 1996; Michael et al. 1999). Mayack et al. (1982) and Neary et al. (1984, 1993 *cited in* Tu et al. 2001) concluded that hexazinone was diluted in the mainstream flow to very low concentrations in forested watersheds.

Imazapic

Imazapic is not known as a groundwater or surface water contaminant. In aquatic systems, imazapic will rapidly photodegrade, with a half-life of 1 to 2 days (Tu et al. 2001). Since aerobic biodegradation occurs in soils, aerobic biodegradation is likely important in aquatic systems. Aquatic dissipation half-lives have been reported from 30 days (water column) to 6.7 years (anaerobic sediments; SERA 2004d). Little is known about the occurrence, fate, or transport of imazapic in surface water or groundwater (Battaglin et al. 2000).

Metsulfuron Methyl

Metsulfuron methyl is stable to hydrolysis at neutral and alkaline pHs and has a half-life of 3 weeks in acid systems (Extension Toxicology Network 1996b). The persistence of metsulfuron methyl (initial concentration 10 µg/L) was investigated using in situ enclosures in a woodland/boreal forest lake, and the half-life was estimated at approximately 29 days (Thompson et al. 1992). Adsorption to sediments and suspended solids is not expected to be an important fate (USDA 1995). Little is known about the occurrence, fate, or transport of metsulfuron methyl in surface water or groundwater (Battaglin et al. 2000). Metsulfuron methyl is not known to be a groundwater contaminant, although it has a high potential to leach into the groundwater.

Picloram

Picloram can move off-site through surface or subsurface runoff, and has been detected in the groundwater of 11 states (Tu et al. 2001). The USEPA's maximum concentration level for picloram in potable water is 0.5 mg/L. Picloram does not bind strongly with soil particles and is not degraded rapidly in the environment. Concentrations in runoff are often reported to be adequate to prevent the growth of non-target terrestrial and aquatic plants; therefore, picloram should not be applied near waters used for irrigation or adjacent to areas with aquatic species of concern.

Picloram may degrade through photolysis, especially in non-turbid and moving water. Woodburn et al. (1989) found the half-life of picloram in water was 2 to 3 days (*cited in* Tu et al. 2001). Maximum picloram runoff generally occurs following the first significant rainfall, after which runoff concentrations drop to levels that persist up to 2 years post-application (Scifres et al. 1971; Johnsen 1980; Mayeux et al. 1984; and Michael et al. 1989 *cited in* Tu et al. 2001). Runoff concentrations of greater than 1 ppb are common following the application of picloram at recommended rates even under low-runoff conditions (Tu et al. 2001).

Sulfometuron Methyl

Sulfometuron methyl degrades quickly by hydrolysis in acidic water, but is stable in neutral water. Biodegradation and photolysis are major loss pathways in aquatic systems, where hydrolysis rates generally are slow. Aquatic dissipation half-lives are estimated at 1 to 3 days to 2 months in aerobic systems, and several months in anaerobic sediments (Extension Toxicology Network 1996d). Little is known about the occurrence, fate, or transport in surface water or groundwater in the U.S. (Battaglin et al. 2000). Sulfometuron methyl is not known to be a groundwater contaminant. In one surface water study, sulfometuron was detected in 2% of 133 samples taken from streams.

Tebuthiuron

Tebuthiuron persists in the environment, perhaps a function of low sorption affinity to soil. Tebuthiuron can be used on ditch banks, but should not be applied directly to water. In one study of 71 streams, tebuthiuron was detected in 16% of 134 stream samples taken, with concentrations up to 0.076 µg/l, but was not detected in groundwater (Battaglin et al. 2001). In water, tebuthiuron is resistant to hydrolysis and photolysis, although some photodegradation has been reported at a pH of 9 (National Library of Medicine 2002). Tebuthiuron is expected to slowly biodegrade in aquatic systems. Aquatic dissipation half-lives are estimated to be longer than 1 month under aerobic conditions, and longer than 12 months under anaerobic conditions (USEPA 1994).

Other Herbicides Previously Approved for Use on BLM Lands

Asulam, atrazine, fosamine, mefluidide, simazine, and 2,4-DP (also known as dichlorprop) are currently approved for use on public lands. However, the historical use of these herbicides by the BLM has been quite limited, with only fosamine used in the last 7 years. 2,4-DP is registered to control aquatic weeds in ditches and for upland purposes, is mobile in soils, and has been detected in surface water and groundwater (National Library of Medicine 2002). Both atrazine and simazine persist in rainwater, groundwater, and surface water. Mefluidide and fosamine are not commonly known to contaminate groundwater or surface water. Fosamine adsorbs to soil and biodegrades, making it less likely to be mobilized. However, upon reaching water it is generally stable until it partitions into sediments (Tu et al. 2001).

Impacts by Alternative

The BLM would focus treatment efforts on watersheds that provide opportunities for watershed improvement and protection (USDI BLM 2000a). In addition, the BLM would strive to increase the number of proper-functioning wetland/riparian areas and uplands to benefit water quality.

Much of this work would be directed at hazardous fuels and weed reduction to improve watershed function and water quality and reduce the risk of catastrophic fires. When fire clears the vegetation, the soils that were anchored by root systems become vulnerable to wind and water erosion. When soils are carried into lakes and streams, water quality diminishes as a function of increased sedimentation and turbidity (USDI BLM 2000d). Work would also be directed at controlling invasive vegetation, such as pinyon-juniper that has overtaken many native shrub and grassland communities. These trees diminish water that native species are reliant upon and can cause increased soil erosion (USDI BLM 1999).

Watersheds dominated by annual grasses, such as downy brome, offer far less protection from wildland fire and erosion than native grasses. The reduced cover provided by annuals allows more rainfall to strike the soil surface, loosening soil particles and forming a seal over the pores at the soil surface. As the pores seal, infiltration decreases, which leads to increased runoff and loss of soil moisture. Eventually, soils are transported to streams and other aquatic bodies, increasing sedimentation and reducing water quality.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would treat an estimated 305,000 acres per year using the current vegetation treatment programs in 14 western states. This alternative is a continuation of the current vegetation management program using both ground-based and aerial treatment methods. Public lands in Alaska, Nebraska, and Texas have not been part of the herbicide program historically, and would not be included under this alternative.

Impacts to surface water and groundwater quality and quantity would be similar to impacts from the ongoing program. Under the No Action Alternative, it is unlikely that 2,4-DP, asulam, atrazine, mefluidide, and simazine would be used, and fosamine may only be used on a limited basis (<100 acres annually). Of these herbicides, atrazine, simazine, and 2,4-DP are known groundwater contaminants.

Based on historic use, 2,4-D, glyphosate, picloram, and tebuthiuron would constitute approximately 70% of herbicide use. All of these herbicides are known groundwater contaminants, although only glyphosate has high surface water runoff potential. In addition, of the other herbicides proposed for use, diquat, diuron, bromacil, dicamba and hexazinone are also known to be groundwater contaminants. For most terrestrial applications, herbicide concentrations are diluted as they move from the treated site to downgradient locations (Michael 2000). Out of 236 studies of pesticide contamination of surface waters in drainage basins throughout the U.S., none reported pesticide concentrations exceeding USEPA safe levels for human health, except where chemicals were applied directly to or spilled into the stream channel (Larson et al. 1997).

Under the No Action Alternative, Overdrive®, diquat, fluridone, and imazapic would not be available for use. Both diquat and fluridone are considered effective against the invasive plant Eurasian watermilfoil, among other problematic aquatic plants (Washington Department of Ecology 2002, Skogerboe 2003). Triclopyr would be the only herbicide under this alternative available to treat submersed vegetation. Not allowing the use of two proposed herbicides available for treatment of aquatic plants would potentially allow the continued negative effects of some forms of weeds and invasive aquatic vegetation on water quality, potentially resulting in degraded wildlife habitat and limited recreation opportunities.

Fewer acres would be treated under this alternative than under the other alternatives. Therefore, impacts on water quality and water quantity from herbicides would be more limited. However, continued impacts to water quality and quantity from invasive plant species over the untreated areas could potentially occur.

Alternative B – Expand Herbicide Use and Allow For Use of New Herbicides in 17 Western States (Preferred Alternative)

Under the Preferred Alternative, an estimated 932,000 acres per year would be treated across 17 western states. Out of all the alternatives, this is the largest acreage proposed for treatment. Therefore, benefits and risks to surface and groundwater would be greater than under the other alternatives. It is estimated that several thousand acres of public lands are being newly infested by noxious invasive weeds each day. The result of this is damage to watersheds and subsequent deterioration in water quality and quantity. Until more acres are treated, it will be impossible for the BLM to bring the spread of invasive plants down to a reasonable level by locating and treating new infestations, and reducing the size of existing infestations.

Under the Preferred Alternative, herbicide use in Alaska, Nebraska, and Texas would be allowed, although little or no herbicide treatment is planned for Alaska. Use in Nebraska and Texas would allow for more comprehensive weed management program that would help reduce the negative effects of invasive species.

This alternative would not allow the use of 2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine, but would allow use of four new herbicides (Overdrive®, diquat, fluridone, and imazapic) in addition to approved herbicides. This alternative would include treatment in areas located in Alaska, Nebraska, and Texas and would allow the BLM to use herbicides that are registered in the future. This alternative allows both ground-based and aerial applications.

Approximately 10% of treatment acres would be treated using these new herbicides. Diquat and fluridone could be directly applied in aquatic systems to control unwanted submersed aquatic vegetation. Approval of diquat and fluridone would provide new capabilities for controlling invasive aquatic plants and could provide benefits to water quality if invasive aquatic plants were eliminated. Fluridone, in particular, has been effective at controlling Eurasian watermilfoil without resulting in impacts to drinking water quality or recreation (Washington Department of Ecology 2002).

Both dicamba and diquat are known groundwater contaminants. However, increased protection of groundwater could be possible if imazapic (not known to contaminate groundwater) was used for treating terrestrial species instead of other herbicides known to contaminate groundwater. Diflufenzopyr is not known to contaminate groundwater, but has a high potential to leach to groundwater. Except for fluridone, which has a high potential for surface water runoff, the proposed herbicides have low potential to flow to aquatic bodies in stormwater runoff.

Alternative C – No Use of Herbicides

No herbicides would be used in the BLM vegetation management program under Alternative C. Some areas would not be treated, while other areas would be treated by mechanical, manual, or biological methods, or fire. Without treatment, land degradation would accelerate, leading to poorer water quality. As discussed in the PER, other treatments also impact water quality and quantity, with fire and mechanical treatments having the greatest effects. However, the risks of impacts to surface water and groundwater quality would be low under this alternative.

The only alternative to herbicide treatment of submersed vegetation is mechanical or manual removal; water drawdown on controlled reservoirs, lakes, and ponds; and flooding with salt or brackish water. These treatments generally are not as effective as chemical treatments for controlling many invasive aquatic plants (Aquatic Ecosystem Restoration Foundation 2004, USDI BLM 2005a). Without effective treatment, some invasive aquatic plants would go largely uncontrolled, potentially resulting in degraded water quality and reduced quantity.

Alternative D – No Aerial Applications

Under Alternative D, herbicide treatment with four newly-approved herbicides and the previously-approved herbicides would be allowed in 17 states. These herbicides would be applied by ground application methods. The estimated area treated would be approximately 529,000 acres per year. Ground-based herbicide treatments could be used to replace aerial treatments in some locations, and non-herbicide treatment methods could be substituted in some areas unsuitable for ground-based herbicide treatment.

Aerial application has the advantage of treating large areas or areas of difficult terrain. However aerial application is more likely to result in misapplications or drift, and thus water quantity and quality could be negatively impacted. The extent of the impact would depend on the weather, the size and location of the treatment area, the use of buffers, and the kind and concentration of herbicide used.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

Under Alternative E, the BLM would not be able to use ALS-inhibiting herbicides (chlorsulfuron, imazapyr, imazapic, metsulfuron methyl, and sulfometuron methyl). Approximately 466,000 acres would be treated under this alternative. Aerial and broadcast treatments and treatments in wetland, riparian, wilderness, and cultural resource areas would be discouraged, while more passive treatment methods would be promoted. Of the six herbicides registered for aquatic use, imazapyr is ALS-inhibiting and would not be allowed. Of the four newly proposed herbicides, imazapic is ALS-inhibiting and would not be allowed.

Impacts associated with size of treatment area are discussed under Alternative C; impacts associated with aerial applications are discussed under Alternative D. Because of the reduced treatment acreage, the negative effects of weedy and invasive species on water quality and quantity could be greater. The risks to water quality and quantity from use of herbicides would be lower than under the Preferred Alternative. Fewer treatments in wetland and riparian areas could correspond to more impacts to surface water quality when wetland areas containing substantial infestations of invasive species go untreated.

Currently, little is known about the occurrence, fate, or transport of ALS-inhibiting herbicides in surface water or groundwater in the U.S. (Battaglin et al. 2000, 2001). An extensive study of Midwestern streams, reservoirs, and groundwater in 1998 found relatively low concentrations of sulfonylurea and imidazolinone herbicides in 83% of 133 samples from streams, in 6 of 8 reservoir samples, and 5 of 25 groundwater samples. These results indicate that some ALS-inhibiting herbicides are mobile and may reach surface water and groundwater.

Mitigation for Herbicide Treatment Impacts

The following mitigation measures should be considered to reduce, minimize, or mitigate impacts to water resources from the use of herbicides:

- Avoid accidental direct spray and spill conditions to reduce the largest potential impacts. Use the typical application rate, rather than the maximum application rate, to reduce risk to most species for most herbicides.
- Limit the application area when possible (e.g., 10 acres or less).
- Establish appropriate (herbicide specific) buffer zones to downstream waterbodies, habitats, or species/populations of interest (see Appendix C, Table C-16).
- Consider the proximity of application areas to salmonid habitat and the possible effects of herbicides on riparian and aquatic vegetation. Maintain appropriate buffer zones around salmonid-bearing streams (see Appendix C, Table C-16, and recommendations in individual ERAs).

Wetland and Riparian Areas

Introduction

The BLM manages over 23 million acres classified as riparian or wetland. Wetland and riparian areas in the western U.S. and Alaska are influenced by human activity, natural disturbance, and local physical and biological conditions. Invasive plant species degrade wetland and riparian area function and present a challenge to vegetation management. An estimated 59,000 acres of wetland habitat and 17,500 stream miles on BLM lands lack characteristics necessary for "high" functioning wetland and riparian habitats (USDI BLM 2005d). Invasive plant species are one factor that degrade wetland function.

The proposed herbicide treatments could cause long-term alterations to vegetation, hydrology, or soils to the extent that a specific area no longer functions properly; is fragmented or the biodiversity of high quality areas is reduced; or TES wildlife or plants or harmed or displaced. Treatments would be beneficial as they contribute to removal or control of invasive species and replacement with native species.

Scoping Comments and Other Issues Evaluated in the Assessment

Concerns regarding treatment of wetland and riparian areas included protection of unique areas and areas of high biological importance; management of invasive species (e.g., saltcedar) that provide habitat for species that use aquatic and riparian areas; and the need to maintain species diversity and sensitive areas like vernal pools. Among alternative treatment proposals was a suggestion that treatment be deferred in wetland and riparian areas where long-term control of invasive species was unlikely.

Factors that Influence the Fate, Transport, and Persistence of Herbicides in Wetland and Riparian Areas

If applied directly to wetlands and riparian areas, herbicides dissipate by transport through water or wind, through chemical or biological degradation, or through adsorption and immobilization in soils. When herbicides are applied to well-drained areas, adjacent wetlands and riparian areas can play a critical role in filtering herbicides from runoff, through physical trapping, and through chemical and biological processes. These processes affect herbicide availability, phytotoxicity, and fate and transport (Anderson 1983).

Saturated wetland soils have chemical and biological characteristics that are different from well-drained upland soils, including oxidation-reduction status, pH, and high organic content. For example, oxygen depletion of saturated soils facilitates oxidation-reduction, reductive chemical processes, and anaerobic microbial processes. Soil pH can be closer to neutral in wetland soils than in well-drained soils; or wetlands soils may be more acidic than well-drained areas if peat is present. The characteristics of wetland soils affect the capacity of soils to adsorb, transport, and transform herbicides. The extent of the effects on herbicide fate is dependent on the duration of saturation, soil temperature, the kind and amount of organic matter, and the nature and content of reactive chemicals present in the soil. For example, some chemical processes which degrade herbicides only occur to measurable degrees when soils are anaerobic or lack free oxygen.

The rate of breakdown in anaerobic systems can be estimated by the measured anaerobic half-life (Table 4-10). Generally, anaerobic degradation processes are much slower than the degradation processes in well-drained soils where oxygen is present.

Methodology for Assessing Impacts to Wetland and Riparian Areas

The BLM reviewed the literature and findings from ERAs to assess the impacts to aquatic plant species from the use of herbicides (ENSR 2005b-k, SERA 2005a). The ERA methods and results for aquatic and terrestrial vegetation are summarized in the Vegetation section of this chapter. Methods used by the BLM are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C; methods used by the Forest Service are available at http://www.fs.fed.us/r6/invasiveplant-eis/.

Herbicide use poses potential risks to aquatic and riparian plant species. However, appropriate implementation of SOPs should minimize these risks (see Table 2-6). These include 1) surveying for TES aquatic and riparian plant species before treating an area; 2) using drift reduction agents to reduce the risk of drift hazard; 3) using a selective herbicide and a wick or backpack sprayer; 4) using the typical application rate, rather than the maximum application rate, where practical; and 5) using an appropriate herbicide-free buffer zone for herbicides not labeled for aquatic use. This information is discussed in the ERA guidance provided in the Vegetation section of this chapter.

Summary of Herbicide Impacts

Impacts from Herbicides Applied to Wetlands and Riparian Areas

Use of herbicides to control aquatic and riparian vegetation can improve habitat quality for fish and wildlife, improve hydrologic function, and reduce soil erosion. Non-native species, such as purple loosestrife, form extensive monotypic stands that displace native vegetation used by wetland animal species for food and cover (Bossard et al. 2000). Purple loosestrife can also alter the hydrology and soil conditions of wetland pastures and impact recreational activities. Hydrilla is an aquatic species that forms large mats that fill the water column and can severely restrict water flow, leading to a decrease in habitat for fish and wildlife and water quality. Milfoils are an aquatic species that have spread widely over the western U.S. and have been found to alter the physical and chemical characteristics of lakes and streams. Much of the BLM's vegetation control efforts in wetland and riparian areas would focus on these species.

Most aquatic herbicides are non-selective and could result in adverse impacts to non-target wetland and riparian species diversity, competitive interactions, species dominance, and vegetation distribution (Kleijn and Snoeijing 1997). Herbicide applications could reduce plant cover leading to increased sedimentation, increased nutrient loading, alterations in native vegetation, and changes to temperature and hydrologic conditions.

An increase in soil erosion and surface water runoff could result from vegetation reduction, which could lead to stream bank erosion and sedimentation in wetlands and riparian areas (Ott 2000). The amount and likelihood of stream bank erosion and sedimentation would be directly proportional to the size of the treatment area (i.e., larger treatment areas would lead to increased risk of stream bank erosion and sedimentation). Additionally, sedimentation could result in a reduction in the acres of wetland and riparian habitat.

The following six chemicals are approved for use in aquatic systems by the USEPA, including wetlands and riparian areas. Two of these chemicals (diquat and fluridone) are newly proposed for use on public lands.

2,4-D

2,4-D salt formulations are approved for use in riparian and aquatic systems. The principal hazard of 2,4-D exposure to non-target plants is from unintended direct deposition or spray drift (SERA 2003a). 2,4-D salt formulations can be used in spot treatments and applied according to the labeled rate without substantially affecting native aquatic vegetation and without significantly changing species diversity (USDA Forest Service 2005, Washington Department of Ecology 2004). 2,4-D has been shown to be effective for treating Eurasian watermilfoil. 2,4-D ester formulations are toxic to fish and aquatic invertebrates and should not be used near aquatic systems. Kuhlmann et al. (1995) found no biodegradation of 2,4-D under anaerobic (sulfate reducing) conditions in a laboratory experiment of sediments and groundwater. In aerobic riparian soils that have a high content of organic material, active microbial community, high pH values, and high temperatures, toxic effects are limited because of rapid degradation of 2,4-D. 2,4-D may inhibit shoot and/or root growth of macrophytes in aquatic systems (Roshon et al. 1999).

Diquat

Diquat is a contact herbicide approved for floating, submerged, and aquatic vegetation and would be used in ponds, lakes, canals, and reservoirs. Diquat persists in the environment, but is quickly adsorbed to soils and sediments, immobilizing it and rendering it unlikely to contaminate leachate or runoff. Target wetland species that could be controlled by diquat include Eurasian watermilfoil, hydrilla, water hyacinth, and giant salvinia. Diquat kills on contact, but it does not kill plant roots, and therefore it is often used for single-season control of submerged aquatic plants and not for plant eradication (Washington Department of Ecology 2004).

As a non-selective aquatic herbicide, diquat should not be applied in wetlands where there is the potential to kill or harm aquatic plants of concern. Large areas should not be treated with diquat in a single application without some procedure to remove treated vegetation, as studies have shown that rapid rates of plant decomposition following treatment may deoxygenate water, potentially resulting in negative effects to fish and other aquatic organisms.

Fluridone

Fluridone is a slow-acting, broad-spectrum aquatic herbicide that can be used at low concentrations on both submerged and emergent aquatic plants. Fluridone photodegrades, volatilizes slowly from water, and adsorbs to suspended solids and sediments (National Library of Medicine 2002).

Fluridone would be used to treat ponds, lakes, canals, and reservoirs, but not flowing waters where contact time cannot be maintained. It is a non-selective herbicide at higher application rates, but is most frequently applied at lower application rates, where it selectively affects submerged aquatic plants while only minimally affecting emergent vegetation. Where the entire waterbody is infested with a non-invasive species (such as Eurasian watermilfoil), a whole-waterbody treatment of fluridone can be used. Fluridone is not suitable for spot treatments (sites less than 5-acres within a larger waterbody), as it is difficult to maintain enough contact time between the plant and the fluridone to kill the plant (Washington Department of Ecology 2004).

Glyphosate

Glyphosate is approved for fresh and brackish water, including estuaries, and wetland and emergent aquatic vegetation. Glyphosate may be used in riparian and aquatic habitats along shorelines for species such as purple loosestrife, reed canarygrass, giant reed, cattail, and for floating aquatic species such as water lily. Glyphosate is also used to control grasses, herbaceous plants, and some broadleaf trees and shrubs in riparian areas. Glyphosate dissipates rapidly from surface water by adsorption and biodegradation and may move into surface water with eroded soil particles.

Freshwater aquatic macrophytes and algae are reported to be sensitive to glyphosate at concentrations as low as

20 mg/l, however stimulation in growth for some green algae at low concentrations (0.02 mg/l) has also been reported (SERA 2003b).

TABLE 4-10
Anaerobic Half-life and Relative Mobility in Soil for Herbicides Analyzed in this PEIS

Herbicide	Anaerobic Soil Half-life (days)
2,4-D	333
2,4-DP	> 200
Asulam	> 14
Atrazine	15-77
Bromacil	144 to 198
Chlorsulfuron	109 to 263
Clopyralid	> 1,000
Dicamba	Not determined
Diflufenzopyr	20
Diquat	> 1,000
Diuron	5 to 100
Fluridone	4 to 270
Fosamine ammonium	4
Glyphosate	12 to 70
Hexazinone	Stable
Imazapic	> 1,000
Imazapyr	> 500
Mefluidide	No information found
Metsulfuron methyl	338
Overdrive®	88
Picloram	> 500
Simazine	71
Sulfometuron methyl	60
Tebuthiuron	Not determined
Triclopyr	< 1

Sources: Krueger et al. 1991: USEPA 1992, 1994, 1995c, 1996, 1999a, 2001b, 2003d ; Krzyszowska et al. 1994: Tomlin 1994: Kuhlmann et al. 1995: SERA 1997, 2003b, 2003d, 2004d, 2004e, 2004f: Harrison et al. 1998: Strek 1998: Suzuki et al. 2001.

Imazapyr

Imazapyr is approved for use in wetlands and riparian areas, including brackish and coastal waters. It is used to control emergent and floating plants. Imazapyr has been shown to be effective in the management of saltcedar, which has invaded many riparian zones throughout the western U.S. Imazapyr is used to treat emergent wetland plants such as cordgrass, reed canarygrass, and phragmites, and floating plants such as water lily. Imazapyr use may result in effects to non-target aquatic vegetation and high concentrations of imazapyr in surface water may adversely affect some aquatic macrophytes (SERA 2004e).

Residual soil contamination with imazapyr could be prolonged in some areas, possibly resulting in substantial vegetative growth inhibition (SERA 2004e). Imazapyr likely does not degrade in anaerobic soils or sediments and has been shown to strongly bind to peat (American Cyanamid 1986, SERA 2004e).

Triclopyr

Triclopyr controls a variety of weed species and can be effective as a spot treatment for Eurasian watermilfoil because it is relatively selective for this species at low application rates. In addition, it is effective in riparian areas as a treatment for purple loosestrife as it does not damage native grasses and sedges (Washington Department of Ecology 2004).

Commercial formulations of triclopyr may contain the triethylamine salt (TEA) or the BEE and both formulations degrade to an acid form. Both formulations are used to selectively treat unwanted riparian woody vegetation; however, only the TEA formulation is approved for selective control of submersed aquatic vegetation (SERA 2003d). Triclopyr BEE is projected to be somewhat more hazardous when used where runoff to open water may occur.

Impacts from Herbicides Applied to Uplands

Non-target wetland and riparian areas could be exposed to herbicides through a variety of routes, including accidental spills or direct spray, local spray drift from adjacent target areas, surface water runoff, and soil erosion (Karthikeyan et al. 2003). Risks to wetland and riparian non-target species would depend on a number of factors, including the amount, selectivity, and persistence of the herbicide used; the application method used; the timing of the application; and the plant species present. Risks to wetlands and riparian areas from surface runoff would be influenced by precipitation rates, soil types, and proximity to the application area. Some herbicides (e.g., sulfometuron methyl) that adsorb into soil particles could be carried off-site, increasing their risk of affecting vegetation in wetlands and riparian areas.

Unintentional applications can have severe negative impacts for wetland and riparian systems. In particular, accidental spills near wetland and riparian areas could be particularly damaging to wetland and riparian vegetation. Spray drift can also degrade water quality in wetland and riparian areas and could damage non-target vegetation.

Bromacil

Bromacil is not selective and accidental exposure could injure riparian shade trees and other desirable non-target wetland and riparian vegetation. Bromacil is mobile and has the ability to persist in wetland environments.

Chlorsulfuron

Chlorsulfuron is effective at low concentrations and is prone to leaching. Hydrolysis rates are the fastest in acidic waters and are slower as the pH rises (Sarmah and Sabadie 2002). When hydrolysis rates drop, biodegradation becomes the primary loss mechanism. Strek (1998) studied the dissipation of chlorsulfuron in an anaerobic sediment/water system and biodegradation progressed slowly with a half-life greater than 365 days, which is much greater than in aerobic soil systems.

Clopyralid

Clopyralid typically leaches and is generally rapidly degraded in soil, except in arid soils with low microbial populations where it remains stable and could potentially reach wetlands and riparian areas. Clopyralid is relatively non-toxic to aquatic plants. Overall, effects to non-target wetland and riparian vegetation from normal application of clopyralid are likely to be limited to sensitive plant species in or very near the treatment area, and could be avoided by maintaining an adequate buffer between the treatment area and wetland and riparian areas (SERA 2004b). It is not likely to affect aquatic plants via off-site drift or surface runoff pathways; however, accidental spills may result in temporary growth inhibition of aquatic plants due to the potential for higher concentrations to occur in an accidental spill scenario.

Dicamba

Direct spray and accidental spill scenarios of dicamba result in moderate to high risk to both terrestrial and aquatic plants. In water, biodegradation is the major mechanism for dicamba degradation. Dicamba is mobile in soils and is therefore likely to reach surface and groundwater. A study on fate of dicamba in a riparian wetland showed dicamba was demethylated to 3,6-dichlorosalicylic acid under either aerobic or anaerobic conditions. The rates of dicamba degradation were generally more rapid in the surface than in the subsurface soil microcosms and indicated that some riparian wetland soils possess limited potential to degrade dicamba (Pavel et al. 1999).

Diflufenzopyr

Diflufenzopyr is an active ingredient in the herbicide formulation Overdrive®, along with dicamba. Diflufenzopyr is not approved for the treatment of aquatic plants, but poses a low risk from off-site drift to riparian species and aquatic plants.

Diuron

Accidental direct spray and spill scenarios for diuron generally result in high risk to aquatic plants. Off-site drift typically poses low to moderate risk to aquatic plants provided the ERA recommended 900-foot buffer is used (ENSR 2005f).

Hexazinone

Aquatic plants are at moderate to high risk from acute and chronic exposure to hexazinone at both the typical and maximum application rates. Aquatic algal species are also sensitive to hexazinone exposure. Furthermore, it is likely that aquatic macrophytes are sensitive based on the effects of hexazinone on algae and terrestrial plants (SERA 1997).

Imazapic

Aquatic plants experience moderate to high risk from accidental spills of imazapic at the maximum application rate and low to moderate risk at the typical application rate (there is no acute risk to aquatic plants in standing water at the typical application rate). Aquatic plants are generally not at risk from off-site drift of imazapic, except when applied aerially at the maximum application rate with a buffer of 100 feet or less. Imazapic rapidly degrades through photodegradation in aquatic systems (SERA 2004d).

Metsulfuron Methyl

Aquatic macrophytes face low risk from acute exposure to metsulfuron methyl at upper exposure limits (SERA 2004f). Metsulfuron methyl is stable to hydrolysis at neutral and alkaline pHs. Larsen and Aamand (2001) evaluated biodegradation of metsulfuron methyl (25 μg/L) under anaerobic and aerobic conditions in sandy sediments, and the herbicide was not biodegraded under any of the conditions applied.

Picloram

The toxicity of picloram to aquatic plants varies substantially among different species. There is low risk to sensitive aquatic macrophytes from acute exposure to picloram at the maximum application rate. Picloram does not bind strongly to soil particles and is not rapidly degraded in the environment, increasing the potential for picloram to be transported to wetland and riparian areas.

Sulfometuron Methyl

Accidental direct spray and spill scenarios of sulfometuron methyl result in high risk to aquatic plants, but aquatic plants are likely not at risk from off-site drift provided a 900-foot or greater buffer is maintained, as recommended in the ERA for sulfometuron methyl (ENSR 2005j). Aquatic plants in standing water are typically at low to moderate risk from surface runoff. Sulfometuron methyl should not be applied during high winds, as drift could cause extensive damage to vegetation at a substantial distance from the application site.

Tebuthiuron

Aquatic plants are at high risk from spills of tebuthiuron, and potentially at high risk from direct spray. Aquatic plants are not at risk from off-site drift of tebuthiuron; however, surface runoff typically results in risk to submerged aquatic plants at the maximum application rate and at typical application rates in sandy soils. Tebuthiuron is resistant to hydrolysis and photolysis in aquatic systems; however, some photodegradation has been reported at alkaline conditions (pH=9), and tebuthiuron is expected to slowly biodegrade in aquatic systems.

Impacts of Other Herbicides Currently Available for Use

Asulam, atrazine, fosamine, mefluidide, simazine and 2,4-DP (also known as dichlorprop) are currently approved for use on public lands in many western states (see Table 2-1). These herbicides have not been used, or have only been used infrequently (fosamine), during the past 7 years. They are not registered for use in riparian or aquatic areas. Atrazine, simazine, and 2,4-DP, are persistent and considered mobile in well-drained soils and could reach wetlands and riparian areas. Persistence is extended under dry and or cold conditions. Mefluidide is not strongly adsorbed soil but has a half-life from 1 to 2 weeks. Fosamine is rapidly metabolized by soil microbes and it does not persist (Han 1979 *cited in* Tu et al. 2001).

Impacts by Alternative

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue its on-going vegetation treatment programs in 14 western states, and would be able to use 20 herbicides previously approved under earlier RODs. Herbicide use under the No Action Alternative would impact target and non-target vegetation over an estimated 305,000 acres annually, including approximately 2,300 acres of riparian and aquatic habitat. Herbicides used to control aquatic and riparian vegetation under this alternative could include 2,4-D, glyphosate, and imazapyr, which are registered for aquatic uses, and dicamba, tebuthiuron, and triclopyr in riparian areas where contact with water can be avoided.

The nature of impacts would be similar to those of occurred in the past 10 years. Negative impacts to wetland and riparian vegetation would be lower than the other herbicide treatment alternatives (B, D, and E) because far fewer acres would be treated. Adverse impacts could be higher on the acres treated under this alternative, however, if newer, more effective herbicides could not be used.

Of the 20 herbicides previously approved, it is unlikely that 2,4-DP, asulam, atrazine, fosamine, mefluidide, or simazine would be used. It is likely that 2,4-D and glyphosate (aquatic uses), and picloram and tebuthiuron (upland uses), would be used most frequently under this alternative. Glyphosate and 2,4-D have been demonstrated to provide benefits through the control of invasive riparian and wetland plant species.

Diflufenzopyr+dicamba (as Overdrive®), diquat, fluridone, and imazapic would not be available for use under this alternative. Risks to wetland and riparian areas from use of these herbicides are similar to or lower than for risks associated with currently-approved herbicides. Not being able to use these four new herbicides increases the risks to wetland and riparian plants from accidental spill and drift scenarios than under the other herbicide-use alternatives. In addition, fluridone is specifically indicated for aquatic use, whereas none of the other currently-approved herbicides are strictly aquatic herbicides. Under the other herbicide treatment alternatives, diquat and fluridone would be used to treat aquatic vegetation, and both have shown to be effective in the control of milfoils, hydrilla, water hyacinth, and giant salvinia. The other herbicides registered for aquatic use, glyphosate and triclopyr, are not as effective in controlling these species.

Under the No Action Alternative, the BLM would not be able to use new chemicals that may become available in the future and which may be more effective and safer to use in wetland and riparian areas than herbicides currently available to the BLM. Public lands in Alaska, Nebraska, and Texas have not been part of the herbicide program historically, and would not be included under this alternative.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Alternative B, the Preferred Alternative, would result in the herbicide treatment of approximately 932,000 acres annually across 17 western states, of which about 10,000 acres would consist of aquatic and riparian habitat. The BLM would only be allowed to use 14 currently-approved herbicides, six fewer than under the No Action Alternative, but the BLM would be able to use the four new herbicides evaluated in this PEIS. In addition, the BLM would be able to treat vegetation using herbicides in Alaska, Nebraska, and Texas, although it is anticipated that few or no herbicide treatments would occur in Alaska. This alternative could result in the most extensive impacts to wetlands and riparian areas (both negative and positive) because it proposes the most acres for treatment (more than four times the acreage proposed under the No Action Alternative).

The BLM's ability to use four new chemicals (fluridone and diquat for aquatic applications, and imazapic and Overdrive® for terrestrial applications), would provide new capabilities to the BLM for controlling problematic invasive species and would provide benefits to these wetland and riparian areas if invasive species were controlled or eliminated. Fluridone, in particular, has been effective at controlling Eurasian watermilfoil (Washington Department of Ecology 2002). Based on recent use patterns, 2,4-D, glyphosate, picloram, and tebuthiuron would continue to comprise the majority of herbicide use under this alternative. The benefits and risk of these herbicides are discussed under the No Action Alternative.

Overdrive® and imazapic would primarily be used on rangelands, but could still provide benefits relative to the No Action Alternative. Overdrive® would be used to treat thistles and knapweeds, while imazapic could be used to control downy brome. These invasive plant species degrade riparian habitats and can lead to shortened fire cycles, followed by soil erosion and sedimentation.

The ability to use herbicides as they become registered with the USEPA would allow BLM managers more options in choosing herbicides to match treatment goals and application conditions and to use herbicides that pose less risk to wetlands and riparian areas as compared to currently-used or proposed herbicides.

The BLM does not propose to use herbicides in Alaska (where the majority of the wetland and riparian areas on BLM lands are found). However, the BLM would retain the option to use herbicides in Alaska should the need arise and benefits of using herbicides outweigh the risks of other treatment methods.

Alternative C – No Use of Herbicides

No herbicides would be used for vegetation management in 17 states under Alternative C. Primary effects to riparian and wetland vegetation would stem from other vegetation treatment methods including fire, manual, mechanical, and biological control (see PER; USDI BLM 2005a). The possible ecosystem benefits of not using herbicides would be the elimination of risk from accidental spills, drift, and persistence of herbicides on non-target biota.

Without the use of herbicides, it is likely than some invasive plants would continue to spread rapidly, resulting in dramatic and potentially irreversible effects on wetland and riparian areas. As discussed previously, invasive species out-compete native vegetation, and lead to widespread incidence of fire and other conditions that can result in loss of ecosystem function wetlands and riparian areas.

Positive ecosystem benefits as a result of vegetation management may be reduced under this alternative as there are certain invasive species for which herbicide use is the only effective method of treatment or for which other methods are impractical due to cost, time, accessibility, or public concerns. For example, rough terrain that may not allow treatment by methods requiring terrestrial vehicle and foot access could potentially be treated using herbicides applied by aircraft. Other treatment methods, such as mechanical, fire, and biological, can result in soil disturbance and sedimentation of aquatic bodies, and may not adequately treat the pest plant.

In addition, it is often difficult to eradicate some species, such as aquatic species and those that resprout from rhizomes by means other than herbicide application. These include milfoils and hydrilla, which form dense mats of aquatic vegetation that crowd out native plants and degrade fish habitat (Bossard et al. 2000), and where chemical treatments, including the use of 2,4-D, diquat, and fluridone, are more effective than other treatments, such as mechanical harvesters that tend to fragment and spread the weed.

Alternative D – No Aerial Applications

Alternative D would allow the use of the same herbicides in the same areas as under the Preferred Alternative, and would have similar benefits resulting from the increased availability of new and future herbicides. However, this alternative would not allow the use of aerial application methods, thereby reducing the total acreage possible for treatment (530,000 total acres). However, this alternative would have little impact on treatment of wetland and riparian habitats as compared to the Preferred Alternative. Nearly all (98%) of acres proposed for treatment in wetland and riparian habitats under the Preferred Alternative would be treated using ground-based methods and could also be treated under Alternative D. This alternative would substantially reduce the impacts of off-site drift to wetlands and riparian areas from application on upland habitats. Drift is a major route of unintended damage to non-target vegetation, with aerial application the primary cause of off-site drift.

Under this alternative, invasive plant populations in remote wetland and riparian areas would likely continue to spread. Ground-based herbicide treatments could be used for some locations, except where areas are too remote, have difficult terrain, or cover large expanses. Areas with extensive coverage of invasive species may not be comprehensively treated using ground-based methods, and subsequent reinvasion could require frequent re-treatment in the same area. Non-herbicide vegetation control may be substituted in areas unsuitable for ground-based herbicide treatment. For example, prescribed fire can be used to control some unwanted vegetation types. However, many invasive riparian and wetland plant species are able to re-sprout after fire. Biological treatments have been shown to be effective in some riparian and wetland areas for some species, however, the number of invasive species with known biological control agents and the effectiveness of these agents are limited. All of these replacement alternatives could result in damage from the use of ground-based equipment.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

Approximately 466,000 acres would be treated under Alternative E, which is slightly less than the acreage that would be treated under Alternative D, and less than half of the acreage that would be treated under the Preferred Alternative. Under this alternative, ALS-inhibiting herbicides would not be allowed including imazapic, imazapyr, chlorsulfuron, metsulfuron methyl, and sulfometuron methyl. Of these, only imazapyr is registered for use in wetland and riparian areas. These herbicides are potent and have the benefit of very low application rates; however this potency leads to residual herbicidal activity. This group of herbicides has been shown to damage off-site native and crop species and several weed species can develop resistance to these herbicides making them less effective.

Under this alternative, herbicide treatments would be discouraged, broadcast spraying would be prohibited, and passive treatment methods would be promoted in wetland and riparian areas. Imazapyr has been shown to be effective against saltcedar, a particularly pernicious riparian area invader that has few effective treatments. This action could potentially increase adverse effects to wetland and riparian areas from invasive species.

Alternative E proposes management that may benefit wetland and riparian areas, such as limiting the effects of livestock grazing and OHV use. However, these restrictions would be applied only to the extent that they are consistent with adopted BLM LUPs.

Mitigation for Herbicide Treatment Impacts

See mitigation measures for Water Resources and Quality and Vegetation sections.

Vegetation

Introduction

The present-day composition and distribution of plant communities in the western U.S. are influenced by many factors, including physical factors (e.g., climate, drought, wind, geology, topography, elevation, latitude, slope, exposure) and natural disturbance and human-management patterns (e.g., insects, disease, fire, cultivation, domestic livestock grazing, wildlife browsing; Gruell 1983). In addition, competition with other species, especially invasive plant species, has had a profound effect on native vegetation. Today, the rapid expansion of invasive species across public lands is one of the primary threats to ecosystem health and one of the greatest challenges in ecosystem management. The recent increase in wildfires is influenced by changes in vegetation on public lands that have occurred during the past 50 years and have resulted in increases in hazardous flammable fuels.

Scoping Comments and Other Issues Evaluated in the Assessment

The largest number of comments submitted was related to vegetation. Numerous scoping comments were centered around a desire for the BLM to focus on long-term ecosystem sustainability and biological diversity. Numerous comments suggested that the PEIS address all invasive plants, not just weeds. One respondent proposed focusing on minimizing the spread of existing weed infestations, while others wanted to ensure that weed control measures do not result in more ecological disturbances than the weeds themselves. A large number of comments recommended evaluating the impact of herbicides on other plant and animal species within the areas considered for treatment. Several comments called for the PEIS to address the impacts of new-generation, high-potency pesticides on non-target plants. There was some concern about weeds becoming herbicide resistant, and about how the BLM would prevent the death of beneficial native plants from herbicides. To improve sage grouse habitat, one respondent recommended that instead of burning sagebrush, strips of vegetation should be treated with herbicides, then allowing cattle to break the vegetation down, followed by planting with grass.

Standard Operating Procedures

Herbicide use does create potential risks to non-target plants; however these risks can be minimized by following certain SOPs, which can be implemented at local level according to specific conditions. The following general procedures are designed to reduce potential unintended impacts to vegetation from the application of herbicides in the BLM vegetation management program:

- Review, understand, and conform to the "Environmental Hazards" section on the herbicide label. This section warns of known pesticide risks to the environment and provides practical ways to avoid harm to organisms or to the environment.
- Avoid accidental direct spray and spill conditions to reduce the largest potential impacts.
- Use the typical application rate, rather than the maximum application rate, to reduce potential risk to most species for most herbicides.
- Minimize application areas where possible.
- Include pre-treatment surveys for sensitive habitat and TES species within or adjacent to proposed treatment areas.
- Notify adjacent landowners prior to treatment.
- Clean OHVs to remove seeds.
- Use native or sterile species for revegetation and restoration projects.
- Use weed-free feed for horses and pack animals.
- Use weed-free straw and mulch for revegetation or other activities.

These procedures would help minimize impacts to plants and ecosystems on public lands to the extent practical, and as a result of this, long-term benefits to natural communities from the control of invasive species would likely outweigh any short-term negative impacts to native plants associated with herbicide use.

Impacts Assessment Methodology

The BLM reviewed the literature and findings from ERAs conducted by the BLM and Forest Service, and from earlier BLM vegetation treatment EISs, to assess the impacts to target and non-target vegetation from the use of herbicides (ENSR 2005b-k; SERA 2005a). The methods presented here are a brief overview of the ERA process to determine the risks of herbicide use for non-target species. The ERA methods are presented in detail in Appendix C. In addition, the BLM also reviewed information that was provided by local field offices in 2002 for development of this PEIS. This information included the location, treatment method, application method, vegetation class, and size of the treatment in acres for treatments proposed during the next 10 to 15 years.

BLM Methodology

Problem Formulation

Both terrestrial and aquatic non-target plants, including surrogates to represent threatened, endangered, and sensitive (TES) species, were evaluated to determine assessment endpoints and associated measures of effect. The essential biological requirements (i.e., survival, growth, and reproduction) for each of these groups of organisms are the attributes to be protected from herbicide exposure. Assessment endpoints, for the most part, reflect direct effects of an herbicide on these organisms, but indirect effects were also considered.

Measures of effect are measurable changes in an attribute of an assessment endpoint (or its surrogate, as discussed below) in response to a stressor to which it is exposed (USEPA 1998). For the screening-level ERA, the measures of effect associated with the assessment endpoints generally consisted of acute and chronic toxicity data (from pesticide registration documents and from the available scientific literature) for the most appropriate surrogate species. Assessment endpoints for non-target vegetation include acute mortality and adverse direct effects on growth, reproduction, or other ecologically important sublethal processes.

Exposure Characterization

The BLM uses herbicides in a variety of programs (e.g., maintenance of rangeland and recreational sites) with several different application methods (e.g., application by aircraft, vehicle, backpack). In order to assess the potential ecological impacts of these herbicide uses, the following exposure scenarios were considered that address herbicide exposure and acute and chronic (short- and long-term) impacts that may occur under a variety of conditions:

- Direct spray of the receptor or waterbody
- Off-site drift of spray to terrestrial areas and waterbodies
- Surface runoff from the application area to off-site soils or waterbodies
- Wind erosion resulting in deposition of contaminated dust
- Accidental spills to waterbodies

The AgDRIFT® computer model was used to estimate off-site herbicide transport due to spray drift. The GLEAMS computer model was used to estimate off-site transport of herbicide in surface runoff and root zone groundwater transport. The CALPUFF computer model was used to predict the transport and deposition of herbicides sorbed (i.e., reversibly or temporarily attached) to wind-blown dust. Each model simulation was conservatively approached with the intent of predicting the maximum potential herbicide concentration that could result from the given exposure scenario.

Effects Characterization

In the majority of cases, toxicological data do not exist for the specific plant receptors of concern. Consequently, toxicological data for surrogate species, obtained from a literature review, were evaluated and used to establish quantitative benchmarks (i.e., toxicity reference values [TRVs]) for the ecological receptors of concern. Data from scientific studies were used to compile statistical endpoints into a matrix for each chemical and for each receptor. Data were further subdivided into acute adverse effect levels, chronic adverse effect levels, and no observed adverse effect levels (NOAELs). For each chemical, receptor, and route of exposure, the lowest reported acute statistical endpoint was selected as the acute TRV. Chronic TRVs, based on longer exposure periods and associated endpoints such as growth and reproduction, were developed when possible to provide supplementary data to the risk assessment. Before the chronic NOAEL TRV was determined, a chronic lowest observed adverse effect level (LOAEL) was identified, which was the lowest herbicide level that was found to cause significant adverse effects in a chronic study. Once a LOAEL was selected, the chronic NOAEL TRV was established as the highest NOAEL value that was less than both the LOAEL and the acute TRV. Once developed, TRVs were compared with predicted environmental concentrations of the herbicide to determine the likelihood of adverse effects to ecological receptors.

Risk Characterization

In order to address potential risks to plant receptors, risk quotients (RQs) were calculated by dividing the estimated exposure concentration (EEC) for each of the previously described scenarios by the appropriate herbicide-specific TRV. To facilitate the translation of RQs into readily applicable estimates of risk, the calculated RQs were compared to Levels of Concern (LOCs) used by the USEPA in screening the potential risk of herbicides. Distinct USEPA LOCs are currently defined for the following risk presumption categories:

- Acute high risk – The potential for acute risk is high
- Acute restricted use - The potential for acute risk is high, but may be mitigated
- Acute endangered species –TES species may be adversely affected
- Chronic risk - The potential for chronic risk is high

The ecological risk implications of various exposure estimates can be readily determined by noting which RQs exceed the corresponding LOCs.

Uncertainty Analysis

For any ERA, a thorough description of uncertainties is a key component of risk determination that serves to identify possible weaknesses in the analysis and to elucidate what impact such weaknesses might have on the final risk conclusions. In this analysis, listed uncertainties were followed by a logical discussion of what bias, if any, the uncertainty may introduce into the risk conclusions. This bias was represented in qualitative terms that best describe whether the uncertainty might: 1) underestimate risk, 2) overestimate risk, 3) be neutral with regard to the risk estimates, or 4) be unable to be determined without additional study.

Forest Service Methodology

The Forest Service risk assessment methodology was similar to that used by the BLM (see SERA 2001a for a complete description of the current methodology). The steps involved in the Forest Service risk assessments include hazard identification, exposure assessment, dose response assessment, and risk characterization.

Hazard identification involved the review of existing data with a focus on the dose-response and dose-severity relationships to determine the effect levels (e.g., NOAEL, LOAEL) and assessment endpoints (e.g., acute toxicity, subchronic or chronic systemic toxic effects, reproductive and teratogenic effects) that are most relevant for the herbicide risk assessments.

In the exposure assessment phase, the Forest Service developed four general and accidental/incidental exposure scenarios (i.e., direct spray, spray drift, runoff, and wind erosion) for groups of non-target vegetation according to the application method and the chemical and toxicological properties of the given herbicide. The Forest Service scenario of contaminated irrigation water—a direct application scenario—was not evaluated by the BLM because their vegetation treatment program does not typically involve irrigation of vegetation.

Dose response assessment described the degree or severity of risk as a function of dose. A dose was derived—usually from a series of experimental doses—that was associated with a negligible, or at least a defined, level of risk. These dose levels are generally referred to as reference values, or more specifically as “reference doses” (RfDs). To derive the reference value, the experimental threshold was divided by uncertainty factors used to account for discrepancies between experimental exposure conditions and the conditions of the receptor might experience during Forest Service exposure. Often, reference values are standard across government agencies.

The risk characterization process then compared the exposure assessment to the dose response assessment to determine a LOC for a specific exposure scenario. Hazard quotients (HQs) were developed through this process. Hazard Quotients are analogous to the RQs developed in the BLM risk assessments—they are calculated as the projected level of exposure (i.e., EEC) divided by an index of an acceptable level of exposure or otherwise defined level of exposure (e.g., a NOAEL divided by an uncertainty factor). In addition, the herbicides were all compared based on their selectivity, potency, persistence in the environment, and ability to move off-site.

As with the BLM risk assessments, information is incomplete on effects to native species (the USEPA conducts studies predominantly on agricultural crop, rather than native, species), so impacts were extrapolated from the risk assessment or herbicide labels. Using herbicide labels to identify close relatives of native or desirable species does help to reduce uncertainty. However, Boutin et al. (2004) concluded that it was likely that the suite of species currently used in most risk assessments were not representative of the habitats found adjacent to agricultural treatment areas, and suggested this might cause an unacceptable bias and underestimated risk.

Impacts Common to All Treatments

The effectiveness of herbicide treatments in managing target plants and the extent of disturbance to native vegetation communities will vary by the extent and method of treatment (e.g., aerial vs. ground) and chemical used (e.g., selective vs. non-selective), as well as by local plant types and physical features (e.g., soil type, slope) and weather conditions (e.g., wind speed) at the time of application. Treatments would likely affect plant species composition of an area and may or may not affect plant species diversity. Species composition and species diversity are equally important contributors to ecosystem function (USDA Forest Service 2005). Because certain herbicides may target certain types of plants (e.g., broadleaf species), an herbicide treatment program for a given ecosystem and area should include multiple types of herbicides. For example, if picloram or clopyralid are the only herbicides used in a highly invaded area, weedy annual grasses, such as medusahead, downy brome, and barbed goatgrass may begin to dominate. The following sections detail the possible effects of herbicide treatments on both target and non-target plants.

Non-target Plants

Herbicides could come into contact with and impact non-target plants through drift, runoff, wind transport, or accidental spills and direct spraying. Potential impacts include mortality, reduced productivity, and abnormal growth. Risk to off-site plants from spray drift is greater with smaller buffer zones and application from greater heights (i.e., aerial application or ground application with a high boom). Risk to off-site plants from surface runoff is influenced by precipitation rate, soil type, and application area. Most accidental scenarios (i.e., direct spray or spill) result in risk to plant receptors. Persistent herbicides (e.g., bromacil) adsorbed to soil particles could also be carried off-site by wind or water, affecting plants in other areas. However, in this analysis, wind transport of herbicide particles does not result in risk to plant receptors in any evaluated scenario (an incident of extensive damage to crop species has been reported as a result of drift of sulfometuron methyl over a large area [see ENSR 2005j]). Application rate is a major factor in determining risk, with higher application rates more likely to result in risk to plants in various exposure scenarios.

Target Plants

Herbicides offer an effective and often resource-efficient means of treating and managing unwanted vegetation. Mechanical and manual methods are often more time and labor intensive than herbicide application, and these methods cause soil disturbance, which can provide the appropriate conditions for invasive weeds to resprout from roots and rhizomes or grow from dormant seeds. In addition, herbicide use may be seen as less dangerous than treatment with prescribed fire in dry areas that have high fire risk. The use of herbicides would benefit plant communities with weed infestations by decreasing the growth, seed production, and competitiveness of target plants, thereby releasing native species from competitive pressures (e.g., water, nutrient, and space availability) and aiding in the re-establishment of native species. The degree of benefit to native communities would depend on the toxicity of the herbicide to the target species and its effects on non-target species as well as the success of the treatments over both the short and long term.

Some treatments are very successful at removing weeds over the short term, but are not successful at promoting the establishment of native species in their place. In such cases, seeding of native plant species would be beneficial. Weeds may resprout or reseed quickly, out-competing native species, and in some cases increasing in vigor as a result of treatments. The success of treatments would depend on numerous factors, and could require the use of a combination of methods to combat undesirable species. In addition, repeated use of a particular herbicide on a particular site could cause target weeds to develop a certain level of resistance to that herbicide over time, reducing the effectiveness of long-term treatments.

In addition to herbicide treatments, the BLM would also be using other forms of vegetation treatment on their lands. A PER has been developed that accompanies this PEIS and discusses these treatment methods along with likely impacts to natural resources from proposed treatments over the next 10 years. In many cases, the treatments would return all or a portion of the treated area to an early successional stage, killing off disturbance-intolerant species (e.g., sagebrush) and freeing up resources such as light and nutrients for early successional species (e.g., annual grasses and forbs). In areas where fire suppression has historically occurred, vegetation treatments would be expected to benefit native plant communities by mimicking a natural disturbance component that has been missing from these communities, altering them over time. In areas that have been highly degraded, merely restoring disturbance to the ecosystem may in some cases adversely affect native plant communities by encouraging the spread of weeds or the persistence of an altered vegetation structure and species composition. These effects would vary depending on the treatment used, the type of vegetation on the treatment site, the amount of degradation on the site, as well as numerous other factors.

Impacts of BLM-Evaluated Herbicides

Bromacil

Bromacil is a non-selective, "broad-spectrum," systemic herbicide, which is most effective against annual and perennial weeds, brush, woody plants, and vines. Bromacil kills target plants by blocking electron transport and the transfer of light energy, thereby disrupting photosynthesis. Because of its non-selective nature, bromacil may be highly effective in areas where a variety of invasive species dominate and where very few non-target plants exist. Bromacil is best used in areas where bare ground is desired (e.g., around fences and structures); it has high residual activity, so it would be effective for an extended period of time.

Also due to its non-selective qualities, bromacil poses higher risk to non-target species in the immediate vicinity of the treatment area. Risk assessment shows that bromacil poses high risk to non-target terrestrial and aquatic plants in accidental direct spray and spill scenarios (Table 4-11). Off-site drift of bromacil generally results in moderate risk to non-target terrestrial plants, with somewhat lower risk as buffer zones get larger and application heights get smaller, and with high risk to TES terrestrial plants under the maximum application rate at lower buffer distances and higher application heights. Most off-site drift scenarios result in low or no risk to aquatic plants. At buffer distances of 900 feet, aquatic plants are not at risk from off-site drift of bromacil. Bromacil does not present risk to typical non-target terrestrial plants as a result of surface runoff, but does present low risk to TES terrestrial plants when applied in watersheds with clay soils and precipitation levels greater than 100 inches per year (in/yr). Aquatic plants are at risk from surface runoff of bromacil: most surface runoff scenarios result in moderate risk to aquatic plants in the pond at the typical application rate and moderate to high risk at the maximum application rate (higher risk with increased precipitation and sand or clay soils). Aquatic plants in the stream are at no to low risk from surface runoff of bromacil under most scenarios, with some moderate risk when bromacil is applied at the maximum application rate and in sand soils or in loam soils with greater application areas (100 and 1,000 acres) and increased precipitation (200 to 250 in/yr). At the typical application rate, chronic risk to aquatic plants in the stream from surface runoff of bromacil is much less than acute risk (there is low chronic risk in larger application areas and in watersheds with sand soils and more than 100 in/yr precipitation). Because bromacil is a non-selective herbicide and does pose significant risk to non-target plants, it would be most appropriately used in areas exclusively composed of invasive species at substantial distances (greater than 900 feet) from non-target populations (Table 4-12).

Chlorsulfuron

Chlorsulfuron is a selective herbicide used on perennial broadleaf weeds and grasses. Chlorsulfuron inhibits the synthesis of ALS, which is the catalyst for the production of amino acids that are required for protein synthesis and cell growth. Chlorsulfuron is effective both pre- and post-emergence, inhibiting seed germination and killing established plants. Chlorsulfuron is highly active with only small concentrations required to kill target plants; however, plant death may take several weeks as plants use stored amino acids (Tu et al. 2001 *cited in* USDA Forest Service 2005). Due to its activity, chlorsulfuron is highly effective in managing aggressive invasive species such as hoary cress, perennial pepperweed, and selected biennial thistles (bull, musk, and Scotch), and yellow starthistle.

Accidental direct spray or spill of chlorsulfuron results in moderate to high risk to terrestrial plants and aquatic plants in the stream (Table 4-11). Accidents mostly result in moderate risk to aquatic plants in the pond (there is high chronic risk at the maximum application rate). Off-site drift of chlorsulfuron presents low to moderate risk to typical non-target terrestrial plant species and higher risk to TES terrestrial plant species. Risk from off-site drift is high with aerial applications and ground applications with high booms and small buffer distances. In more than half of the modeled scenarios, there is no risk to aquatic plants from off-site drift of chlorsulfuron. Risk to aquatic plants was never predicted when chlorsulfuron was applied either aerially or on the ground with 900-foot buffer distances (Table 4-12). However, low risk to aquatic plants does result with smaller buffer distances. Terrestrial plants are not at risk from surface runoff of chlorsulfuron; however, aquatic plants are at low risk at higher precipitation levels and in watersheds with loam soils, particularly at the maximum application rate (aquatic plants in the stream are not at chronic risk in any scenario). Because of its activity, chlorsulfuron should be applied at the lowest possible dose and with buffer distances of at least 900 feet from non-target plant populations, particularly if these non-target plants are perennial and broadleaved or grasses. This herbicide may be best used

TABLE 4-11
Risk Categories Used to Describe Typical Herbicide Effects to Vegetation According to Exposure Scenario and Ecological Receptor Group

Application Scenario	BROM[1]		CHLOR[1]		DICAMBA		DIFLU[1]		DIQUAT		DIURON		FLUR[1]		IMAZ[1]		OVER[1]		SULFM[1]		TEBU[1]	
	Typ[2]	Max[2]	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Direct Spray																						
Terrestrial plants	H[3] [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	M [1:1]	H [1:1]	H [1:1]	H [1:1]	M [1:1]	H [1:1]	NE	NE	L [1:1]	M [1:1]	M [1:1]	H [1:1]	0 [1:1]	L [1:1]	M [1:1]	H [1:1]
TES terrestrial plants	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	NE	NE	L [1:1]	M [1:1]	H [1:1]	H [1:1]	H [1:1]	H [1:1]	M [1:1]	H [1:1]
Aquatic plants pond	H [1:2]	H [2:2]	M [1:2]	M [2:2]	L [1:2]	L [1:2]	L [1:2]	L [2:2]	H [2:2]	H [2:2]	H [2:2]	H [2:2]	0 [2:2]	0 [2:2]	L [1:2]	L [2:2]	M [1:2]	M [1:2]	H [2:2]	H [2:2]	L [2:2]	M [2:2]
Aquatic plants stream	H [2:2]	H [2:2]	M [2:2]	M [2:2]	L [1:2]	L [1:2]	L [1:2]	L [1:2]	H [2:2]	H [2:2]	H [2:2]	H [2:2]	0 [2:2]	0 [2:2]	L [2:2]	M [2:2]	M [1:2]	H [1:2]	H [2:2]	H [2:2]	M [1:2]	H [1:2]
Accidental Spill to a Pond																						
Aquatic plants pond	NE	H [1:1]	NE	H [1:2]	NE	M [1:1]	NE	L [1:1]	NE	H [2:2]	NE	H [1:1]	NE	L [2:2]	NE	H [2:2]	NE	M [1:1]	NE	H [2:2]	NE	H [2:2]
Off-Site Drift																						
Terrestrial plants	M [3:6]	M [3:6]	M [5:12]	M [8:12]	M [4:6]	M [3:6]	0 [4:6]	0 [4:6]	L [7:12]	M [7:12]	0 [5:6]	L [4:6]	NE	NE	0 [18:18]	0 [13:18]	0 [5:6]	0 [4:6]	0 [12:12]	0 [12:12]	0 [6:6]	0 [4:6]
TES terrestrial plants	M [3:6]	H [3:6]	M [7:12]	M [7:12]	H [2:6]	H [3:6]	L [3:6]	L [4:6]	M [7:12]	M [7:12]	M [3:6]	H [3:6]	NE	NE	0 [17:18]	0 [13:18]	L [3:6]	L [4:6]	H [5:12]	H [8:12]	0 [5:6]	L [3:6]
Aquatic plants pond	0 [9:12]	L [7:12]	0 [24:24]	0 [24:24]	0 [9:12]	0 [8:12]	0 [12:12]	0 [12:12]	NE	NE	L [8:12]	M [6:12]	NE	NE	0 [36:36]	0 [34:36]	0 [12:12]	0 [12:12]	L [13:24]	L [12:24]	0 [12:12]	0 [12:12]
Aquatic plants stream	0 [8:12]	L [6:12]	0 [24:24]	0 [22:24]	0 [8:12]	L [6:12]	0 [8:12]	L [6:12]	NE	NE	L [6:12]	M [6:12]	NE	NE	0 [36:36]	0 [33:36]	0 [8:12]	0 [6:12]	L [14:24]	L [10:24]	0 [12:12]	0 [12:12]
Surface Runoff																						
Terrestrial plants	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	NE	NE	0 [42:42]	0 [42:42]	NE	NE	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]
TES terrestrial plants	0 [39:42]	0 [38:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [42:42]	0 [34:42]	0 [33:42]	NE	NE	0 [38:42]	0 [34:42]	NE	NE	0 [42:42]	0 [42:42]	0 [34:42]	0 [33:42]	0 [32:42]	0 [28:42]	0 [38:42]	0 [34:42]
Aquatic plants pond	M [70:84]	H [45:84]	0 [64:84]	0 [53:84]	0 [78:84]	0 [45:84]	0 [84:84]	0 [84:84]	NE	NE	M [50:84]	H [64:84]	NE	NE	0 [80:84]	0 [62:84]	0 [70:84]	0 [67:84]	L [42:84]	L [38:84]	0 [65:84]	L [55:84]
Aquatic plants stream	0 [45:84]	L [55:84]	0 [80:84]	0 [77:84]	0 [84:84]	0 [83:84]	0 [84:84]	0 [84:84]	NE	NE	L [35:84]	L [39:84]	NE	NE	0 [84:84]	0 [83:84]	0 [84:84]	0 [84:84]	0 [69:84]	0 [60:84]	0 [84:84]	0 [74:84]

TABLE 4-11 (Cont.)
Risk Categories Used to Describe Typical Herbicide Effects to Vegetation According to Exposure Scenario and Ecological Receptor Group

Application Scenario	BROM[1]		CHLOR[1]		DICAMBA		DIFLU[1]		DIQUAT		DIURON		FLUR[1]		IMAZ[1]		OVER[1]		SULFM[1]		TEBU[1]	
	Typ[2]	Max[2]	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Wind Erosion																						
Terrestrial plants	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	NE	NE	0 [9:9]	0 [9:9]	NE	NE	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]
TES terrestrial plants	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	NE	NE	0 [9:9]	0 [9:9]	NE	NE	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]	0 [9:9]
Aquatic plants pond	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Aquatic plants stream	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

[1] BROM = Bromacil; CHLOR = Chlorsulfuron; DIFLU = Diflufenzopyr; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.
[2] Typ = Typical application rate; and Max = Maximum application rate.
[3] Risk categories: = 0 = No risk (majority of RQs < most conservative LOC for non-TES species); L = Low risk (majority of RQs 1-10x most conservative LOC for non-TES species); M = Moderate risk (majority of RQs 10-100x most conservative LOC for non-TES species); H = High risk (majority of RQs >100 most conservative LOC for non-TES species); and NE = Not evaluated. The Risk Category is based on the risk level of the majority of risk quotients observed in any of the scenarios for a given exposure group and receptor type. The reader should consult the risk tables in Chapter 4 of the ERAs (ENSR 2005b-k) to determine the specific scenarios that result in the displayed level of risk for a given receptor group. The number in brackets represents the number of RQs in the indicated risk category: number of scenarios evaluated.
TES = Threatened, endangered, and sensitive species.

at low rates and spot applications on highly aggressive species and in areas where target plants are the dominant species.

Dicamba

Overdrive® is a formulation of dicamba and diflufenzopyr, and an analysis of risks to vegetation for dicamba was conducted during preparation of the Overdrive® ERA.

Accidental direct spray and spill scenarios result in high risk to non-target terrestrial plants and low to moderate risk to aquatic plants (Table 4-11). Off-site drift of dicamba poses moderate to high risk to terrestrial plants with buffers of less than 1,000 feet for typical species and less than 1,050 feet for TES species.

Aquatic plants in streams are at low risk from off-site drift of dicamba when it is applied at the maximum rate. Surface runoff does not pose a risk to TES terrestrial plants. Dicamba could be effective in suppression or control of weeds in when applied at least 1,000 feet from non-target plant populations of interest or 1,050 feet from TES plant species (Table 4-12).

Diflufenzopyr

Diflufenzopyr, an active ingredient in the herbicide formulation Overdrive® along with dicamba, is a selective, systematic herbicide active ingredient used for the management of annual broadleaf weeds post-emergence and the management and/or suppression of many perennial broadleaf weeds and annual grasses. Accidental direct spray and spill scenarios result in moderate to high risk to non-target terrestrial plants and low chronic risk to aquatic plants (Table 4-11). Off-site drift of diflufenzopyr poses low risk to terrestrial plants with buffers of less than 100 feet for typical species and less than 900 feet for TES species. Aquatic plants are not at risk from off-site drift or surface runoff of diflufenzopyr. Surface runoff does pose low to moderate risk to TES terrestrial plants in watersheds with clay and loam soils and 25 in/yr of precipitation or more. Dicamba could be effective in suppression or management of several broadleaf weeds in native perennial grasslands when applied at least 100 feet from non-target plant populations of interest or 900 feet from TES plant species (Table 4-12). Its use should be avoided in areas containing TES plants that have clay and/or loam soil types and moderate to high levels of precipitation.

Diquat

Diquat is a non-selective, contact herbicide for weed management in non-cropland and aquatic areas. The BLM proposes to use diquat only in aquatic areas. Diquat is a cell membrane disrupter that is activated by exposure to sunlight to form oxygen compounds that damage cell membranes. As a non-selective aquatic herbicide, diquat is best used to control aggressive invasive plant species in waterbodies were few native plant species exist. Appropriate target species include water milfoils, hydrilla, water hyacinth, and giant salvinia. Diquat does kill plant parts on contact, but it does not kill the roots of the plant, and therefore, is often used for single-season control of submersed aquatic plants (Washington Department of Ecology 2004).

Accidental spray and spill of diquat poses moderate risk to terrestrial plants at the typical application rate and high risk at the maximum application rate (Table 4-11). Aquatic plants are at high risk from accidental sprays or spills of diquat. Off-site drift of diquat to terrestrial areas results in low risk to terrestrial plants, mostly from aerial application, but also from ground applications at smaller buffer distances. Non-TES terrestrial plants are not at risk if diquat is applied aerially or on the ground with greater than 900-foot buffers (Table 4-12). As a non-selective aquatic herbicide, diquat should not be applied in waterbodies where there are aquatic plants of concern. Riparian species within 900 feet of the waterbody should also be considered as they may be at risk from off-site drift of diquat; this risk would be lessened if diquat were applied via a ground application method. Diquat should not be used if TES riparian plants are present.

Diuron

Diuron is a non-selective, broad-spectrum herbicide, effective both pre- and post-emergence. Diuron disrupts photosynthesis by blocking electron transport and the transfer of light energy, thereby resulting in plant death. Because of its non-selective nature, diuron may be highly effective in areas where a variety of invasive species dominate and where very few non-target plants exist. Diuron is best used in areas where bare ground is desired (e.g., around fences and structures).

Accidental direct spray and spill scenarios generally result in high risk to terrestrial and aquatic plants (risk to typical terrestrial plant species is moderate at the typical application rate; (Table 4-11). Off-site drift of diuron presents risk to TES terrestrial plants in all modeled scenarios, with higher risk at the maximum application rate and at smaller buffer distances. Typical terrestrial plant species are also at risk from off-site drift of diuron when applied at the maximum application rate and with buffer distances less than 900 feet and when applied at the typical application rate with a high boom and a buffer less than 100 feet. Off-site drift of diuron poses low to moderate risk to aquatic plants under most application scenarios (in some cases application with a 900-foot buffer does not result in risk at to aquatic plants depending on the application rate, the application height, and the type of waterbody; (Table 4-12). In a few cases (clay soils with more than 50 in/yr precipitation and loam soils with 250 in/yr), surface runoff of diuron poses low risk to TES terrestrial plants. Surface runoff results in moderate to high risk to aquatic plants in the pond in the majority of scenarios. Aquatic plants in the stream are at low risk from surface runoff under most scenarios. Diuron is most safely applied with spot applications at the typical application rate, especially in the vicinity of waterbodies with aquatic plants of interest or near TES plants.

Fluridone

Fluridone is a slow-acting, broad-spectrum, systemic aquatic herbicide that can be used selectively at low concentrations. Fluridone kills target plants by causing the breakdown of chlorophyll, thereby preventing plants from synthesizing food. Because of this mode of action, fluridone needs to remain in contact with the target aquatic species for an extended period of time, depending on the species, in order to effectively manage the target species. Fluridone is one of the two herbicides newly proposed for use by the BLM that can effectively target harmful and invasive underwater aquatic plants; in particular, it would be used to manage hydrilla and watermilfoil species. Often these aquatic invasives are great disrupters of aquatic ecosystem function. Fluridone may be most effectively used when smaller waterbodies are heavily or completely infested with these invasive plants—i.e., in situations where complete eradication is possible in order to prevent spreading of remaining plants. However, at low concentrations, some native aquatic plants, especially pondweeds, may escape harm (Washington Department of Ecology 2004).

Risk to terrestrial plants from fluridone application was not able to be evaluated because of a lack of toxicity testing. Aquatic plants are at low risk from an accidental spill of fluridone mixed for the maximum application rate (Table 4-11). Because the risks of off-site drift of fluridone to terrestrial plants are unknown, care should be taken in the application of fluridone, even though it appears to be safe to non-target aquatic plants if used as registered. Off-site deposition rates of fluridone suggest that small percentages (0-24%) of the chemical would drift off-site where they could affect terrestrial plants; these percentages are the lowest (0-2%) when fluridone is applied on the water surface with buffer distances of 100 feet or more. The low toxicity of fluridone to aquatic plants suggests that it may not be effective against certain aquatic species. Rates and application methods will have to be adjusted according to target species identity to achieve management goals, while maintaining care to minimize off-site drift, particularly if non-target plants of interest are within 100 feet of the application site (Table 4-12).

Imazapic

Imazapic, an ALS-inhibitor, is a selective, systemic herbicide used on annual and perennial broadleaf weeds and grasses. Like other ALS-inhibitors, imazapic is quite active with only small concentrations required to kill target plants. Due to its activity, imazapic may be highly effective, particularly with spot applications, in controlling aggressive invasive species that have not responded to other herbicides or treatment methods. Several short-term studies have shown that pre-emergent/fall application of imazapic can be effective in controlling invasive species (e.g., leafy spurge) while improving the establishment of native grassland plants (Beran et al. 1999a; Markle and Lym 2001; Masters et al. 2001; Kirby et al. 2003). However, despite its selectivity, studies have found that if some supposed tolerant plants are directly sprayed by imazapic at typical application rates, they are likely to be injured (many native bunchgrasses remain tolerant [SERA 2001b]). Imazapic is proposed for BLM use in fuels reduction due to its effectiveness against downy brome and in forested rangeland management because of its effectiveness against hoary cress and perennial pepperweed. Accidental direct spray and spill scenarios result in low risk to terrestrial plants at the typical application rate and moderate risk at the maximum application rate (Table 4-11). Aquatic plants experience low to high risk from accidents at the maximum application rate and low to moderate risk at the typical application rate (there is no acute risk to aquatic plants in the pond at the typical application rate). When imazapic is applied aerially with buffers of 300 feet or less, off-site drift presents low risk to terrestrial plants. Aquatic plants are generally not at risk from off-site drift of imazapic, except when applied aerially at the maximum application rate with a buffer of 100 feet or less (Table 4-12). Surface runoff of imazapic presents

TABLE 4-12
Buffer Distances to Minimize Risk to Vegetation from Off-site Drift of BLM-evaluated Herbicides

Application Scenario	BROM[1]	CHLR[1]	DICM[1]	DIFLU[1]	DIQT[1]	DIUR[1]	FLUR[1]	IMAZ[1]	OVER[1]	SULF[1]	TEBU[1]
Buffer Distance (feet) from Non-target Aquatic Plants											
Typical Application Rate											
Aerial	NA	0	NA	NA	NE	NA	NE	0	NA	1,300	NE
Low Boom[2]	100	0	0	100	NE	900	NE	0	100	900	0
High Boom[2]	900	0	0	900	NE	1,000	NE	0	900	900	0
Maximum Application Rate											
Aerial	NA	300	NA	NA	NE	NA	NE	300	NA	1,500	NE
Low Boom[2]	900	0	0	900	NE	1,000	NE	0	900	900	0
High Boom[2]	900	0	0	900	NE	1,000	NE	0	900	900	0
Buffer Distance (feet) from Non-target Terrestrial Plants											
Typical Application Rate											
Aerial	NA	1,350	NA	NA	1,200	NA	NE	0	NA	0	NE
Low Boom[2]	950	900	1,000	100	100	0	NE	0	0	0	0
High Boom[2]	950	900	1,000	100	900	100	NE	0	100	0	0
Maximum Application Rate											
Aerial	NA	1,350	NA	NA	1,200	NA	NE	900	NA	0	NE
Low Boom[2]	1,000	1,000	1,050	100	900	200	NE	0	100	0	50
High Boom[2]	1,000	1,000	1,050	100	900	500	NE	0	100	0	50
Buffer Distance (feet) from Threatened, Endangered, and Sensitive Plants											
Typical Application Rate											
Aerial	NA	1,400	NA	NA	1,200	NA	NE	0	NA	1,500	NE
Low Boom[2]	1,200	1,000	1,050	100	900	1,000	NE	0	100	1,100	0
High Boom[2]	1,200	1,000	1,050	900	900	1,000	NE	0	900	1,000	50
Maximum Application Rate											
Aerial	NA	1,400	NA	NA	1,200	NA	NE	900	NA	1,500	NE
Low Boom[2]	1,200	1,050	1,050	900	1,000	1,000	NE	0	900	1,100	100
High Boom[2]	1,200	1,000	1,050	900	1,000	1,000	NE	0	900	1,000	500

[1] BROM = Bromacil; CHLR = Chlorsulfuron; DICM = Dicamba; DIFLU = Diflufenzopyr; DIQT = Diquat; DIUR = Diuron; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULF = Sulfometuron methyl; and TEBU = Tebuthiuron.
[2] High boom is 50 inches above ground and low boom is 20 inches above ground.
NE = Not evaluated and NA = not applicable.
Buffer distances are the smallest modeled distance at which no risk was predicted. In some cases, buffer distances were extrapolated (if the largest distance modeled still resulted in risk) or interpolated (if greater precision was required).

low risk to aquatic plants in the pond at the maximum application rate with sandy soils and precipitation greater than 25 in/yr. Overall, application of imazapic at the typical application rate, with buffers greater than 300 feet during aerial application, should not result in risk to non-target plants.

Overdrive®

Overdrive® is an herbicide formulation containing the active ingredient dicamba and diflufenzopyr. It is a selective, systematic herbicide for the management of broadleaved weeds pre- or post-emergence. Diflufenzopyr inhibits the transport of auxin (a hormone that regulates plant growth and development), and dicamba functions as a synthetic auxin. When used together, these chemicals disrupt plant hormone balance and protein synthesis (Retzinger and Mallory-Smith 1997). Because Overdrive® targets dicotyledons (broadleaved plants), it can be used in native grasslands, particularly if invasive broadleaves are more of a problem than invasive annual grasses. This herbicide would provide a good option for vegetation and wildlife habitat management in forested rangeland settings. It would provide activity on several broadleaf species, including kochia, pigweed, Russian thistle, biennial thistles (bull, musk, and Scotch), knapweeds (diffuse, Russian, and spotted) and field bindweed.

Direct spray and accidental spill scenarios result in moderate to high risk to terrestrial and aquatic plants

(Table 4-11). Off-site drift of Overdrive® poses low risk to TES terrestrial plants at distances greater than 100 feet (Table 4-12). Surface runoff generally does not result in risk to non-target plants, except to TES terrestrial species when Overdrive® is applied in watersheds with silt and clay soils and precipitation greater than 25 in/yr and to aquatic species in watersheds with silt, clay, and sand soils and precipitation greater than 25 in/yr or in all soil types with precipitation greater than 200 in/yr (at the maximum application rate). It appears that Overdrive® can be safely applied in areas that do not contain TES plants and where non-target plants of interest are not broadleaved (i.e., they are monocotyledons such as grasses and lilies).

Sulfometuron Methyl

Sulfometuron methyl, an ALS-inhibitor, is a broad-spectrum, pre- and post-emergent herbicide used to target broadleaf weeds and annual and perennial grass species. Like chlorsulfuron and imazapic, sulfometuron methyl is highly active, but is less selective than chlorsulfuron. Therefore, sulfometuron methyl should not be used in situations where selectivity is required, but could be useful for lands with multiple highly aggressive invasive species that have not responded to other herbicides or treatment methods. Sulfometuron methyl is effective in the management of downy brome, hoary cress, and perennial pepperweed. As with other highly active herbicides, care should be taken to apply sulfometuron methyl with methods and under conditions that limit the potential for spread off-site.

Accidental direct spray and spill scenarios result in high risk to aquatic species and TES terrestrial plant species and low risk to typical plant species at the maximum application rate (Table 4-11). Off-site drift of sulfometuron methyl presents high risk to TES terrestrial plants, but does not result in risk to typical plants species under modeled scenarios. This result is in contrast to past reported incidents of damage to crops resulting from off-site drift covering large distances from the site of application. In addition, other risk evaluations have reported potential damage to non-target plants even when applied at distances of greater than 900 feet (Table 4-12). Aquatic plants are at low risk from off-site drift, with some higher levels of risk at smaller buffer distances. Aquatic plants are not at risk from off-site drift if a 900-foot or greater buffer distance is used. Surface runoff of sulfometuron methyl results in low to moderate risk to TES terrestrial plants in watersheds with clay or silt soils or loam soils and 100 in/yr precipitation or greater. Aquatic plants in the pond are at low to moderate risk from surface runoff under most scenarios. Aquatic plants in the stream are at low to moderate risk in watersheds with sand soils or greater than 50 in/yr of precipitation. Sulfometuron methyl should not be applied in the vicinity of TES plant species. In addition, this active ingredient should be applied with buffers greater than 900 feet from aquatic areas and non-target terrestrial plants of interest. Furthermore, it has been shown that application in areas with dry soils that have been recently disturbed, and therefore have higher risks of off-site drift, can be problematic; however, application in watersheds with high probability for surface runoff (sandy soils, high precipitation) could also result in additional risk to aquatic plants.

Tebuthiuron

Tebuthiuron is a relatively non-selective herbicide absorbed by plant roots through the soil for use against broadleaved and woody weeds and grasses. Tebuthiuron disrupts photosynthesis by blocking electron transport and the transfer of light energy. Because of its non-selectivity, tebuthiuron should be used in areas dominated by invasive species, particularly woody invasives, such as in rangelands or ROW invaded by shrubs, trees and other undesirable species. The strength of this herbicide is its use as a habitat modifier in the BLM sagebrush management program. At low rates of application, tebuthiuron is used to thin the sagebrush, creating a more favorable habitat for sagebrush-dependent species.

Accidental direct spray and spill scenarios result in high risk to terrestrial plants at the maximum application rate and moderate risk at the typical application rate (Table 4-11). Aquatic plants are at high risk from spills, aquatic plants in the pond are at low to moderate risk from direct spray, and aquatic plants in the stream are at moderate to high risk from direct spray. Off-site drift results in low risk to terrestrial plants in several scenarios with less than 900-foot buffers—mostly at the maximum application rate with buffers less than 100 feet (Table 4-12). Aquatic plants are not at risk from off-site drift of tebuthiuron; however, surface runoff results in risk to aquatic plants in the pond under most scenarios at the maximum application rate and in select scenarios at the typical application rate (e.g., most sand soils). Aquatic plants in the stream are at risk from surface runoff in a few scenarios at the maximum application rate (e.g., sand soils with precipitation 50 in/yr and greater and large application areas). Threatened, endangered, and sensitive terrestrial plants in watersheds with clay and silt soils and precipitation of 50 in/yr and greater are also at risk from surface runoff of tebuthiuron. Most risk to vegetation from registered use of tebuthiuron can be avoided by applying at the typical application rate, using buffers of more than 100 feet, and avoiding application near TES species.

Impacts of Forest Service-evaluated Herbicides

The following information for eight herbicides proposed for use by the BLM is taken from ERAs performed by the Forest Service to support assessment of the environmental consequences of using these herbicides in Forest Service vegetation management programs. Because the Forest Service completed these ERAs prior to the completion of the PEIS, the BLM would use these ERAs to assess the potential ecological impacts of using these herbicides in future BLM vegetation management activities. The BLM previously evaluated and approved these eight herbicides in earlier EISs. As part of their risk assessments, the Forest Service developed worksheets, which allowed the BLM to assess risks of the herbicides using BLM maximum application rates and LOCs (rather than the Forest Service rates and LOCs), allowing the risk assessment process for the Forest Service-evaluated herbicides to parallel the BLM process as much as possible. However, modeled risk scenarios for terrestrial plants may be different than used for the BLM-evaluated herbicides, depending on the specificity of available toxicity data. The assessment of impacts below is presented using the Forest Service upper estimates of HQs, to maximize the conservatism of the assessment. In addition to this, it should be noted that the development of HQs by the Forest Service (as well as the BLM) is already conservative for many reasons e.g., use of most sensitive values for exposure and dose/response assessments).

2,4-D

2,4-D is a plant growth regulator and acts as a synthetic auxin hormone. 2,4-D alters the metabolism and growth characteristics of plants, often causing a proliferation of abnormal growth that interferes with the transport of nutrients throughout the plant. Broad-leaved plants are more susceptible than narrow-leaved plants like grasses. Plant community diversity studies have shown that 2,4-D can be effectively used in invasive species management without significantly changing species diversity (USDA Forest Service 2005). This herbicide has limited residual activity and limited effects on perennial species, but it does have some use for managing biennial thistles (bull, musk, Scotch) in forested rangeland situations, possibly for the enhancement of wildlife species. 2,4-D may also be used in riparian and aquatic areas. It is effective on broadleaved plants, such as water milfoil, and may be used in spot treatments at the labeled rate without substantially affecting native aquatic plants (Washington Department of Ecology 2004).

The principal hazard of 2,4-D exposure to non-target plants is from unintended direct deposition or spray drift (SERA 1998). If non-target plants are accidentally sprayed at normal application rates, they are likely to be damaged (Table 4-13). Although the exposure of plants to off-site drift of 2,4-D was not directly modeled, drift of 2,4-D following low-flight agricultural application resulted in herbicide deposition of 5% of the application rate at 100 feet downwind from application. Thus, at the high range of the BLM application rate for terrestrial scenarios (1.9 lbs a.i./ac), the deposition at 100 feet would be 0.1 lbs a.i../ac, decidedly less than the lowest rate expected to affect sensitive plants (0.5 lbs a.i./ac). If 2,4-D were to drift off-site with aquatic applications at the maximum application rate (8 lbs a.e./ac), the deposition at 100 feet would be 0.4 lbs a.i./ac. This is slightly below the minimum application rate used by the Forest Service, suggesting that at a buffer distance of 100 feet damage to less sensitive plants (e.g., grasses) is unlikely; the effects on sensitive plants (e.g., broadleaves) are less certain. At a buffer distance of 200 feet, herbicide deposition is predicted to be 2% of the application rate, resulting in deposition of 0.16 lbs a.i./ac at a maximum application rate of 8 lbs a.i./ac, a concentration that is unlikely to affect non-target plants. Therefore, at the maximum application rate damage to off-site plants from terrestrial plants is not likely with buffer distances of 100 feet or greater, and in aquatic applications, a buffer of 200 feet or greater should protect off-site plants from damage at the aquatic maximum application rate.

2,4-D is an herbicide registered for use on aquatic vegetation; the toxicity of 2,4-D to aquatic plants is low at the typical application rate but moderate at the maximum application rate (Risk increases with cases of direct application to waterbodies or accidental direct spills.) One study suggests that 2,4-D application to waterbodies may result in adverse effects on aquatic macrophytes, with the concentrations that inhibited shoot and/or root growth by 25 and 50% being below the expected environmental concentrations from typical use (Roshon et al. 1999).

Clopyralid

Clopyralid is a selective herbicide most effectively used post-emergence for the control of broadleaf weeds. Clopyralid is a plant growth regulator that is rapidly absorbed across leaf surfaces and acts as a synthetic auxin hormone, causing a proliferation of abnormal growth that interferes with the transport of nutrients, which then can result in substantial damage or death of the plant. The modeled BLM application rates were 0.35 lb a.e./ac (typical) and 1 lb a.e./ac (maximum). Clopyralid would be considered for use on forested rangeland areas for the management of several weedy species, including diffuse and spotted knapweed, yellow starthistle, and bull, Canada, Scotch, and musk thistles.

As expected, direct spray of clopyralid results in high risk to sensitive plant species; direct spray also results in low risk to tolerant plant species at the maximum application rate (Table 4-13). Off-site drift of clopyralid from low-boom ground applications and aerial applications may cause damage to sensitive plant species at distances of about 500 feet from the application site at the typical application rate (SERA 1999) and at upwards of 900 feet at the maximum application rate (Table 4-14). Hazard quotients are greater for aerial applications (moderate to high risk at smaller buffer distance and higher application rates) than low-boom ground applications (low to moderate risk). Tolerant species are not at risk from off-site drift. In addition, the Forest Service risk assessment states that damage to non-target species via off-site drift could probably be minimized or avoided during the application process—e.g., well-directed ground applications (e.g., spot applications) conducted under conditions that do not favor off-site drift would probably have no impact on off-site plant species.

Clopyralid tends to leach into the soil column with rain where it is rapidly degraded, except in arid soils with low microbial populations, and is not readily absorbed by roots, suggesting that surface runoff is also unlikely to affect off-site vegetation. However, sensitive plant species face low to moderate risk from surface runoff of clopyralid applied at the maximum application rate in clay soils, which allow minimal infiltration, at most precipitation levels (i.e., greater than 10 in/yr). Wind erosion of treated soil in arid climates could cause damages within 200 to 900 feet of the application site.

Clopyralid is relatively non-toxic to aquatic plants. It is not likely to affect aquatic plants via off-site drift or surface runoff pathways; however, accidental spills may result in temporary growth inhibition of aquatic plants—spills present high risk to aquatic macrophytes and low risk to sensitive algae species. Overall, effects to non-target vegetation from normal application of clopyralid are likely to be limited to sensitive plant species in or very near the treatment area.

Glyphosate

Glyphosate is a non-selective systemic herbicide that can damage all groups or families of non-target plants to varying degrees. Glyphosate inhibits the shikimate pathway for the production of aromatic amino acids and certain phenolic compounds. This leads to a variety of toxic effects in plants, including the inhibition of photosynthesis, respiration, and nucleic acid synthesis, thereby resulting in cellular disruption, decreased growth, and death at sufficiently high levels of exposure. Because of its non-selective nature, glyphosate may be highly effective in spot applications or in areas where a variety of invasive species dominate and where very few non-target plants exist. Glyphosate is best used in areas where bare ground is desired (e.g., around fences and structures); however, it has low residual activity, so it would not be effective for an extended period of time. Glyphosate may also be used in riparian and aquatic habitats on shoreline and floating-leaved species such as purple loosestrife, giant reed, cattails, and water lilies. BLM application rates modeled were 2 lbs a.e./ac (typical) and 7 lbs a.e./ac (maximum).

Direct spray results in moderate to high risk to sensitive plant species and low to moderate risk to tolerant plant species (Table 4-13). Unintended drift, particularly following aerial application, is one of the more plausible exposure scenarios for non-target terrestrial plants (SERA 2003b). The estimates for off-site drift encompass plausible exposures attributable to wind erosion. For relatively tolerant species, there is no indication that glyphosate is likely to result in damage at distances as close as 50 feet from the application site (Table 4-14). For sensitive species at the maximum application rate, low to moderate risk is predicted at off-site distances of 100 feet or less for ground broadcast and aerial applications. At the typical application rate, drift from ground broadcast results in low risk to sensitive species with a buffer 25 feet, and drift from aerial application results in low risk with a buffer of 100 feet and less. It should be noted, however, that all of these drift estimates are based on low-boom ground or aerial broadcast sprays. If glyphosate is directly applied using backpacks, little if any damage due to drift would be anticipated. In addition, one field study suggests that drift from glyphosate could affect long-term

TABLE 4-13
Risk Categories Used to Describe Effects of Forest Service-evaluated Herbicides According to Exposure Scenario and Ecological Receptor Group

	2,4-D		Clopyralid		Glyphosate[1]		Hexazinone		Imazapyr		Metsulfuron		Picloram		Triclopyr[1]	
	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Terrestrial Plants																
Direct spray, sensitive plants	NE[3]	NE	H	H	M	H	NE	NE	H	H	H	H	H	H	H	H
Direct spray, tolerant plants	NE	NE	0	L	L	M	NE	NE	M	M	L	M	L	M	NE	NE
Off-site drift, low boom, sensitive plants	NE	NE	L [4:6]	M [3:6]	0 [5:6]	L [3:6]	L [3:6]	L [4:6]	L [4:6]	M [3:6]	L [4:6]	M [4:6]	M [3:6]	M [4:6]	L [3:6]	M [3:6]
Off-site drift, low boom, tolerant plants	NE	NE	0 [6:6]	0 [6:6]	0 [6:6]	0 [6:6]	0 [6:6]	0 [4:6]	0 [6:6]	0 [5:6]	0 [6:6]	0 [6:6]	0 [6:6]	0 [6:6]	NE	NE
Off-site drift, aerial, sensitive plants	NE	NE	M [2:6]	H [2:6]	L [3:6]	M [2:6]	NE	NE	M [2:6]	H [2:6]	M [2:6]	H [2:6]	L [3:6]	M [3:6]	M [2:6]	H [2:6]
Off-site drift, aerial, tolerant plants	NE	NE	0 [6:6]	0 [6:6]	0 [6:6]	0 [5:6]	NE	NE	0 [4:6]	0 [3:6]	0 [5:6]	0 [4:6]	0 [6:6]	0 [5:6]	NE	NE
Surface runoff, sensitive plants	NE	NE	0 [23:30]	0 [22:30]	0 [30:30]	0 [30:30]	NE	NE	0 [18:30]	0 [18:30]	0 [21:30]	0 [18:30]	0 [21:30]	0 [22:30]	M [13:30]	H [13:30]
Surface runoff, tolerant plants	NE	NE	0 [30:30]	0 [28:30]	0 [30:30]	0 [30:30]	NE	NE	0 [30:30]	0 [30:30]	0 [25:30]	0 [22:30]	0 [30:30]	0 [27:30]	NE	NE
Aquatic Plants																
Accidental spill, sensitive macrophytes	NE	NE	H	H	M	M	NE	NE	H	H	H	H	0	0	H	H
Accidental spill, sensitive algae	NE	NE	L	L	NE	NE	NE	NE	M	H	M	H	M	M	H	H
Accidental spill, tolerant algae	NE	NE	0	0	NE	NE	NE	NE	0	0	L	M	0	0	NE	NE
Acute exposure, sensitive macrophytes	L	M	0	0	0	0	H	H	L	L	L	L	0	L	L	M
Acute exposure, sensitive algae	NE	NE	0	0	NE	NE	NE	NE	0	0	0	0	0	0	NE	NE
Acute exposure, tolerant algae	NE	NE	0	0	NE	NE	NE	NE	0	0	0	0	0	0	NE	NE
Chronic exposure, sensitive macrophytes	0	0	0	0	0	0	M	H	0	0	0	0	0	0	0	L
Chronic exposure, sensitive algae	NE	NE	0	0	NE	NE	NE	NE	0	0	0	0	0	0	NE	NE
Chronic exposure, tolerant algae	NE	NE	0	0	NE	NE	NE	NE	0	0	0	0	0	0	NE	NE

[1] Risk categories for the more toxic formulations are presented here.
[2] Typ = Typical application rate; and Max = Maximum application rate.
[3] 0 = No risk (HQ < LOC); L = Low risk (HQ = 1 to 10 x LOC); M = Moderate Risk (HQ = 10 to 100 x LOC); H = High risk (HQ > 100 LOC); and NE = Not evaluated. Risk categories are based on upper estimates of hazard quotients and the BLM LOC of 1.0. The reader should consult the text of this section of the individual Forest Service risk assessments to evaluate risks at central estimates of hazard quotients. If more than one scenario is involved in an exposure pathway (i.e., off-site drift and surface runoff), then the number of scenarios with the given risk category (out of the total number of evaluated scenarios) is displayed in parentheses. The reported risk category is that of the majority of the RQs for each exposure pathway. As a result, risk may be higher than the reported risk category for some scenarios within each category. The reader should consult the text of this section of the Forest Service risk assessment worksheets (SERA 2005b) to determine the specific scenarios that result in the displayed level of risk for a given receptor group.

sustainability of populations of lichens and bryophytes (Newmaster et al. 1999).

Plant species are not likely to be affected by runoff of glyphosate under any conditions. In particular, because glyphosate strongly absorbs to soil, plant roots do not readily absorb it. A field study conducted using glyphosate found no effect to plant diversity in an 11-year examination of site-preparation using herbicides, though structural composition and perennial species presence were different. These changes may have ecological implications if species lost (e.g., native huckleberry, *Vaccinium*, and cherry, *Prunus*, species) were heavily fed upon by wildlife or were used in traditional gathering (Miller et al. 1999).

There is little indication from the risk assessment that adverse effects on aquatic plants are plausible with typical application practices (SERA 2003b). A single study suggests that glyphosate application may result in adverse effects on aquatic macrophytes (Roshon et al. 1999). The risk assessment does indicate that accidental spills pose moderate risk to aquatic macrophytes.

Hexazinone

Hexazinone is an "s-triazine" herbicide that inhibits photosynthesis and the synthesis of RNA, proteins, and lipids. Although some foliar absorption may occur, the major route of exposure involves hexazinone moving from the soil surface to the root system of plants, where, in most species, it is readily absorbed and translocated throughout the plant. The differential toxicity of hexazinone to plants is based on variations in the ability of different plants to absorb, degrade, and eliminate the herbicide. BLM modeled application rates of 1 lb a.i./ac (typical rate) and 8 lbs a.i./ac (maximum rate). Hexazinone is effective against woody species (e.g., juniper, mesquite, cottonwood), and therefore, is not used in forested rangeland areas. It may be used for fuels reduction.

As with other herbicides, hexazinone may affect non-target plants through accidental direct spray and off-site drift scenarios (SERA 1997). During aerial applications at a rate of 1 lb a.i./ac and at distances of 30 meters (m; 100 feet) or less from the application site, some damage to sensitive non-target vegetation is plausible due to drift of liquid formulations (low risk). At maximum application rates, sensitive species may be at low to moderate risk from drift following aerial applications at distances of 500 feet or less (no risk is predicted at 900 feet from the application site; (Tables 4-13 and 4-14). Tolerant species could experience low risk from aerial drift at maximum application rates at distances of 50 feet or less (no risk is predicted at 100 feet). Ground applications of granular formulations or spot treatments with liquid applications of hexazinone should be associated with little significant drift; however, there are no studies available in the literature to support this speculation. In addition, soil contamination and consequent transport of hexazinone to off-site non-target vegetation may occur. Based on the limited dose-response data available in plants, the levels of exposure detected are likely to be toxic to non-target as well as target vegetation. The magnitude of any observed effects will be determined predominantly by local conditions, particularly soil type and rainfall. In porous and/or sandy soils with low levels of organic matter and under conditions of high rainfall, adverse effects on off-site vegetation are most plausible.

Aquatic plants are at moderate to high risk from acute and chronic exposure to hexazinone at both the typical and maximum application rates. Aquatic algal species are also sensitive to hexazinone exposure. Furthermore, it is likely that aquatic macrophytes are sensitive based on the effects of hexazinone on algae and terrestrial plants (SERA 1997; Roshon et al. 1999).

Imazapyr

Imazapyr is an ALS-inhibiting herbicide used in the control of a variety of grasses, broadleaf weeds, vines, and brush species. Although post-emergence application is more effective than pre-emergence application, toxicity can be induced either through foliar or root absorption. Due to its activity, imazapyr may be highly effective in controlling aggressive invasive species that have not responded to other herbicides or treatment methods. The strength of this herbicide is in the management of saltcedar in riparian zones. In addition, imazapyr can be used to treat emergent plants such as spartina, reed canarygrass, and phragmites, and floating-leaved plants such as water lilies. BLM application rates modeled were 0.45 lb a.i./ac (typical rate) and 1.5 lbs a.i./ac (maximum rate).

Imazapyr is an effective herbicide and even "tolerant" plants that are directly sprayed with imazapyr at normal application rates are likely to be damaged (SERA 2004e). In this risk assessment, direct broadcast spray resulted in high risk to sensitive plant species and moderate risk to tolerant species (Table 4-13). Off-site drift of imazapyr may cause damage to sensitive plant species at distances of 900 feet from the application site after both ground broadcast (low boom) and aerial application at the typical application rate and at distances of 900 feet or more at the maximum application rate (low to moderate risk for ground applications and low to high risk for aerial applications at both application rates; 900 feet was the maximum distance modeled), depending on several site-specific conditions, such as wind speed and foliar interception (Table 4-14). Tolerant species are not likely to be affected by off-site drift of imazapyr, except drift at the maximum application rate following 1) low boom ground application at distances of 25 feet or less and 2) aerial application at distances of 100 feet or less. In addition, wind erosion of soil contaminated with imazapyr could lead to adverse effects in sensitive plant species, particularly in relatively arid environments and if local soil surface and topographic conditions favor wind erosion; however, the risk assessment estimated daily soil losses from erosion to be 0.001 to 0.1% of the application rate, similar to loss predicted from off-site drift at distances greater than 500 feet from the application site (SERA 2004e).

When applied to areas in which runoff is favored (e.g., clay soils over a wide range of rainfall rates or loam soils at annual rainfall rates of 100 in/yr or more), damage from runoff appears to pose a greater hazard than drift. At the typical application rate, the risk assessment predicted low risk with clay soils and 15 to 20 in/yr and with loam soils and more than 100 in/yr; moderate risk with clay soils and 25 to 150 in/yr; and high risk with clay soils and more than 200 in/yr. At the maximum application rate, the risk assessment predicted moderate risk with clay soils and 15 to 25 in/yr and with loam soils and more than 100 in/yr; and high risk with clay soils and more than 50 in/yr. Residual soil contamination with imazapyr could be prolonged in some areas, possibly resulting in substantial growth inhibition (Rahman et al. 1993 *cited in* SERA 2004e). In relatively arid areas in which microbial degradation may be the predominant factor in the decline of imazapyr residuals in soil, residual toxicity to sensitive plant species could last for several months to several years (estimated at 10 months to 5.5 years [SERA 2004e]).

Some effects are also plausible in aquatic plants. Peak concentrations of imazapyr in surface water could be associated with adverse effects in some aquatic macrophytes (low risk at both application rates); longer term concentrations of imazapyr, however, are substantially below the level of concern (SERA 2004e).

Unicellular algae do not appear to be at risk from routine imazapyr application (Roshon et al. 1999, SERA 2004e). Accidental spills of imazapyr pose high risk to aquatic macrophytes and moderate to high risk to sensitive algae species.

Metsulfuron Methyl

Metsulfuron methyl is a selective ALS-inhibiting herbicide used pre- and post-emergence in the control of many annual and perennial weeds and woody plants. Due to its potency, metsulfuron methyl may be highly effective in controlling aggressive invasive species that have not responded to other herbicides or treatment methods. Metsulfuron methyl can be used in forested areas for the management of wildlife habitat and invasive plant species such as hoary cress, perennial pepperweed, biennial thistles (bull, musk, and Scotch), and yellow starthistle. The BLM application rates modeled were 0.03 lb a.i./ac (typical rate) and 0.15 lb a.i./ac (maximum rate).

For terrestrial plants, the dominant factor in determining the risk characterization is the potency of metsulfuron methyl relative to the application rate (SERA 2004f). The typical application rate considered in this risk assessment, 0.03 lb/ac, is over 800 times higher than the NOEC in the vegetative vigor (direct spray) assay of the most sensitive non-target species and approximately 8 times higher than the NOEC for the most tolerant species in the same assay. Direct spray results in high risk to sensitive species and low to moderate risk to tolerant species (Table 4-13). Damage to sensitive non-target species could be expected in ground broadcast applications at distances of about 900 feet from the application site at the typical application rate in areas in which off-site drift is not reduced by foliar interception ((Table 4-14; SERA 2004f). Risks to sensitive non-target terrestrial plants from off-site drift are slightly higher for aerial applications (low to high risk) than for low-boom ground applications (low to moderate risk). In addition, tolerant plants face low risk from aerial applications with buffers of 25 feet at the typical application rate and 50 feet at the maximum application rate. Directed foliar applications (i.e., via backpack sprayer) may reduce risk from off-site drift by an unquantifiable amount (SERA 2004f).

Runoff of metsulfuron methyl could be substantial under favorable conditions. In watersheds with clay soils and 15 to 250 in/yr of precipitation, sensitive terrestrial plants face mostly high risk from exposure via runoff; tolerant plants face low risks at the typical application rate with 50 to 250 in/yr and low to moderate risks at the maximum application rate with 15 to 250 in/yr. Plants in watersheds with loam soils face lower risks of damage via runoff of metsulfuron methyl,

TABLE 4-14
Buffer Distances to Minimize Risk to Vegetation from Off-site Drift of Forest Service-evaluated Herbicides

Application Scenario	2,4-D	Clopyralid	Glyphosate	Hexazinone	Imazapyr	Metsulfuron Methyl	Picloram	Triclopyr
Buffer Distance (feet) from Sensitive Plants								
Typical Application Rate								
Aerial	NE	900	300	300	900	900	>900	500
Low Boom	NE	900	50	NE	900	900	>900	300
Maximum Application Rate								
Aerial	NE	1,000	300	900	>900	>900	>900	>900
Low Boom	NE	1,000	300	NE	>900	>900	>900	>900
Buffer Distance (feet) from Tolerant Terrestrial Plants								
Typical Application Rate								
Aerial	NE	0	25	NE	100	50	25	NE
Low Boom	NE	0	25	0	25	25	25	NE
Maximum Application Rate								
Aerial	NE	25	50	NE	300	100	50	NE
Low Boom	NE	25	25	100	50	25	25	NE

NE = Not evaluated.
Buffer distances are the smallest modeled distance at which no risk was predicted. In some cases, buffer distances were extrapolated (if the largest distance modeled still resulted in risk) or interpolated (if greater precision was required).

with risk only predicted for sensitive plants at the typical rate and 100 in/yr or 100-250 in/yr at the maximum application rate.

In very arid regions, in which runoff might not be substantial, wind erosion could result in damage to off-site plant species, depending on local conditions. Daily soil losses as a result of wind erosion range from 0.001 to 0.1% of the application rate—similar to off-site losses associated with drift at a distance of 500 feet or more from the application site (SERA 2004f).

Damage to aquatic plants appears substantially less than for terrestrial plants, except in accidental spill scenarios. The HQs for routine acute and chronic exposure of aquatic algae are all substantially below the LOC (SERA 2004f). Aquatic macrophytes face low risk from acute exposure to metsulfuron methyl at upper exposure limits. Accidental spills pose high risk to aquatic macrophytes, moderate to high risk to sensitive algae species, and low to moderate risk to tolerant algae species.

Picloram

Picloram is a pyridine herbicide that acts as a plant growth regulator. It mimics naturally occurring plant auxins or hormones in a manner that leads to uncontrolled and abnormal growth that can in turn lead to gross signs of toxicity or death (SERA 2003c). Picloram is more toxic to broadleaf and woody plants than grains or grasses (Extension Toxicology Network 1996c, SERA 2003c). Picloram is reportedly a good choice for vegetation management in habitat modification situations because it can manage undesirable broadleaf species, including woody species, without injury to desirable grasses. It may be particularly effective in maintaining levels of species diversity in grasslands invaded by spotted knapweed, where its persistence in soils allows it to help initially suppress spotted knapweed seedlings (Rice et al. 1997); repeated application may be required to successfully control knapweed due to its long-term seed viability (USDA Forest Service 2005). The resistance potential of non-target plants to picloram has not been generally documented; however, it is known that the yellow starthistle has developed resistance to picloram, with resistant plants being more tolerant by factors ranging from 3 to 35 fold compared to non-resistant plants (Fuerst et al. 1996 *as cited in* SERA 2003c). The BLM application rates modeled were 0.35 lbs a.e./ac (typical rate) and 1.0 lbs a.e./ac (maximum rate).

Picloram can be considered highly selective to broadleaf plants, but may be toxic to many different plant species if directly sprayed at the typical application rate of 0.35 lb a.e./ac (SERA 2003c). The risk assessment showed that direct spray of picloram poses high risk to sensitive plant species and low to moderate risk to tolerant plant species at the typical and maximum application rates

(Table 4-13). Off-site drift of picloram associated with ground and aerial applications may cause damage to sensitive plant species at distances of nearly 1,000 feet from the application site (risk is low to moderate for low-boom ground applications and low to high for aerial applications), depending on wind speed and foliar interception ((Table 4-14; SERA 2003c). Tolerant plant species would probably not be impacted by the drift of picloram (low risk is predicted only at the maximum application rate and a buffer zone of 25 feet) and might show relatively little damage unless they were directly sprayed.

Runoff may present a significant risk to sensitive non-target terrestrial plant species under conditions in which runoff is favored (i.e., mostly high risk is predicted in watersheds with clay soil over a very wide range of rainfall amounts). Low risk is also predicted for sensitive plants in watersheds with loam soils and 100-150 in/yr precipitation and for tolerant species in watersheds with clay soils and 150 to 250 in/yr precipitation—both when picloram is applied at the maximum application rate.

Daily soil losses due to wind erosion, expressed as a portion of application rate, could be in the range of 0.00001 to 0.001. This is substantially less than off-site losses associated with runoff from clay but similar to off-site losses with drift in the range of about 200 feet to 900 feet. As with the drift scenarios, wind erosion could lead to adverse effects in sensitive plant species. Wind erosion of soil contaminated with picloram is most plausible in relatively arid environments and if local soil surface and topographic conditions favor this type of event. Furthermore, there is high potential for picloram to leach into groundwater in most soils (USDA Forest Service 2005). In addition, because picloram persists in soil, non-target plant roots can take up picloram, and this could impact revegetation efforts.

The toxicity of picloram to aquatic plants varies substantially among different species; however, the only HQ from routine exposures that reaches a level of concern results in low risk to sensitive aquatic macrophytes from acute exposure to picloram at the maximum application rate. In addition, an accidental spill of picloram poses moderate risk to sensitive algae species.

Triclopyr

Triclopyr is a selective, systemic herbicide used on broadleaf and woody species. Triclopyr mimics auxin, a plant growth hormone, thus disrupting the normal growth and viability of plants. Commercial formulations of triclopyr include triclopyr acid or that containing the triclopyr BEE; these triclopyr derivatives are evaluated separately in the Forest Service risk assessment, including separate worksheet calculations. Triclopyr could be used to manage woody riparian and aquatic species of interest, including salt cedar and willow. Triclopyr can be effective as a spot treatment for Eurasian watermilfoil because it is relatively selective for this species at low application rates. In addition, it is effective in riparian areas as a treatment for purple loosestrife because it does not damage native grasses and sedges (Washington Department of Ecology 2004). The BLM application rates modeled in the worksheets were 1.0 lbs a.e./ac (typical rate) and 10.0 lbs a.e./ac (maximum rate).

Because of the relatively low toxicity of triclopyr acid (terrestrial plant NOEC=0.333 lb/ac) compared to triclopyr BEE (terrestrial plant NOEC = 0.003 lb/ac), the risk characterization for the former is much less severe than the latter (SERA 2003d). Direct spray of both formulations poses high risk to plants (Table 4-13). The potential impact of off-site drift with broadcast applications varies substantially with the application rate. At an application rate of 1 lb a.e./ac, potentially damaging exposure could occur within about 300 feet of the application site. At the maximum application rate of 10 lb a.e./ac, damaging drift could occur at distances of over 900 feet from the application site ((Table 4-14; SERA 2003d).

At an application rate of 1 lb/ac, potentially damaging runoff from triclopyr acid would be anticipated only at relatively high rainfall rates in watersheds with clay soils (i.e., low risk for sensitive and tolerant species with rainfall of 200 in/yr or greater). While a lesser amount of triclopyr BEE will runoff, the higher toxicity of triclopyr BEE leads to HQs above the level of concern (low to moderate risk) starting at relatively modest rainfall rates (i.e., 15 to 25 inches per year) in all modeled soil types (i.e., clay, loam, sand). At an application rate of 10 lb a.e./ac, damage due to runoff after the application of triclopyr acid would be expected at annual rainfall rates as low as 25 inches per year in clay, loam, and sand soils (mostly low risk). For triclopyr BEE, the HQs are of concern for all but the most arid areas (low to high risk).

Both formulations of triclopyr have been found to decrease the relative long-term abundance and diversity of lichens and bryophytes; normal application rates in aerial spraying were found to reduce abundance by 75 percent, with colonists and drought tolerant species being less susceptible than later-successional mesophytic forest species (Newmaster et al. 1999). Triclopyr was also found to inhibit growth of four types of ectomychorrhizal fungi associated with conifer roots at concentrations of 1,000 parts per million (Estok et al. 1989, *as cited in* SERA 2003d).

Aquatic stream plants are at low risk from routine acute exposure to triclopyr acid at the maximum application rate. For longer-term exposures, risk to aquatic plants from triclopyr TEA is substantially below the LOC even at the maximum application rate. Triclopyr BEE is much more toxic to aquatic plants; however, the projected levels of exposure are much less even for acute scenarios because of the rapid hydrolysis of triclopyr BEE to triclopyr acid, as well as the lesser runoff of triclopyr BEE resulting from low water solubility and high affinity for soils (SERA 2003d). Nonetheless, triclopyr BEE is projected to be somewhat more hazardous when used where runoff to open water may occur. The level of concern for acute exposure to aquatic stream plants results in low risk at the typical application rate and moderate risk at the application rate. Accidental spill of triclopyr acid poses low to moderate risk to aquatic macrophytes and algae, whereas accidental spill of triclopyr BEE poses high risk to aquatic macrophytes and algae.

Summary of Herbicide Impacts Evaluated in ERAs

The effects of herbicides on target plants depend on their mode of action. Contact herbicides (e.g., diquat) only kill the plant parts that they touch, while translocated herbicides (e.g., dicamba) are transported throughout the plant. Herbicides that provide long term weed management (e.g., bromacil) affect plants when they are present in the soil, with the degree of damage and non-selectivity often increasing with herbicide concentration (Holecheck et al. 1995). Selective herbicides only affect certain plant species, whereas non-selective herbicides affect all or most plant species. The non-selective herbicides evaluated in this EIS include bromacil, diquat, diuron, fluridone (except at low concentrations), glyphosate, sulfometuron methyl, and tebuthiuron. The other herbicides (2,4-D, chlorsulfuron, clopyralid, diflufenzopyr, hexazinone, imazapic, imazapyr, metsulfuron methyl, Overdrive, picloram, and triclopyr) exhibit some selective qualities and would be most effective when used to target these plant species. Because of their selective nature, they may be able to be used in areas where non-target vegetation exists in communities with target vegetation. In addition, diquat and fluridone would be used exclusively for the management of aquatic plants; 2,4-D, glyphosate, imazapyr, and triclopyr could be used for aquatic as well as terrestrial vegetation management.

The herbicides that create the most short-term risk to non-target plant species, given that application scenarios follow SOPs, are those that are applied in a manner that increases the likelihood for off-site transport (e.g., drift, surface runoff). The risk characterization process of the ERA indicated that risk to typical and TES terrestrial plants is moderate with off-site drift of bromacil and chlorsulfuron and risk to TES terrestrial plants is moderate to high with off-site drift of diquat, diuron, and sulfometuron methyl. Diuron presents some moderate risk from off-site drift to aquatic plants if applied at the maximum application rate. None of the herbicides pose risk under wind erosion scenarios.

Impacts to non-target plants would be lessened if herbicides are able to selectively target the desired species type. Herbicides that are selective for broad-leaved plants (e.g., imazapic, clopyralid) would only affect broad-leaved species, which would typically only be the target species (e.g., sagebrush) in grass-dominated plant communities (e.g., rangeland). However, some changes in species composition could occur in these communities as competitive relationships are altered. The lasting effects of treatments using non-selective herbicides would depend on the species present in the seedbank to re-establish at the site. In many cases, reseeding or replanting treatments must occur after the application of non-selective herbicides to ensure the presence of native species on the site following treatment.

The ALS-inhibiting herbicides evaluated in this EIS are chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl. These herbicides are applied at low application rates, with only small concentrations necessary to damage plants. These herbicides did result in some risks to non-target plants; however, risks were similar to risk from the other evaluated herbicides. Nevertheless, because of the potency of these herbicides, they may be most appropriate for use when the target plant is the dominant cover species or when there is a particularly aggressive invasive species that has not been able to be controlled by other methods (USDA Forest Service 2005).

Other Herbicides Previously Approved for Use on Public Lands

Asulam, atrazine, fosamine, mefluidide, simazine, and 2,4-DP (also known as dichlorprop) are currently approved for use on public lands. However, the historical use of these by the BLM has been quite limited, with only fosamine used in the last 7 years (and less than 50 acres annually). Asulam is used in post-emergent control of broadleaf weeds, perennial grasses, and nonflowering plants in forestry and rangeland areas and ROW (Information Ventures, Inc. 1995a). Atrazine provides selective weed control in conifer reforestation, and on ROW, and energy, mineral, cultural, and recreation sites. It is toxic to many plants and should not be used under windy conditions near desirable trees, shrubs, or plants (Information Ventures, Inc. 1995b). Fosamine is used to control brush and herbaceous plants. No acute effects to aquatic plants are expected from normal use of fosamine, but movement of fosamine from the treatment site due to drift or runoff can adversely affect non-target and TES species (USEPA 1995d). Mefluidide is registered for forestry, rangeland, and ROW. Contact with non-target species may injure or kill susceptible plants (Information Ventures, Inc. 1995c). Simazine is a selective herbicide that is used to control broadleaf and grass weeds in forestry, rangeland, and ROW uses. It is toxic to many plants (Information Ventures, Inc. 1995d). 2,4-DP is registered to control aquatic weeds in ditches and for a variety of upland uses. It is a broadleaf herbicide (Pesticide Management Educator Program 2001).

Impacts by Alternative

The overall goal of treating vegetation would be to restore natural fire regimes and to reduce or eliminate populations of undesirable vegetation. Treatments aimed at achieving these goals should result in a more desirable successional stage in forest and rangeland habitats, increase plant species diversity, and create a more stratified age structure for wildlife.

Species diversity and vegetative structural components would be enhanced under most treatments, although some treatments could be designed to reduce the size or density of stands of trees or shrubs. Herbicides would provide better control of resprouting vegetation than other treatment methods, particularly when applied before burning. Herbicides would be used on rangelands dominated by annual grasses, such as downy brome and medusahead, followed by revegetation with perennial grasses and forbs. Herbicides would also be used to suppress or thin shrubs in favor of herbaceous vegetation. In some areas, herbicide treatments might reduce the cover of perennial grasses and forbs over the short term, but perennial vegetation communities should improve over the long term as shrub stands are thinned to allow more light and nutrients to reach the understory and competition for annual grasses and forbs is reduced.

The following sections detail the expected effects of each of the five alternatives on target and non-target plant communities, and provide comparisons of effects among alternatives. These effects may vary depending on the percentage of acres treated using different application methods and different herbicides, as well as on the size of treatment events.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue current vegetation treatment programs in 14 western states, and would treat an estimated 305,000 acres per year using both ground-based and aerial methods. Public lands in Alaska, Nebraska, and Texas would not be eligible for herbicide treatments under this alternative.

Under this alternative, the BLM would be able to use the 20 herbicides previously approved in earlier EIS RODs. However, based on the recent pattern of BLM herbicide use, it is likely that approximately three fourths of the area treated would involve the use of only four herbicides: 2,4-D, glyphosate, picloram, and tebuthiuron (Table 2-4).

As the No Action Alternative would be a continuation of current vegetation treatment practices, the nature of impacts to vegetation would be similar to the impacts that have occurred in the past. As a result, invasive species would likely continue their rapid expansion across western landscapes. Negative impacts to vegetation (i.e., harm to non-target plants) could be lower than under the other herbicide-use alternatives based on the number of acres treated. However, long-term benefits on plant communities (i.e., eradication of unwanted vegetation and resulting improvements in ecosystems) would be much reduced under this alternative than the other alternatives. Invasive plant populations would likely continue to expand at the current rate or greater, increasing damage to native plant communities and inhibiting ecosystem functions associated with those communities.

In addition, because the new herbicides proposed in this PEIS (Overdrive®, diquat, fluridone, and imazapic) would not be used, risks to vegetation would be different under this alternative. Under accidental direct spray, spill, and off-site drift scenarios, these four herbicides (especially imazapic) pose lower risks to terrestrial plants than bromacil and chlorsulfuron, and present similar or lower risks to terrestrial plants than the other pre-approved herbicides. Imazapic has been reported to successfully control the spread of aggressive invasives, including downy brome, Russian knapweed, and perennial pepperweed, and have positive effects on native prairie restoration (Whitson 2001, Shinn and Thill 2002). In addition, aquatic plants are at similar or lower risk from the new herbicides than from the pre-approved herbicides (e.g., bromacil, diuron) under all application scenarios. Since the BLM would not use the new herbicides under the No Action Alternative, risks to terrestrial plants from accidents and off-site drift during each application event could be greater than under the other herbicide-use alternatives, where more injurious herbicides could be replaced with less harmful new herbicides under appropriate situations. However, risks to TES terrestrial plants from surface runoff are highest with the use of diflufenzopyr, suggesting that per treatment risks to these species under surface runoff scenarios might be less under this alternative than under the other herbicide-use alternatives (under standard operating procedures the use of Overdrive® could be avoided when applying near TES plants with conditions that would promote runoff).

Over half of treatments under the No Action Alternative would occur in the Temperate Desert Ecoregion, with a third of the treatments targeted to improve sagebrush and other evergreen shrublands, and a third targeted at annual and perennial invasive grasses and forbs (Table 4-15). The focus of much of the treatments in this ecoregion is to benefit sage-grouse and other wildlife that use sagebrush communities by creating openings in dense and crowded sagebrush and rabbitbrush stands, removing invasive species, and promoting production of perennial grasses and forbs desired by wildlife (Paige and Ritter 1999). Picloram may be active in the soil for an extended period of time after application and is potentially more damaging to perennial grasses than 2,4-D. Application of picloram to control rabbitbrush and forbs in this ecoregion should decrease production of some desirable shrubs, forbs, and grasses, although grass production should recover as picloram dissipates (USDI BLM 1991a).

Glyphosate could be used as a spot treatment to treat unwanted annual grasses and forbs. It is effective on downy brome, but is non-selective and can harm desirable plant species if not used carefully. Tebuthiuron is a broad-spectrum herbicide that has a long period of activity in the soil and is effective in thinning sagebrush. However, tebuthiuron may damage grasses and other desirable plants. Application of high rates of tebuthiuron has been shown to decrease perennial grasses and allow annual grasses, as well as rabbitbrush, to increase.

Forty percent of herbicide treatments would occur in the Subtropical Steppe, Temperate Steppe, and Subtropical Desert ecoregions. Within these regions, over half of treatments would be targeted at evergreen shrublands. As in the Temperate Desert Ecoregion, treatments would focus on management of sagebrush/rabbitbrush and control of annual and perennial invasive forbs and grasses.

Over three-quarters of treatments in the Subtropical Steppe Ecoregion would be focused on sagebrush and other evergreen shrublands, while 12% of the treatments in this ecoregion would focus on pinyon-juniper and other evergreen woodland species. Picloram and tebuthiuron are the main herbicides used to treat pinyon-juniper woodlands. Both picloram and tebuthiuron may persist in the soil for several years and may injure understory grasses, shrubs, and forbs. Individual tree treatments with these herbicides are often more effective in controlling trees and less injurious to understory species than broadcast applications. Using picloram on some sites can also result in dominance by annual grasses, such as downy brome or medusahead, if these species become resistant to picloram (USDI BLM 1991a).

Over three-quarters of treatments in the Temperate Steppe Ecoregion would be focused on annual and perennial grasses and forbs, including downy brome, knapweeds, and thistles. Control of broadleaf plants by selective herbicides, such as 2,4-D, usually increases grass production. 2,4-D is also effective in controlling weedy forbs, such as bull, musk, and Scotch thistle. 2,4-D can also be tank mixed with other herbicides, such as glyphosate, dicamba, picloram, and triclopyr to enhance the activity of these herbicides. Applications of selective herbicides, such as 2,4-D, are expected to increase grasses and decrease broadleaf species. Applications of picloram may damage sensitive grasses as well as broadleaf plants, and can substantially alter the composition of grassland communities (USDI BLM 1991a).

Herbicides such as picloram and tebuthiuron are used to control woody species such as mesquite, creosotebush, and snakeweed in Subtropical Desert habitats. These herbicides usually decrease woody plant growth and increase growth of grasses, although it may take several years before grass and forb production increases in response to reduced competition from shrubs. Picloram is effective in controlling snakeweed, while tebuthiuron is effective in controlling creosotebush and tarbrush. However, tebuthiuron can be injurious to many grasses and forbs, and may promote the development of annual forbs, including Russian thistle. Dicamba has been used to control undesirable herbaceous and woody species and has minimal impact on grasses if applied at normal application rates (0.5 to 1 lb a.i./acre; USDI BLM 1991a).

Under this alternative, the BLM would be able to continue to use 2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine, although it is unlikely that these herbicides would be used. The BLM has substituted other herbicides for these herbicides in recent years that are more effective or have fewer environmental and/or human health risks. Bromacil, dicamba, and glyphosate have been substituted for asulam; bromacil, diuron, sulfometuron methyl, and tebuthiuron have replaced atrazine; triclopyr has replaced fosamine; sulfometuron methyl has replaced mefluidide (and imazapic would also replace mefluidide); diuron and hexazinone have replaced simazine; and 2,4-D, dicamba, imazapyr, and triclopyr have replaced 2,4-DP.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Alternative B, the Preferred Alternative, would result in the treatment of approximately 932,000 acres across the 17 western BLM states. In addition to the 14 currently-approved herbicides, the BLM would be able to use the four others evaluated in this PEIS. This alternative would result in the most extensive impacts to vegetation (both negative and positive) because it proposes the most acres for treatment (3 times the acreage proposed under the No Action Alternative). The use of the four new herbicides and the ability to use future herbicides that become registered with the USEPA would allow BLM managers more options in choosing herbicides to best match treatment goals and application conditions, and might therefore reduce overall per capita risk to vegetation and increase positive ecosystem benefits from treatment. In addition, the ability to use future registered herbicides would allow the BLM to employ the most technologically-advanced herbicides, which would likely reduce risk to non-target plants and increase management benefits. This alternative would also reduce risks and negative impacts associated with other vegetation management methods (e.g., risk of escaped prescribed fires; see the PER accompanying this PEIS). Furthermore, it is useful to have a range of herbicides and herbicide types available for use to combat diverse weed problems, and to minimize the chance that invasive species will become resistant to herbicides that are sprayed in the same location for several years. Weed resistance to herbicides can be minimized by using multiple herbicides with different sites of action in the same application, alternating herbicides with different sites of action each year, or alternating herbicide use with other effective forms of treatment (e.g., prescribed fire, mechanical removal).

Based on BLM patterns of use, 2,4-D, glyphosate, picloram, and tebuthiuron would comprise about 70% of the currently-used herbicides that would be used under this alternative. The risks and benefits of using these herbicides are discussed under the No Action Alternative. Approximately 10% of all treatment acres would be treated with the new herbicides, and of these, approximately 8% of the acres would be treated using imazapic. Imazapic could be used in all areas except riparian and wetland areas. Imazapic would be used to control downy brome, hoary cress, perennial pepperweed, and several other invasive species that are known to displace native vegetation and alter wildfire intensity and frequency.

About 2% of acres would be treated using Overdrive®. Overdrive® would be used on rangelands, ROW, oil, gas and mineral sites, and cultural and recreation sites. This herbicide is not effective in downy brome control, but does have activity on oak species that may be controlled to reduce hazardous fuels. It also provides activity on several annual broadleaf species including kochia, pigweed, and Russian thistle; several biennial species including bull, musk, and Scotch thistle, teasel, and diffuse knapweed; and several perennial species including spotted and Russian knapweed and field bindweed. The herbicide is also effective in controlling poisonous plants, such as western whorled milkweed.

In addition to being able to use four new herbicides under this alternative, the BLM would be able to use herbicides in Alaska, Nebraska, and Texas. Although no herbicide treatments are planned on public lands in Alaska under this alternative, the ability to use herbicides in Nebraska and Texas would allow for more comprehensive weed management programs in these

TABLE 4-15
Percentage of Acres Projected to be Treated Using Herbicides in Each Ecoregion for Each Vegetation Subclass under the No Action Alternative

Vegetation Subclass[1]	Ecoregion							
	Tundra	Subarctic	Marine	Mediterranean	Subtropical Desert	Subtropical Steppe	Temperate Desert	Temperate Steppe
Evergreen forest	0	0	86	74	0	<1	3	1
Deciduous forest	0	0	0	0	0	0	3	0
Mixed evergreen/deciduous forest	0	0	0	0	0	0	0	0
Evergreen woodland	0	0	0	1	3	12	5	2
Deciduous woodland	0	0	0	<1	7	4	0	0
Mixed evergreen/deciduous woodland	0	0	0	0	0	0	0	0
Evergreen shrubland	0	0	0	6	88	77	30	6
Deciduous shrubland	0	0	0	0	0	3	<1	0
Evergreen dwarf-shrubland	0	0	0	0	0	0	0	0
Deciduous dwarf-shrubland	0	0	0	0	0	0	0	0
Perennial graminoid	0	0	14	<1	0	1	9	22
Annual graminoid or forb	0	0	0	16	0	<1	21	3
Perennial forb	0	0	0	1	<1	1	14	29
Riparian/wetland	0	0	0	2	<1	1	1	0
More than one subclass	0	0	0	0	2	1	14	38

[1] See Table 3-4 and Vegetation section in Chapter 3 for a description of vegetation subclasses.

states, which should reduce the negative effects of invasive species on native vegetation.

Under this alternative, over 70% of acres would be treated in the Temperate Desert Ecoregion, a much greater proportion than would be treated under the No Action or other alternatives (Table 4-16). Fifteen percent of treatments would occur in the Temperate Steppe Ecoregion. As with the No Action Alternative, treatments in the Temperate Desert Ecoregion would be targeted primarily toward sagebrush, rabbitbrush, and other evergreen shrubland species, and annual grass and perennial forb weeds, while those in the Temperate Steppe Ecoregion would focus on control of invasive annual and perennial grasses and forbs.

Alternative C – No Use of Herbicides

Under Alternative C, non-target plants would not be affected by herbicide use. Effects to vegetation would stem from other vegetation treatment methods (see the accompanying PER; USDI BLM 2005a). In general, the potential negative impacts to non-target plants from manual and mechanical treatment methods are expected to be lower than for chemical and prescribed fire methods (the impacts from biological methods are less certain). Positive ecosystem benefits as a result of vegetation management may be reduced under this alternative as compared to the Preferred Alternative as there are certain invasive species for which herbicide use is the only effective method of treatment or for which other methods are impractical due to cost, time, accessibility, or public concerns (e.g., saltcedar in riparian areas). For example, rough terrain may prevent treatment by methods that require ground vehicle and foot access, while aerial treatment with herbicides would be possible. Vegetation treatment on ROW and oil and gas production facilities would have to be done by manual and mechanical means, or not done at all. Both options may be unfeasible for ROW, while the latter option would compromise the safety of oil and gas production facilities (USDI BLM 1991a).

In addition, it is often difficult to eradicate some species, such as shrubs that resprout from roots, by means other than herbicide application (e.g., rabbitbrush, honey mesquite, sand shinnery oak, cholla). Similarly, pre-emergent herbicides that persist in the soil are the most effective means of controlling invasive plants with seeds that remain viable for long periods of time. Furthermore, where prescribed fire is an appropriate alternative to larger-scale herbicide use (such as in rangelands), neighboring communities may object to the resulting smoke production or risk from escaped fires.

Under this alternative, without the use of herbicides, invasive plant populations would likely continue to spread, possibly at increased rates, and cause further damage to susceptible native vegetation communities, particularly in areas and for species where other treatment methods are not effective or possible (e.g., large tracts of rangeland or grassland dominated by invasive, resprouting shrubs or without enough fine fuels to carry prescribed fires).

Alternative D – No Aerial Applications

Alternative D would allow the use of the same herbicides in the same areas as allowed under the Preferred Alternative, and would have similar benefits resulting from the increased availability of new and future herbicides. However, this alternative would not allow aerial applications, thereby dramatically reducing the treatment acreage (530,000 acres) because some large and remote areas cannot be effectively treated by ground application methods. This alternative would substantially reduce the impacts of off-site drift to non-target vegetation as compared to alternatives where aerial spraying would be allowed. Drift is a major route of unintended damage to plants, and aerial application is a primary cause of off-site drift. Therefore, impacts per treatment would also be much lower under this alternative than under alternatives A and B and would be similar to or less than per area impacts from Alternative E. However, without the use of aerial spraying, large areas of vegetation would not be treated under Alternative D.

Under this alternative, it is likely that long-term negative effects on desired plant communities and ecosystems would be greater than any potential short-term negative effects that would result from aerial applications. In addition, direct and indirect impacts from other vegetation treatment options might increase if used more extensively to compensate for the reduced number of acres treated by herbicides. These impacts could include increased vegetation damage from the use of ground-based equipment as compared to other alternatives.

Prescribed fire and mechanical treatment would be substituted for aerial herbicide treatments as much as possible in large areas proposed for treatment. Fire would not be effective in areas with insufficient fuels to carry fire, while mechanical treatments might not be suitable in areas where sprouting species, such as rabbitbrush, might increase after mechanical treatment. This alternative would preclude treatment of large expanses of downy brome and other invasive annual grasses using imazapic and other herbicides. Fire could also result in substantial damage to sagebrush stands and enhance the development and spread of downy brome and other annual grasses (USDI BLM 1991a).

Nearly all (91%) aerial treatments are proposed for the Subtropical Steppe and Temperate Desert ecoregions. Of these, two-thirds would occur in evergreen shrublands to thin sagebrush stands and remove invasive vegetation, such as downy brome. The remaining treatments would focus primarily on control of undesirable annual and perennial grasses and forbs. Controlling sprouting woody species in areas where an herbaceous community is desired could be difficult because herbicide use would be limited and sprouting might be enhanced by burning and mechanical methods. Under this alternative, more acres in these ecoregions would continue to be dominated by shrubs, and the herbaceous component of plant communities would not be as diverse or productive as communities where aerial applications of herbicides were used.

About 7% of aerial treatments would occur in the Temperate Steppe Ecoregion, with most of these treatments used to control perennial forbs such as knapweed, thistles, and leafy spurge. Prescribed fire could be used to treat large acreages, but control of noxious weeds and other broadleaf species would not be as effective in this ecoregion as under the Preferred Alternative.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Alternative E was developed based on a proposal for ecosystem-based vegetation management submitted by the American Lands Alliance, an alliance of several environmental and conservation groups (see Appendix G). Approximately 466,000 acres would be treated under Alternative E, which is slightly less than what would be treated under Alternative D and less than half of what would be treated under the Preferred Alternative. However, this alternative would still be an increase from the average annual treatment acreage over the past 8 years and likely to occur under the No Action

TABLE 4-16
Percentage of Acres Projected to be Treated Using Herbicides in Each Ecoregion for Each Vegetation Subclass under the Preferred Alternative

Vegetation Subclass[1]	Ecoregion							
	Tundra	Subarctic	Marine	Mediterranean	Subtropical Desert	Subtropical Steppe	Temperate Desert	Temperate Steppe
Evergreen forest	0	0	79	76	0	<1	1	1
Deciduous forest	0	0	0	0	0	0	<1	<1
Mixed evergreen/deciduous forest	0	0	0	0	0	0	0	<1
Evergreen woodland	0	0	0	6	0	1	2	<1
Deciduous woodland	0	0	0	<1	5	5	0	0
Mixed evergreen/deciduous woodland	0	0	0	0	0	0	0	0
Evergreen shrubland	0	0	0	8	26	42	36	21
Deciduous shrubland	0	0	0	0	32	4	<1	0
Evergreen dwarf-shrubland	0	0	0	0	0	0	0	0
Deciduous dwarf-shrubland	0	0	0	0	0	0	0	0
Perennial graminoid	0	0	21	<1	0	33	8	26
Annual graminoid or forb	0	0	0	10	0	8	20	2
Perennial forb	0	0	0	<1	<1	1	12	23
Riparian/wetland	0	0	0	<1	2	4	1	0
More than one subclass	0	0	0	0	34	3	21	26

[1] See Table 3-4 and Vegetation section in Chapter 3 for a description of vegetation subclasses.

Alternative. In addition to a relatively low impact to vegetation as a result of the low number of acres treated, per treatment impacts under Alternative E would also be lower than under the other herbicide-use alternatives because of the restrictions detailed by this alternative—most notably prohibition of the use of ALS-inhibiting active ingredients.

Sulfonylurea herbicides and other ALS-inhibiting herbicides (e.g., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl) block the synthesis of amino acids that are required for protein production and cell growth; thereby resulting in plant death. These herbicides are biologically active at small concentrations, which is beneficial to herbicide applicators because a small dose may be used, thereby saving money and possibly resulting in fewer cases of unintended damage to wildlife and the environment (e.g., groundwater contamination [Obrigawitch et al. 1998]). However, because of their high potency, these chemicals may pose excessive dangers to non-target plants. Off-site movement of even small concentrations of these herbicides can result in extensive damage to surrounding plants, and damage to non-target plants may result at concentrations lower than those reportedly required to kill target invasive species (Fletcher et al. 1996), including concentrations that cannot be detected by any standard chemical protocol (Whitcomb 1999). One study reported that drift of chlorsulfuron caused 82 to 100% reductions in the yield of several crop species when it was applied at 0.008 to 0.004 times the label-suggested application rate (such as might occur with off-site drift) at critical stages of plant development (Fletcher et al. 1996). However, another study reported that sulfonylurea herbicides present similar risks to non-target plants as other herbicides used at higher application rates (Obrigawitch et al. 1998). In addition, a predominant problem with ALS-inhibiting herbicides is that they can quickly confer resistance to weed populations, particularly since they are often used extensively as the primary weed control method, and they have a single mode of action and long residual activity, allowing ample opportunity for the ALS-encoding gene in the target weed to mutate—resulting in a resistant version of ALS (Whitcomb 1999, Tranel and Wright 2002).

Sulfometuron methyl has been implicated in several cases of large-scale damage to non-target species as a result of off-site drift. In Franklin County, Washington, drift of sulfometuron methyl (as the active ingredient in the herbicide Oust®) caused over a million dollars in damage to over 700 mi of roadside, including 300,000 young trees in one nursery (Turner 1987). Response to these types of findings varies from warnings about applying these herbicides during critical reproductive periods of non-target plants or during likely drift conditions to suggestions that the use of these herbicide types should be severely limited or discontinued or that the practice of aerial spaying should be abandoned. For example, in 1981 the Environmental Effects Division of the USEPA recommended against registering sulfonylurea herbicides because they persist for long periods of time in the environment and they cannot be detected at low levels.

Under this alternative, the BLM would not be able to use chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, or sulfometuron methyl. However, other herbicides proposed for use by the BLM pose risks that are similar to those associated with these five herbicides; therefore, it is uncertain whether this use restriction would actually reduce risk to non-target plants.

This restriction, however, could ameliorate some of the public concern associated with herbicide use on public lands by prohibiting the use of potent herbicides. However, the potency of these herbicides allows them to be used in very small amounts, which could be beneficial for off-site species potentially exposed to runoff and drift of herbicides. In addition, these herbicides may be most effective on particularly aggressive invasive species that have not responded to other herbicides or treatment methods, and under this alternative control of these aggressive species may not be possible. Furthermore, as mentioned in the No Action Alternative, it is useful to have a range of herbicides and herbicide types available for use to combat diverse weed problems, and to minimize the chance that invasive species will become resistant to herbicides that are sprayed in the same location for several years.

Alternative E incorporates other management practices that would be likely to have positive impacts on vegetation communities. The suggested use of 500 foot buffers between broadcast herbicide applications and TES plants would reduce risks to sensitive plants from off-site drift and surface runoff; however, herbicide damage from off-site drift has been noted up to a mile from application, and the ERA predicted risk to terrestrial plants from bromacil and diuron (TES plants only) up to 900 feet from application. Alternative E would limit the use of broadcast applications, which would reduce the risks to non-target plants associated with off-site drift, but these applications would be available for use in appropriate situations (i.e., where no other method is practical and non-target plant species and aquatic areas are distant from the application area), which would allow some positive ecosystem benefits from larger scale herbicide applications. In addition, herbicides would not be used in riparian conservation areas, which would protect sensitive aquatic plant species and attendant ecosystem functions in these key areas. However, if these areas were to become degraded by invasive species, it could be more difficult to control and eradicate these species using non-herbicide methods, which would also imperil native plants and important riparian ecosystem functions in these and adjoining areas.

While per treatment ecosystem benefits could be greater under Alternative E than under the other herbicide-use alternatives as a result of this ecosystem-based management approach, overall positive vegetation and ecosystem benefits across the 17 western states (that cannot be attained by other treatment methods) would be lower under this alternative because of the relatively low treatment acres and the inability to use certain practices in situations that might require their use (e.g., use of ALS-inhibitor herbicides on highly aggressive weeds).

Mitigation for Herbicide Treatment Impacts

In addition to the SOPs identified earlier in this section and in Table 2-6, the following measures are recommended to reduce impacts to non-target vegetation from the use of herbicides:

- Minimize the use of terrestrial herbicides (especially bromacil, diuron, and sulfometuron methyl) in watersheds with downgradient ponds and streams if potential impacts to aquatic plants are of concern.
- Establish appropriate (herbicide specific) buffer zones to downstream waterbodies, habitats, or species/populations of interest (see Tables 4-12 and 4-14). Consult the ERAs for more specific information on appropriate buffer distances under different soil, moisture, vegetation, and application scenarios.

Special Status Plant Species

Introduction

As discussed in Chapter 3, public lands in the western U.S. support over 1,000 plant species that have been given a special status based on their rarity or sensitivity. Special status plants include approximately 150 species that are federally listed as threatened or endangered, or are proposed for federal listing. The remaining special status species include candidates for federal listing, and other species that warrant special attention and could potentially require federal listing in the future. Many of these species are threatened by competition with non-native plants and other invasive species. The *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* (BA; USDI BLM 2005b) provides a description of the distribution, life history, and current threats for each federally-listed plant species, as well as species proposed for listing. The BA also discusses the risks to threatened and endangered species, and species proposed for listing (collectively referred to as TEP plants) associated with each of the herbicides proposed for use by the BLM under the different alternatives.

Impacts Assessment Methodology

The BLM reviewed the literature and findings from ERAs conducted by the BLM and Forest Service to assess the impacts to sensitive plant species from the use of herbicides (ENSR 2005b-k; SERA 2005a). The ERA methods are summarized earlier in the Vegetation section of this chapter. Methods used by the BLM are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C; methods used by the Forest Service can be viewed on the Internet at http://www.fs.fed.us/r6/invasiveplant-eis/.

Although BLM ERAs used the same LOC for all non-target plant species, separate plant toxicity endpoints were selected to provide extra protection to special status plant species (see Table 4-11). Thus, ERAs for some herbicides predicted higher risks for special status plant species than for "typical" plant species under certain exposure scenarios. Risk assessments completed by the Forest Service also used different toxicity endpoints for sensitive and tolerant plant species. Risks to special status plant species were determined by comparing the HQs for sensitive plant species developed by the Forest Service with the same LOC that was used to determine risks to plants in the BLM ERAs (see Table 4-13).

Herbicide use does create potential risks to sensitive plant species; however, these risks can be minimized by following certain SOPs, which can be implemented at the local level according to specific conditions (see Table 2-6). These include 1) surveying for threatened, endangered, and sensitive (TES; includes TEP species and other species of concern to the BLM) plant species before treating an area; 2) using drift reduction agents to reduce the risk of drift hazard; 3) using a selective herbicide and a wick or backpack sprayer; and 4) using the typical application rate, rather than the maximum application rate where practical.

Summary of Herbicide Impacts

Many special status plant species are threatened by the spread of non-native plants. Although a discussion of individual plant species is beyond the scope of this PEIS, the BA provides additional information on which TEP plant species are most at risk from competition with non-native plants. The continued spread of these species in habitats occupied by special status species is expected to further encroach on numerous species, potentially resulting in reductions in population size and vigor, and even extirpation, in some cases. Furthermore, species with very small populations are also at risk of extirpation as a result of fire, even in habitats that are adapted to fire.

Fuels reduction and control of competing vegetation are important components of management programs for special status plant species. However, the sensitivity of these species requires special care during management to ensure that the management actions themselves do not harm or endanger populations. In the case of TES plant species, manual spot applications of herbicides may be the only suitable means of applying herbicides that can adequately ensure the protection of sensitive populations. In the case of special status plant species that are not federally listed or proposed for listing, the impacts associated with herbicide use would be a factor of the herbicide's ability to control non-native plants that threaten the species' habitat over the long-term, and the extent of short-term harm that the herbicide would cause the species. For species with populations that are declining but secure, some mortality or a reduction in population size over the short term could be acceptable, provided the overall habitat for the species was improved, and provided herbicides did not remain in the soil and continue to impact growth and regeneration over the long term. In addition, treatment of weeds in areas that are close to sites that currently support special status species may improve habitat to such a degree that the rarer species are allowed to spread into portions of their original range that are no longer suitable for supporting them.

In some cases, rare plants are present because the site is pristine or relatively undisturbed. Herbicide use would not be required in these places. Similarly, most of the areas where aggressive herbicide treatments would take place (such as oil and gas ROW, heavily grazed rangelands) are unlikely (though not unknown) to support extensive populations of special status species.

All of the herbicides analyzed in ERAs would pose risks to terrestrial special status plant species in a situation where plants were directly sprayed, at either typical or maximum application rates, during a treatment. Herbicides with the greatest likelihood of harming special status plants (i.e., those that pose a high risk when applied at the typical application rate) would include bromacil, chlorsulfuron, clopyralid, diflufenzopyr, diquat, imazapyr, metsulfuron methyl, Overdrive®, picloram, sulfometuron methyl, and triclopyr. These herbicides would also present the most risk to terrestrial special status plant species as a result of drift from a nearby application site. The herbicide with the lowest risk to terrestrial plants is imazapic, which, according to ERAs, can be broadcast sprayed by ground methods 25 feet from a sensitive plant without risk.

The likelihood of adverse effects to special status terrestrial plants as a result of surface runoff from an upslope treatment site is dependent both on the herbicide used and the site conditions. Certain sites, such as those with clay soils that experience high annual rainfall, are more susceptible to surface runoff of rainwater. The timing of the herbicide application prior to a major rain event and the persistence of the herbicide on the site are also factors. Based on information from the ERAs, herbicides with the greatest likelihood of affecting special status plant species via surface runoff include imazapyr, metsulfuron methyl, picloram, and triclopyr. Of these herbicides, picloram has the longest soil half-life (see Soil Resources section). Herbicides with the least likelihood of impacting special status terrestrial plant species include imazapic, chlorsulfuron, and glyphosate, which pose no risk to sensitive plants via surface runoff, and bromacil, which poses low risks to sensitive plants only under a narrow range of site conditions.

The vast majority of the BLM's special status plant species are terrestrial. However, there are also aquatic plant species (including species in wetland habitats) for which separate risk analyses were completed. Aquatic plants could be harmed by a normal application of an aquatic herbicide, accidental direct spray or spray drift of a terrestrial herbicide from a nearby upland, accidental spill, or surface runoff from an upslope area into the water body where the plant is located. Use of 2,4-D and diquat to control vegetation in aquatic habitats would pose the greatest risks to any special status plant species also in the habitat. Aquatic herbicides that would be safe for use in aquatic habitats where special status plant species occur include fluridone and aquatic formulations of glyphosate. In addition, triclopyr acid could be applied directly to the water column at the standard concentration without harm to sensitive aquatic plants.

The terrestrial herbicides that would pose the greatest risks to special status aquatic plants as a result of accidental direct spray, spray drift, or surface runoff include 2,4-D (assumed), bromacil, diquat, diuron, hexazinone (assumed), and sulfometuron methyl. Most terrestrial herbicides would pose quite a high risk to special status plants as a result of an accidental spill. Notable exceptions would be picloram, with no risk, and diflufenzopyr with low risks. Based on the results of risk assessments, the safest terrestrial herbicides to use near aquatic habitats would be picloram and diflufenzopyr.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under this alternative, approximately 305,000 acres of public lands would be treated with herbicides annually. Based solely on acres treated, special status plant species would be less likely to be exposed to herbicides under this alternative than under the other herbicide-use alternatives. Therefore, less harm to special status plants and plant populations from herbicide exposure should occur. For TES plant species, risks for impacts from herbicide exposure should not be substantially different under all the action alternatives, since the BLM would design herbicide treatments to avoid risks to these species (which would include the use of protective spray buffers and other mitigation measures identified in the BA). Nonetheless, the likelihood of an accidental exposure would be lower under the No Action Alternative, since less herbicide would be sprayed on public lands annually.

Because fewer acres would be treated with herbicides than under the other herbicide-use alternatives, less fuels reduction (i.e., through control of downy brome) and control of non-native species using herbicides would occur under the No Action Alternative. Although most fuels reduction is done using other treatment methods, it is expected that the risk of a fire damaging populations of special status species would be higher than under the other alternatives, since there likely would likely be less total fuels reduction on public lands. Furthermore, since existing weed infestations would not be controlled as rigorously with herbicides, it is expected that populations of non-native species would spread at a faster rate than under the other herbicide-use alternatives. In some circumstances, populations of special status plant species that occur in the same habitats as targeted weed species, and that are threatened by their spread, would be more likely to decline as a result of competition with weeds under this alternative than under the other herbicide-use alternatives.

Under this alternative, only those herbicides currently used by the BLM would be used to treat vegetation. Based on herbicide usage in the past decade, the majority of the total acreage would be treated with picloram, tebuthiuron, and 2,4-D. Risks to terrestrial plants associated with picloram are relatively high. Risks associated with tebuthiuron are low to moderate. Risks associated with 2,4-D are unknown, and, given the lack of phytotoxicity information for this herbicide, assumed to be high. Risks to aquatic plants associated with picloram are very low. Risks associated with tebuthiuron range from low to high. Risks associated with 2,4-D are low to moderate. Therefore, risks to most special status plants would likely vary from low to high under this alternative, depending on the herbicide used.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Under this alternative, approximately 932,000 acres of public lands would be treated with herbicides annually. Based solely on acres treated, special status plant species would be more likely to be exposed to herbicides under this alternative than under the other alternatives. Therefore, more harm to special status plants and plant populations from herbicide exposure would likely occur. In the case of TES plant species, the likelihood of an accidental exposure to herbicides would be greater than under the other alternatives, since more acres would be treated, and more herbicide would be utilized. However, impacts to these species from herbicide exposure should not be substantially different than under the other alternatives, since the BLM would design herbicide treatments to avoid risks to these species (which would include the use of protective spray buffers and other mitigation measures identified in the BA). In addition, areas most in need of treatment, which would also receive the most intensive herbicide treatments, are not likely to support extensive populations of TES plant species.

Because more acres would be treated with herbicides than under the other alternatives, more fuels reduction and control of non-native species using herbicides would occur under the Preferred Alternative. Therefore, populations of special status species would be most likely to benefit from herbicide treatments through habitat improvements under this alternative. It is expected that the extent and rate of spread of weeds would be lowest under this alternative, and that there would be less competition with populations of special status plant species than under the other alternatives.

Under the Preferred Alternative, the BLM also would be able to use only 14 of the 20 herbicides that would be available under the No Action Alternative, but would also be able to use four new herbicides, and additional new herbicides that become available for use in the future. The two new terrestrial herbicides, imazapic and diflufenzopyr, have low risks to sensitive terrestrial plants under most conditions. Therefore, risks to special status species could be reduced under this alternative, provided the BLM used these herbicides in place of herbicides with higher risks to sensitive plants, such as picloram and 2,4-D.

Of the two new aquatic herbicides, fluridone poses no risk to sensitive non-target plants during an application, but there are moderate to high risks associated with using diquat. Given that the risks associated with diquat are higher than those associated with aquatic herbicides currently used by the BLM, impacts to aquatic special status plant species would likely be greater under the Preferred Alternative than under the No Action Alternative, especially if diquat was used in place of other less toxic herbicides.

Finally, the greater number of herbicides available for use, and the flexibility of additional future options, under the Preferred Alternative would potentially allow the BLM to come up with treatment programs that are more effective at reducing weed infestations, safer for sensitive, non-target plants, and less likely to result in reduced effectiveness of herbicides from repeated use than under the No Action alternative.

Alternative C – No Use of Herbicides

Under this alternative, no public lands would be treated with herbicides. Therefore, special status species on public lands would not be exposed to herbicides unless chemicals were transported onto the land from off-site. The risks to special status plant species for harm due to herbicide exposure would be near zero under this alternative, and therefore much lower than under the other alternatives. However, since the acreage treated using other methods (such as mechanical and biological treatments) would increase the most under this alternative, the associated risks to special status plant species would be greater than under the other alternatives. In the case of TES plant species, there would be little likelihood of an accidental exposure to herbicides. However, impacts to these species from herbicide exposure should not be substantially different than under the other alternatives, since measures to protect these species would be implemented under the other alternatives.

Under this alternative, the BLM would be less effective at controlling weed infestation than under the other alternatives. Non-native plant species, including those that compete with, or are a threat to, special status plant species, would spread at a faster rate than under the other alternatives. Although other treatment methods could be substituted for herbicide treatments, it is unlikely that these control measures would be as effective under all circumstances. Furthermore, some treatments must be combined with herbicide treatments to achieve the desired result (e.g., burning or mechanical treatments followed by spraying). These treatments would be used on their own under this alternative, and would not be as effective at controlling weed infestations.

Under this alternative, TES plant species and their habitats would not benefit from manual spot treatments of herbicides, which can be used to control weed infestations in areas that are too sensitive to receive more disturbing or wide-scale treatments. Under this alternative, the BLM would have fewer tools to control weeds near populations of TES species, many of which are threatened by non-native species. Overall, less would be done to improve the habitat of these species, making them more at risk for future population declines or extirpations.

Alternative D – No Aerial Applications

Under this alternative, approximately 530,000 acres would be treated with herbicides annually, fewer than under the Preferred Alternative, but more than under all of the other alternatives. Based solely on acres treated, special status plant species would be less likely to be exposed to herbicides than under the Preferred Alternative, but more likely to be exposed to herbicides than under the other alternatives. Accordingly, the second greatest amount of herbicide-related impacts to special status plant populations would occur under this alternative. In the case of TES plant species, impacts would be similar to those under the other alternatives, since all herbicide treatments would be designed to avoid risks to these species. Risks for accidental exposure could be higher than under alternatives, A, C, and E.

Plant species of concern would not be exposed to herbicides directly from off-site drift associated with an aerial application. Adverse effects to terrestrial and aquatic TES plants could potentially occur by ground applications at distances ranging from 25 to 1,500 feet.

The amount of fuels reduction and control of non-native species, and the related benefits to special status species from habitat improvement would also be second highest under this alternative. Because aerial spraying would not occur under this alternative, the BLM would be unable to treat areas that are inaccessible by ground methods. In these areas, weed infestations would persist and likely spread, potentially impacting nearby populations of special status plant species.

Under this alternative, the herbicides available for use by the BLM would be the same as those discussed for the Preferred Alternative. The benefits associated with flexibility in selecting herbicides, and in using new herbicides that become available in the future, would be the same as those discussed under the Preferred Alternative. In some instances, herbicides with lower risks to special status plant species could be selected instead of herbicides that are currently being used. In addition, the BLM would have more flexibility to could come up with treatment programs that are more effective at reducing weed infestations, safer for sensitive, non-target plants, and less likely to result in reduced effectiveness of herbicides from repeated use than under the No Action alternative.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Under this alternative, approximately 466,000 acres would be treated with herbicides annually, more than under the No Action Alternative, but fewer than under the other herbicide-use alternatives. Based solely on acres treated, special status plant species would be less likely to be exposed to herbicides, and therefore would suffer fewer herbicide-related impacts than under the other action alternatives (with the exception of Alternative C). Suggested 500-foot buffers would help to protect these species further from impacts related to herbicide exposure, although for some herbicides this buffer would be insufficient to prevent all impacts to non-target sensitive plants. In the case of TES plant species, impacts would be similar to those under the other alternatives, since all herbicide treatments would be designed to avoid risks to these species. Risks for accidental exposure could be higher than under alternatives A and C.

The amount of fuels reduction and control of non-native species, and the related benefits to special status species from habitat improvement would also be greater than under alternatives A and C. Although fewer total acres would be treated than under Alternative D, and broadcast spraying would be minimized, the BLM would be able to conduct aerial spraying to reduce weed infestations in some areas if other means could not be used. Habitat improvements for these species would largely depend on the amount of other treatments (including manual spot applications of herbicide) that would be feasible in these areas.

The increased emphasis on passive restoration under Alternative E would likely benefit certain populations of special status plant species by helping to prevent the spread of weeds and limiting some forms of disturbance. With this type of management in place, it is possible that fewer herbicide treatments would be necessary in certain areas, minimizing risks to special status plants. In areas where such restrictions would be inconsistent with BLM management practices, they would not be enacted, and no benefit to special status plant species would occur.

Under this alternative, the BLM would not be able to ALS-inhibiting herbicides (chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl, and any other ALS-inhibiting herbicides that are made available in the future). Chlorsulfuron, imazapyr, metsulfuron methyl, and sulfometuron methyl pose high risks to special status terrestrial species as a result of spray drift, and low to high risks as a result of surface runoff. Prohibiting use of these herbicides could benefit special status terrestrial plant species, provided that one or more herbicides with lower risks to non-target plants was used in their stead. Imazapic, however, is the herbicide with the lowest risk to sensitive terrestrial plant species out of all the herbicides analyzed in the ERAs. Therefore, prohibiting its use would eliminate a suitable low risk option for treating weeds and other invasive vegetation such as downy brome, mustards, and thistles, and would require the BLM to use an herbicide with greater risk of harming special status plant species, unless a safer replacement was made available in the future.

The risks of ALS-inhibiting herbicides on special status aquatic plant species range from none to moderate, depending on the application rate and exposure scenario, and are similar to the risks associated with most of the herbicides the BLM would be allowed to use under this alternative. Therefore, potential impacts to aquatic plants from off-site drift and runoff would be much the same under this alternative as under alternatives B, and D, except that there would potentially be less use of herbicides in riparian areas under Alternative E, limiting the likelihood of exposure.

Since the BLM would be able to use new herbicides that are made available in the future under this alternative, there would be more flexibility for creating effective treatment programs that minimize risks to special status plant species than under alternatives A and C. The inability to use ALS-inhibiting herbicides would reduce this flexibility below the level offered under alternatives B and D.

Mitigation for Herbicide Treatment Impacts

The following mitigation is recommended to reduce the likelihood of impacts to special status plant species from herbicide applications. This mitigation should be implemented in addition to the SOPs designed to protect plants presented in Chapter 2 (Alternatives) and the general mitigation recommended in the Vegetation section.

- To protect TES plant species, implement all mitigation measures for plants presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* (USDI BLM 2005b).
- Where feasible, implement the mitigation measures for plants presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* to minimize impacts to non-TES special status plants, unless treatments are specifically designed to improve habitats for these species.

- Consider manual spot applications over broadcast spraying where populations of special status plant species occur.
- At the local level, consider effects to special status plant species when designing herbicide treatment programs.

Fish and Other Aquatic Organisms

Introduction

The BLM administers lands directly affecting almost 110,000 mi of fish-bearing streams and 3 million acres of reservoirs and natural lakes (USDI BLM 2005c). These habitats range from isolated desert springs of the Southwest to large interior rivers and their numerous tributaries throughout the Pacific Northwest and Alaska. Today, the rapid expansion of invasive species across public lands is one of the primary threats to ecosystem health and one of the greatest challenges in ecosystem management.

The BLM herbicide treatment program is designed to benefit ecosystems by removing and controlling the spread of invasive plant species. In aquatic systems, these plants (e.g., Eurasian watermilfoil, hydrilla) may clog slow-moving waterbodies, contaminating water with an overabundance of organic material. This reduces light and dissolved oxygen levels, eliminating habitat and decreasing growth or killing native species of plants and animals.

Riparian systems may also be invaded by non-native species, which may be detrimental to native aquatic species. Non-native plants invading riparian areas (e.g., giant reed grass, saltcedar, Japanese knotweed) often support fewer native insects than native species, which could affect food availability for insectivorous fish species, such as salmonids. The replacement of native riparian plant species with some invasive species may adversely affect stream morphology (including shading and instream habitat characteristics), bank erosion, and flow levels. Removal of invasive species through herbicide use, when physical and climatic conditions and herbicide formulations allow treatments to be safe for native species and water quality, can help to restore a more complex vegetative and physical structure and natural levels of processes such as sedimentation and erosion.

Scoping Comments and Other Issues Evaluated in the Assessment

Numerous scoping comments were centered around a desire for the BLM to focus on long-term ecosystem sustainability and biological diversity. There was some concern about herbicide bioaccumulation in fish. Many reviewers expressed a desire that the BLM use newer, less toxic herbicides and/or limit or avoid herbicide use.

Standard Operating Procedures

This assessment of impacts assumes that SOPs (listed in Table 2-6) are used to reduce potential unintended impacts to fish and other aquatic organisms. These include developing and updating an operational plan for each herbicide project. The plan would include information on project specifications, key personnel responsibilities, communication procedures, safety, spill response, and emergency procedures. For application of herbicides not approved for aquatic use, the plan should also specify minimum buffer widths between treatment areas and water bodies. Buffers would reduce terrestrial herbicides potential for off-site transport. Treatment would be minimized during periods when fish are in life stages most sensitive to the herbicide(s) used, with spot, rather than aerial treatments used near water bodies. The BLM would avoid accidental direct spray and spill conditions to reduce the largest potential impacts. Herbicides would be applied within the parameters of prescribed environmental conditions stated on the label. The BLM would use the typical application rate, rather than the maximum application rate, when feasible to reduce risk to most species for most herbicides. Where feasible, the BLM would use spot hand applications within 20 feet of perennial and non-perennial streams with flowing water at the time of application. For treatment of aquatic vegetation, the BLM would 1) treat only that portion of the aquatic system necessary to achieve acceptable vegetation management, 2) use the appropriate application method to minimize the potential for injury to desirable vegetation and aquatic organisms, and 3) follow use restrictions on the herbicide label.

Impacts Assessment Methodology

BLM Risk Assessment Methodology

A literature review and ERA were conducted to assess the impacts to fish and other aquatic resources from the use of herbicides. The methods presented here are a brief overview of the ERA process to determine the risks of herbicide use for fish and aquatic invertebrates. The ERA methods are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C of this document.

There are four steps to the ERA process:

- Problem Formulation – determination of assessment endpoints and associated measures of effect
- Exposure Characterization – development of exposure scenarios and pathways
- Effects Characterization – compilation and analysis of the stressor-response relationships and other evidence of adverse impacts from exposure to each herbicide
- Risk Characterization – quantitative estimation and interpretation of the ecological risks of each herbicide

Problem Formulation

Assessment endpoints represent "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes" (USEPA 1998). Fish and aquatic species, including threatened, endangered, and sensitive (TES) species, were evaluated. The essential biological requirements (i.e., survival, growth, and reproduction) for each of these groups of organisms are the attributes to be protected from herbicide exposure. Assessment endpoints, for the most part, reflect direct effects of an herbicide on these organisms, but indirect effects were also considered.

Measures of effect are measurable changes in an attribute of an assessment endpoint (or its surrogate, as discussed below) in response to a stressor to which it is exposed (USEPA 1998). For the screening-level ERA, the measures of effect associated with the assessment endpoints generally consisted of acute and chronic toxicity data (from pesticide registration documents and from the available scientific literature) for the most appropriate surrogate species.

Exposure Characterization

The BLM uses herbicides in a variety of programs (e.g., maintenance of rangeland and recreational sites) with several different application methods (e.g., application by aircraft, vehicle, or backpack). In order to assess the potential ecological impacts of these herbicide uses, a variety of exposure scenarios were considered. These scenarios were selected based on actual BLM herbicide usage under a variety of conditions. The exposure scenarios considered in the ERAs were organized by potential exposure pathways. In general, the exposure scenarios describe how a particular receptor group may be exposed to the herbicide as a result of a particular exposure pathway. These exposure scenarios were designed to address herbicide exposure and acute and chronic (short- and long-term) impacts that may occur under a variety of conditions (e.g., accidental spills, surface runoff, and off-site drift into waterbodies).

Fish and other aquatic animals are exposed to herbicides in three primary ways: (1) dermally, by direct absorption through the skin from swimming in herbicide-contaminated waters; (2) breathing, by direct uptake of herbicides through the gills during respiration; and (3) orally, by drinking herbicide-contaminated water or feeding on herbicide-contaminated prey. The susceptibility of fish and other aquatic organisms to herbicides depends on the herbicide formulation as well as the fish other aquatic organism species. Fish and other aquatic organism tolerance to herbicides is usually a result of species size and metabolism. The degree to which any particular route of entry operates depends on the nature of the application, characteristic of the herbicide, and the characteristics of the area treated.

A major problem associated with herbicide use is the drift of sprayed herbicides to a susceptible resource other than the target resource. Off-site drift of herbicides may eventually reach off-site waterbodies and contaminate fish other aquatic organism populations.

Riparian areas directly affect water quality, habitat, and the food web for fish and other aquatic species. The temporary removal or loss of vegetation combined with the introduction of fine sediment to streams due to soil disturbance increases the potential for herbicide residual to enter aquatic habitats. Runoff and overland flow are dictated not only by the amount of water present, but also the gradient of the area; the steeper the area, the more extensive the runoff.

The AgDRIFT® computer model was used to estimate off-site herbicide transport due to spray drift. The GLEAMS computer model was used to estimate off-site transport of herbicide in surface runoff and root zone groundwater transport. The CALPUFF computer model was used to predict the transport and deposition of herbicides sorbed (i.e., reversibly or temporarily attached) to wind-blown dust. Each model simulation was approached with the intent of predicting the maximum potential herbicide concentration that could result from the given exposure scenario.

Aquatic exposure pathways were evaluated using fish, aquatic invertebrates, and non-target aquatic plants for two types of generic aquatic habitat: 1) a small pond (¼-acre pond of 1 m (39.4 inches) depth, resulting in a volume of 1,011,715 L [267,296 gallons]); and 2) a small stream representative of Pacific Northwest low-order streams that provide habitat for critical life-stages of anadromous salmonids.

Effects Characterization

Literature Review. The literature review process for deriving TRVs consisted of assembling relevant literature, evaluating these information sources, and then establishing specific numeric values for each ecological receptor. Literature sources included published manuscripts, unpublished study reports, USEPA herbicide registration data, and electronic databases. Once data from these various sources were compiled, the information was reviewed to determine its acceptability for deriving ecological TRVs for each of the 10 herbicides evaluated by the BLM.

Toxicity Reference Value. In the majority of cases, toxicological data do not exist for the specific ecological receptors of concern (i.e., specific fish and aquatic invertebrate species of interest) considered in the risk assessment. Consequently, toxicological data for surrogate species (e.g., bluegill sunfish for warmwater species and rainbow trout for coldwater species) were evaluated and used to establish quantitative benchmarks for the ecological receptors of concern. These benchmark values are referred to as TRVs. Once developed, TRVs were compared with predicted environmental concentrations to determine the likelihood of adverse effects to ecological receptors.

Risk Characterization

The risk characterization phase of an ERA consists of a quantitative estimate of the ecological risks, a description of data used in support of these risk estimates (including data gaps where appropriate), and an overall interpretation of the potential ecological impacts of each herbicide (following consideration of uncertainties in the analyses).

In order to address potential risks to ecological receptors, risk quotients (RQs) were calculated by dividing the EEC for each of the previously described scenarios by the appropriate toxicity endpoint, an herbicide-specific TRV. For fish, the TRV was a species-specific toxicity value derived from the literature.

To facilitate the translation of RQs into readily applicable estimates of risk, the calculated RQs were compared to LOCs used by the USEPA in screening the potential risk of pesticides. These LOCs are used by the USEPA's Office of Pesticide Programs (OPP) to analyze potential risk to non-target organisms and to assess the need to consider regulatory action. Distinct USEPA LOCs are currently defined for the following risk presumption categories:

- Acute high risk – the potential for acute risk is high.
- Acute restricted use - the potential for acute risk is high, but may be mitigated.
- Acute endangered species – TES species may be adversely affected.
- Chronic risk - the potential for chronic risk is high.

The ecological risk implications of various exposure estimates can be readily determined by noting which RQs exceed the corresponding LOCs. LOCs of 0.1 (acute high risk) and 1 (chronic risk) were used for non-TES fish and aquatic invertebrates.

Forest Service Methodology

The Forest Service risk assessment methodology was similar to that used by the BLM (see SERA 2001a for a complete description of the current methodology). The steps involved in the Forest Service risk assessments include hazard identification, exposure assessment, dose response assessment, and risk characterization.

Hazard identification involved the review of existing data with a focus on the dose-response and dose-severity relationships to determine the effect levels (e.g., NOAEL, LOAEL) and assessment endpoints (e.g., acute toxicity, subchronic or chronic systemic toxic effects, reproductive and teratogenic effects) that are most relevant for the herbicide risk assessments.

In the exposure assessment phase, the Forest Service developed four general and accidental/incidental exposure scenarios (i.e., direct spray, spray drift, runoff, and wind erosion) for groups of non-target vegetation according to the application method and the chemical and toxicological properties of the given herbicide. The Forest Service scenario of contaminated irrigation water—a direct application scenario—was not evaluated by the BLM because the BLM vegetation treatment program does not typically involve irrigation of vegetation. However, the BLM analyzed a scenario for accidental direct spray over streams for all terrestrial and aquatic herbicides. This would be the exposure route (for aquatic animals) most likely to represent what could occur while treating edges of ditches. The BLM analysis of accidental direct spray and drift could be used to assess the exposure of crops from contaminated irrigation ditch water and would likely provide a more conservative estimate of risks to crops than a direct application scenario using contaminated irrigation water.

Dose response assessment described the degree or severity of risk as a function of dose. The risk characterization process then compared the exposure assessment to the dose response assessment to determine a "level of concern" for a specific exposure scenario. Hazard quotients were developed through this process. Hazard quotients are analogous to the RQs developed in the BLM risk assessments—they are calculated as the projected level of exposure (i.e., EEC) divided by an index of an acceptable level of exposure or otherwise defined level of exposure (e.g., a NOAEL divided by an uncertainty factor). In addition, the herbicides were all compared based on their selectivity, potency, persistence in the environment, and ability to move off-site. The BLM used BLM herbicide application rates, which may differ from those of the Forest Service, when assessing for exposure.

As with the BLM risk assessments, information is incomplete on effects to native species, so impacts were extrapolated from the risk assessment or herbicide labels. Using herbicide labels to identify close relatives of native or desirable species does help to reduce uncertainty. However, Boutin et al. (2004) concluded that it was likely that the suite of species currently used in most risk assessments were not representative of the habitats found adjacent to agricultural treatment areas, and suggested this might cause an unacceptable bias and underestimated risk.

Impacts by Treatment

The extent of disturbance to fish and other aquatic populations caused by herbicide treatments would vary by the extent and method of treatment and chemical used. Herbicides could come into contact with and impact fish and aquatic invertebrates through drift, runoff, wind transport, or accidental spills and direct spraying. Potential impacts include mortality, reduced productivity, abnormal growth, and alteration of critical habitat. In general, risk to aquatic invertebrates and fish from spray drift is greater with smaller buffer zones and application rates, and application from greater heights (i.e., aerial application or ground application with a high boom). Risk to aquatic invertebrates and fish from surface runoff is influenced by precipitation rate, soil type, and application area. Most accidental scenarios (i.e., direct spray or spill) would result in risk to aquatic invertebrates and fish. Persistent herbicides (e.g., sulfometuron methyl) adsorbed to soil particles could also be carried off-site by wind or water, affecting fish and 'aquatic invertebrates in nearby aquatic areas. However, in this analysis, wind transport of herbicide particles did not result in risk, or only low risk (diuron) to fish (i.e., surrogate receptors) in any evaluated scenario. Application rate was a major factor in determining risk, with higher application rates more likely to result in risk to fish in various exposure scenarios.

The risk characterization process of the ERA suggested that chlorsulfuron, dicamba, diflufenzopyr, Overdrive®, and sulfometuron methyl are very safe to fish and aquatic invertebrates, as these herbicides do not result in risk to these receptor types in any of the evaluated scenarios, including accidental direct spray or spill scenarios. In addition, imazapic does not result in risk to fish or aquatic invertebrates except when directly sprayed over a stream at the maximum application rate. There is no risk to fish or aquatic invertebrates with off-site drift of bromacil and tebuthiuron. Diuron can present a moderate to high risk to fish and aquatic invertebrates as a result of surface runoff, if applied at the maximum application rate. The aquatic herbicides (i.e., diquat, fluridone, and glyphosate) do result in risk (low to high) to fish and aquatic invertebrates when applied to ponds and streams; this risk is higher with application of diquat than fluridone, which at the typical application rate only results in risk to aquatic invertebrates in the stream (aquatic herbicides are not typically applied to streams; therefore, this is an accidental scenario). Tables 4-17 and 4-18 show the level of risk to fish and aquatic invertebrates for the different herbicides according to application scenario.

All of the herbicides pose some risk to non-target terrestrial and aquatic plants, and these risks should be considered, as damage to riparian and aquatic plants may affect fish and aquatic invertebrates. The sections on Vegetation and Wetlands in this chapter discuss these risks as well as herbicide application practices that can be used to reduce risk.

The ALS-inhibiting herbicides evaluated in this PEIS are chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl (all terrestrial herbicides). These herbicides inhibit the synthesis of ALS, which is the catalyst for the production of amino acids that are required for protein synthesis and cell growth. ALS-inhibiting herbicides are considered to be highly potent and are applied at low application rates because only small concentrations are necessary to damage plants. Two ALS-inhibiting herbicide, imazapic and imazapyr, did result in low risk to aquatic invertebrates and/or fish when accidentally directly sprayed over the stream at the maximum application rate; however, this risk is similar to or less than risks from the other evaluated herbicides and could be avoided by applying at the typical application rate. Therefore, the ALS-inhibiting herbicides do not appear to create unnecessary risk to fish and aquatic invertebrates. In addition, it is possible that because they are able to be applied at very low rates, there is less risk of off-site transport associated with their use. Nevertheless, because of the potency of these herbicides and their possible high profile with the public, they may be most appropriate for use when the target plant is the dominant cover species or when there is a particularly aggressive invasive species that has not been able to be controlled by other methods (USDA Forest Service 2005).

Impacts of BLM-evaluated Herbicides

Bromacil

Bromacil is a non-selective, broad-spectrum, systemic herbicide that can be persistent in aquatic systems. It is not registered for use in riparian and aquatic systems. Bromacil does not tend to bioconcentrate appreciably in fish tissue. Bromacil poses a low to moderate risk to fish and aquatic invertebrates in typical and accidental direct spray and spill scenarios in the impacted stream and pond. Acute toxic effects of bromacil, where 50% mortality (median lethal concentration; LC_{50}) occurred, were at concentrations of 36 mg a.i./L, with coldwater fish (rainbow trout) slightly more sensitive to bromacil than warmwater fish (fathead minnow and bluegill sunfish). Chronic toxicity was evaluated using fathead minnows. Growth was reduced in this species after 64-days of exposure at 1 mg a.i./L, the highest concentration tested (Call et al. 1987).

Compared to fish, aquatic invertebrates are less sensitive to acute bromacil exposures. Acute toxicity tests exposing water fleas (*Ceriodaphnia dubia* and *Daphnia magna*) to concentrations of 65 mg a.i./L, found 50% of the test organisms were immobilized after 48 hours of exposure.

Off-site drift of bromacil generally does not result in risk to fish and aquatic invertebrates in the stream or pond. Surface runoff poses no risks to aquatic invertebrates or fish in the stream, but could pose low acute and chronic risk for fish in the pond (at the typical application rate, low chronic risk occurs in watersheds with sand or loam soils and 10 to 50 inches per year of precipitation). Because bromacil has a higher affinity for water than organic carbon, it is likely to runoff from soils into waterbodies.

Because of the non-selective nature of bromacil and its increased likelihood for runoff, it should not be applied near waterbodies, especially ponds. Sufficiently upland application of bromacil should have little to no impact on fish and aquatic organisms.

Chlorsulfuron

Chlorsulfuron is a selective, ALS-inhibitor herbicide. It is not registered for use in aquatic systems.

Chlorsulfuron's physical and chemical properties suggest that it is highly soluble in water, and is likely to remain dissolved in water and runoff from soils into waterbodies. In addition, this herbicide has a long half-life in ponds but is not likely to bioconcentrate in aquatic wildlife. However, none of the evaluated scenarios, including accidental direct spray and spill of chlorsulfuron, pose any risk to fish and aquatic invertebrates in streams and ponds.

Acute toxicity studies on rainbow and brown trout found LC_{50} occurred after 96 hours of exposure at concentrations as low as 40 mg a.i./L (Grande et al. 1994). Acute toxicity tests LC_{50} for warmwater fish, including fathead minnows, bluegill sunfish, and channel catfish, ranged from approximately 50 mg a.i./L to nearly 300 mg a.i./L. These results suggest that coldwater and warmwater fish species may have comparable sensitivity to chlorsulfuron.

Chlorsulfuron is not likely to negatively impact fish and aquatic invertebrates, and it may have positive effects on these organisms if it is used to selectively target nuisance species in riparian zones, such as perennial pepperweed and hoary cress.

Dicamba

Dicamba is an active ingredient that can be used as a stand-alone product or in the herbicide formulation Overdrive® along with diflufenzopyr. It is not registered for use in aquatic environments. Overdrive® can be applied using a wick applicator in riparian areas, and provides good control of several thistle and knapweed species that can become prevalent in riparian areas. The ERA analysis shows that accidental direct spray and spill scenarios do not result in risk to fish and aquatic invertebrates.

Acute toxicity tests were conducted for both coldwater and warmwater fishes. Exposures ranging from 24 to 144 hours indicate that dicamba is relatively nontoxic to freshwater fish (SERA 2004c). For rainbow trout, the LC_{50} occurred after 96 hours of exposure at concentrations of 28 mg a.i./L. The 96-hour LC_{50} for bluegill sunfish was determined to be greater than 50 mg a.i./L. Off-site drift and surface runoff of dicamba also present no risk to fish and aquatic invertebrates.

Acute toxicity tests using water fleas (*Daphnia* spp.) found concentrations of 11 mg a.i./L immobilized 50 percent of test organisms after 96 hours of exposure in one study, but other species of fleas water fleas were very tolerant of dicamba (> 750 mg/L LC_{50}; SERA 2004c).

Dicamba is not likely to negatively impact fish and aquatic invertebrates, and it may have positive effects on these organisms if it is used to selectively target nuisance species in riparian zones.

Diflufenzopyr

Diflufenzopyr, an active ingredient in the herbicide formulation Overdrive® along with dicamba, is a selective, systematic post-emergence herbicide active ingredient. It is not registered for use in aquatic environments. Overdrive® can be applied using a wick applicator in riparian areas, and provides good control of several thistle and knapweed species that can become prevalent in riparian areas. The physical and chemical properties of diflufenzopyr suggest that this herbicide would be removed from an aquatic environment relatively rapidly following contamination and would not appreciably bioconcentrate in fish tissue. The ERA analysis shows that accidental direct spray and spill scenarios do not result in risk to fish and aquatic invertebrates.

Acute toxicity tests were conducted for both coldwater and warmwater fishes. For rainbow trout, the LC_{50} occurred after 96 hours of exposure at concentrations of 106 mg a.i./L, with no adverse effect observed at 80 mg a.i./L (USEPA 2003b). The 96-hour LC_{50} for bluegill sunfish was determined to be greater than 135 mg a.i./L, with no adverse effects at concentrations of 16 mg a.i./L (USEPA 2003b). Results from these tests suggest diflufenzopyr has relatively low toxicity to fish species. Off-site drift and surface runoff of diflufenzopyr also present no risk to fish and aquatic invertebrates.

Acute toxicity tests using the water flea (*Daphnia magna*) found concentrations of 15 mg a.i./L immobilized 50 percent of test organisms after 48 hours of exposure (USEPA 2003b). The same tests found the no adverse effect concentration was 9.7 mg a.i./L.

Diflufenzopyr is not likely to negatively impact fish and aquatic invertebrates, and it may have positive effects on these organisms if it is used to selectively target nuisance species in riparian zones.

Diquat

Diquat is a non-selective, contact herbicide for the management of undesirable vegetation under non-cropland terrestrial and aquatic situations. The BLM proposes to use diquat to control aquatic plants. Plant species controlled using diquat includes watermilfoil, hydrilla, water hyacinth, and giant salvinia. Acute toxic effects of diquat were evaluated for coldwater fish species rainbow trout, coho salmon, and brown trout. Studies found a 96-hour LC_{50} occurred at concentrations of 14.83 mg a.i./L (USEPA 2003b). Acute toxicity was also tested on 12 warmwater fish species. Studies found a 96-hour LC_{50} was found to be as low as 0.75 mg a.i./L (Paul et al. 1994). In chronic studies, the LOAEL in coldwater fish (rainbow trout) was 0.5 mg a.i./L, based on reduced swimming performance (Dodson and Mayfield 1979). In warmwater fish, chronic studies found adverse effects at concentrations as low as 1.5 mg a.i./L (USEPA 2003b).

Studies on water scud reported the lowest LC_{50} concentration was 0.14 mg a.i./L (USEPA 2003b). No observable adverse effect concentrations (NOEC) for aquatic invertebrates ranged from 0.044 to over 2 mg a.i./L (Moss 1978, USEPA 1995c).

One study reported the likelihood of bioconcentration in aquatic species, but other studies suggest that diquat's bioconcentration potential is minimal (Howard 1991; Petit et al. 1995; MacKay et al 1997). Accidental spill of

TABLE 4-17
Risk Categories Used to Describe BLM-evaluated Herbicide Effects on Non-TES Fish and Aquatic Invertebrates According to Exposure Scenario

Application Scenario	BROM[1]		CHLOR[1]		DICAMBA		DIFLU[1]		DIQUAT		DIURON		FLUR[1]		IMAZ[1]		OVER[1]		SULFM[1]		TEBU[1]	
	Typ[2]	Max[2]	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Direct Spray																						
Fish pond	L[3]	L	0	0	0	0	0	0	L	L	M	M	0	O	0	0	0	0	0	0	0	0
Fish stream	L	M	0	0	0	0	0	0	L	M	H	H	0	L	0	0	0	0	0	0	0	0
Aquatic invertebrates pond	0	0	0	0	0	0	0	0	M	H	M	H	0	L	0	0	0	0	0	0	0	L
Aquatic invertebrates stream	0	L	0	0	0	0	0	0	H	H	M	H	0	L	0	0	0	0	0	0	L	M
Accidental Spill to Pond																						
Fish pond	NE	M	NE	0	NE	0	NE	0	NE	H	NE	H	NE	M	NE	0	NE	0	NE	0	NE	L
Aquatic invertebrates pond	NE	L	NE	0	NE	0	NE	0	NE	H	NE	H	NE	H	NE	0	NE	0	NE	0	NE	L
Off-Site Drift																						
Fish pond	L[3]	L	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Fish stream	L	M	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates pond	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates stream	0	L	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Surface Runoff																						
Fish pond	0	0	0	0	0	0	0	0	NE	NE	0	L	NE	NE	0	0	0	0	0	0	0	0
Fish stream	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates pond	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates stream	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0

[1] BROM = Bromacil; CHLOR = Chlorsulfuron; DIFLU = Diflufenzopyr; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.

[2] Typ = Typical application rate; and Max = Maximum application rate.

[3] Risk categories: 0 = No risk (majority of RQs < most conservative LOC for non-TES species); L = Low risk (majority of RQs 1-10x most conservative LOC for non-TES species); M = Moderate risk (majority of RQs 10-100x most conservative LOC for non-TES species); H = High risk (majority of RQs >100 most conservative LOC for non-TES species); and NE = Not evaluated. The risk category is based on the risk level of the majority of risk quotients observed in any of the scenarios for a given exposure group and receptor type. The reader should consult the risk tables in Chapter 4 of the ERAs (ENSR 2005b-k) to determine the specific scenarios that result in the displayed level of risk for a given receptor group.

diquat poses high risk to fish and aquatic invertebrates. Direct spray of diquat to ponds (as would occur with typical aquatic applications) results in low risk to fish and moderate risk to aquatic invertebrates. Direct spray to streams, which are not typical application sites, results in low risk to fish and mostly high risk to aquatic invertebrates. Because diquat is an aquatic herbicide, risk to aquatic organisms via off-site drift and surface runoff scenarios was not evaluated.

The short-term risks of diquat to fish and aquatic invertebrates suggest that diquat should be used on a restricted basis, and then only in ponds that support very few native aquatic species because they are saturated with invasive plants. Other aquatic herbicides evaluated in this EIS, fluridone, 2,4-D, and imazapyr pose much lower risk to fish and aquatic invertebrates and could be used instead of diquat when native aquatic species are present, as appropriate, if they have activity on the target species. Glyphosate is also used to control aquatic plants, but may present similar levels of risk as diquat, depending on application rate, product formulation, and the receptor of concern.

Diuron

Diuron is a broad-spectrum herbicide with a relatively short half-life and little to no impact on measured water quality variables (Perschbaucher et al. 2004). It would not be used in riparian or aquatic habitats. Previous studies suggest that diuron tends to remain in the soil rather than moving into groundwater or running off into waterbodies (Mueller-Warrant and Griffith 2005). In acute toxicity tests, the 96-hour LC50 value was 0.71 and 2.8 mg a.i./L for cold- and warmwater fish, respectively (USEPA 2003b). Chronic exposure was tested in the warmwater fish larvae, fathead minnow, for 64 days. Adverse effects were recorded at concentrations of 0.078 mg a.i./L, while no observable adverse effects were recorded at concentrations of 0.033 mg a.i./L (Call et al. 1987). In 96-hour aquatic toxicity tests, acute toxicity was observed in aquatic invertebrates exposed to concentrations at 0.16 mg a.i./L (USEPA 2003b).

Diuron does have a low to moderate tendency to bioaccumulate in aquatic organisms (National Library of Medicine 2002). Accidental direct spray and spill scenarios pose a moderate to high risk to fish and aquatic invertebrates. At the typical and maximum application rate, off-site drift of diuron results in no to low risk to fish and aquatic invertebrates. At the maximum application rate, off-site drift of diuron poses low risk to fish and aquatic invertebrates in the stream and pond under most application scenarios with a buffer zone of 100 feet or less. According to this ERA, surface runoff does pose low risk to fish and no or low risk to aquatic invertebrates in ponds in the majority of scenarios. Surface runoff also poses a low risk to fish in the stream in watersheds with at least 25 inches of rain per year (mostly at the maximum application rate) and a low risk to aquatic invertebrates at the typical and maximum application rates in watersheds with at least 10 inches of precipitation per year. In all cases, effects were less likely in watersheds with loam soils.

Use of diuron should be restricted as it results in more risks to fish and aquatic invertebrates than most other herbicides. Another herbicide should be used in its place if possible, especially when the application site is near a waterbody.

Fluridone

Fluridone is a slow-acting, broad-spectrum aquatic herbicide that can be used selectively for management of aquatic species, including hydrilla and watermilfoil. As fluridone is relatively non-persistent, it is not expected to affect water quality for a substantial period of time (Muir et al. 1980). In acute toxicity tests, the 96-hour LC_{50} value for the coldwater fish, rainbow trout, was 4.2 mg a.i./L (Hamelink et al. 1986). Acute toxicity for warmwater fish, including bluegill sunfish, fathead minnow, and channel catfish, for 96-hour LC_{50} has been recorded at concentrations of 8.2 mg a.i./L. Chronic toxicity on fathead minnows showed adverse effects at concentrations of 0.96 mg a.i./L and no adverse effects at concentrations at 0.48 mg a.i./L. Acute toxicity studies on aquatic invertebrates (water fleas and scuds) recorded concentrations of 1.3 mg a.i./L.

Fluridone has little tendency to bioaccumulate in fish (Washington Department of Health 2000). Accidental spill of fluridone poses moderate to high risk to fish and aquatic invertebrates. Direct spray of fluridone over a pond (normal application) at the maximum application rate results in low risk to fish and aquatic invertebrates. Accidental direct spray of fluridone over a stream (aquatic herbicides are not typically applied to streams) results in no or low risk to fish and aquatic invertebrates at the maximum application rate. Because fluridone is an aquatic herbicide, off-site drift and surface runoff scenarios were not evaluated.

To the extent that typical use of fluridone is successful in removing damaging invasive vegetation with a minimal of residence time in the waterbody, water quality and wildlife habitat in waterbodies would likely improve over the long term. Because there are no risks to fish and aquatic invertebrates from normal use of fluridone at the typical application rate, appropriate use of this herbicide would likely result in an overall benefit to fish and aquatic invertebrates. Fluridone poses much lower risk to fish and aquatic invertebrates than diquat.

Imazapic

Imazapic, an ALS-inhibitor, is a selective, systemic herbicide. It would not be used for treatment of aquatic vegetation, but could be used in riparian areas where the application can be monitored to ensure that the herbicide does not come in direct contact with water. Leafy spurge and the perennial mustards would be target species.

Acute toxicity studies on rainbow trout, bluegill sunfish, and channel catfish at concentrations of 100 mg a.i./L showed no adverse effects. The 96-hour LC_{50} values for these species were greater than 100 mg a.i./L (Yurk et al. 1992a, b *cited in* SERA 2001b; USEPA 2003b). Chronic exposure of flathead minnow eggs and larvae failed to show adverse effects at concentrations of 96 mg a.i./L (USEPA 2003b). Acute toxicity tests using the water fleas (*Daphnia magna*) showed no acute toxicity after 48-hours exposure to 100 mg a.i./L.

The average half life for imazapic in a pond is 30 days, and this herbicide has little tendency to bioaccumulate in fish (Barker et al. 1998). According to the manufacturer's label, imazapic has a high runoff potential from soils for several months or more after application. Accidental direct spray and spill scenarios generally result in no risk to fish and aquatic invertebrates at the typical and maximum application rates. Risk assessments show fish and aquatic invertebrates are not at risk from off-site drift or surface runoff of imazapic.

When imazapic is used appropriately, it should not impact fish or aquatic invertebrates in the stream or pond. There is only a relatively small chance of risk to stream aquatic invertebrates in the case of accidental direct spray. The use of imazapic may have positive effects on fish and aquatic invertebrates if it is used to selectively target nuisance species in riparian zones.

Overdrive®

Overdrive® is an herbicide formulation containing the active ingredients dicamba and diflufenzopyr. It is a selective, systematic herbicide, with low residence times in waterbodies and a low bioconcentration potential (National Library of Medicine 2002). Overdrive® application does not result in risk to fish or aquatic invertebrates under any application scenario (also see toxicity studies under dicamba and diflufenzopyr).

Overdrive® is not likely to negatively impact fish and aquatic invertebrates, and it may have positive effects on these organisms if it is used to selectively target nuisance plant species in riparian zones, provided herbicide use is seen as an acceptable vegetation treatment method in these sensitive areas.

Sulfometuron Methyl

Sulfometuron methyl, an ALS-inhibitor, is a broad-spectrum, pre- and post-emergent herbicide. It is not approved for use in aquatic systems, but could be used to treat perennial pepperweed, hoary cress, and other weeds associated with riparian systems if the application was made far enough from water to ensure that the active ingredient did not get into water. Sulfometuron methyl has relatively low residence times in aquatic systems, and bioaccumulation in aquatic organisms has not been detected (Extension Toxicology Network 1996d). In acute toxicity tests, the 96-hour LC_{50} value was greater than 148 mg a.i./L and less than 150 mg a.i./L for cold- and warmwater fishes, respectively (USEPA 2003b). Chronic exposure of fathead minnow larvae showed adverse effects at concentrations of 1.16 mg a.i./L, while the no effect concentration was 0.71 mg a.i./L. In 48-hour aquatic toxicity tests, acute toxicity was observed in aquatic invertebrates at a concentration of 802 mg a.i./L (Naqvi and Hawkins 1989). In 21-day chronic tests, adverse effects were observed in aquatic invertebrates at a concentration of 24 mg a.i./L.

None of the evaluated scenarios result in risk to fish and aquatic invertebrates from application of sulfometuron methyl. Therefore, if herbicide treatments are needed in riparian areas, sulfometuron methyl may be able to effectively target nuisance plants without negative impact to fish and aquatic invertebrates. In addition, use of sulfometuron methyl in riparian zones may have positive effects on fish and aquatic invertebrates if it results in more diverse vegetation structure and native plant communities.

Tebuthiuron

Tebuthiuron is a relatively non-selective herbicide absorbed by plant roots through the soil. Tebuthiuron has little tendency to bioaccumulate in aquatic organisms (National Library of Medicine 2002), but may have moderate residence times in waterbodies (over 1 year in anaerobic conditions). In acute toxicity tests, the 96-hour LC_{50} values were 115 and 112 mg a.i./L for cold- and warmwater fish, respectively. Chronic exposure of fry of the coldwater fish, rainbow trout, showed adverse effects at a concentration of 52 mg a.i./L, while the no effect concentration was 26 mg a.i./L (USEPA 2003b). In warmwater fish, chronic toxicity was observed at 18 mg a.i./L, while no effects occurred at 9.3 mg a.i./L. In 48-hour toxicity tests on aquatic invertebrates, acute toxicity was observed at a concentration of 297 mg a.i./L, while chronic tests on chironomids exhibited adverse effects at a concentration of 0.2 mg a.i./L (Temple et al. 1991; USEPA 2003b).

Accidental spill to the pond results in low risk to fish and aquatic invertebrates. Accidental direct spray of tebuthiuron over the pond results in low chronic risk to aquatic invertebrates, and accidental direct spray over the stream results in low to moderate chronic risk to aquatic invertebrates. Fish are not at risk from accidental direct spray. Off-site drift and surface runoff of tebuthiuron does not pose a risk to fish or aquatic invertebrates.

If tebuthiuron is applied at the typical application rate, under normal application scenarios, it is likely to have little or no impact on fish or aquatic invertebrates.

Impacts of Forest Service-evaluated Herbicides

The following information for eight herbicides used by the BLM is taken from ERAs prepared by the Forest Service to support their assessment of the environmental consequences of using these herbicides in Forest Service vegetation management programs. The BLM previously evaluated and approved these eight herbicides in an earlier EIS—*Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a).

Most of the Forest Service risk assessments note that adverse effects on non-target plants, particularly those that are directly exposed to herbicides, are to be expected. They also note that effects on plants may lead to secondary ecological effects due to changes in habitat, food supply, lighting, and other conditions. These secondary changes, which are a result of changes in plant cover or composition, are not specific to a particular herbicide or even to herbicide use in general, and, therefore, are not specifically addressed or quantified in their risk assessments.

2,4-D

2,4-D is an herbicide that has formulations registered for use on aquatic vegetation, including water hyacinth and watermilfoil, and as a tank mix partner to control purple loosestrife. The toxicity of 2,4-D to fish and other aquatic organisms is relatively low (Norris et al. 1991). Risk increases with cases of direct application to waterbodies or accidental direct spills. The ester formulations of 2,4-D (including the BEEs found in Aqua-Kleen) are approximately 200 to 1,000 times more toxic to fish than the amine formulations, when toxicity is measured by acute (24- to 48-hour) LC_{50} values. While these esters are chemically stable, they are short-lived in natural water because of biological degradation. After an accidental spill of 2,4-D into a waterbody, the maximum concentrations are estimated at 6 mg/L/lb applied. However, this concentration diminishes rapidly because of microbial degradation, binding to suspended particulate, or dispersion. At a typical application rate of 1 lb a.e./ac, 2,4-D poses a low risk to fish and aquatic invertebrates, while at a maximum rate of 1.9 lbs a.e./ac, acute doses of 2,4-D poses a moderate risk to fish and aquatic invertebrates in accidental direct spray and spill scenarios in the impacted stream and pond (Table 4-18). Routine acute and chronic exposure scenarios do not result in risk to fish, even at peak EECs.

Rainbow trout exposed to a butoxyethanol ester of 2,4-D experienced 20% mortality at a 9 mg/L concentration, 50% mortality at a 10 mg/L, and 90% mortality at 10.5 mg/L (Dodson and Mayfield 1979). Sublethal effects to fish after the release of 2,4-D has also been reported. Swimming behavior of green sunfish was affected by the butoxyethanol ester after 60 minutes of exposure to 100 ppm (SERA 1998), while spawning of bluegills was delayed 2 weeks in ponds treated with 5 and 10 mg/L of the herbicide (Norris et al. 1991).

The relative toxicity of 2,4-D varies considerably for aquatic invertebrates. Work on the water flea, *Simocephalus vetulus*, to the sodium salt of 2,4-D showed a complete mortality following 96 hours of exposure to concentrations ranging from 0.5 to 5.0 milli Molarity (Kaniewska-Prus 1975 *cited in* SERA 1998). These tests showed that the 2,4-D formulation decreased respiration rates. No difference in oxygen consumption was observed between untreated *Daphnia pulex* and those exposed to 3 mg/L of the butoxyethanol esters of 2,4-D (Sigmon 1979 *cited in* SERA 1998). Yet, midges tested at the same concentrations and 2,4-D formulation experienced greater mortality, lower pupation, and emergence rates following exposure (Sigmon 1979 *cited in* SERA 1998).

Clopyralid

Clopyralid is a selective herbicide most effectively used post-emergence for the control of broadleaf weeds. It is not registered for aquatic vegetation management, but could be used in riparian areas if the application does not impact standing water. Clopyralid is used to treat teasel, common cocklebur, and several species of thistles and knapweeds that could be found in riparian areas. The BLM application rates modeled were 0.35 (typical) to 1.0 (label maximum) lb a.i./ac. Based on limited acute bioassays, clopyralid appears to be relatively non-toxic to fish and aquatic invertebrates. The risk assessment only predicted risk in accidental spill scenarios, with low risk to fish and aquatic invertebrates at the typical rate and low risk to fish and moderate risk to aquatic invertebrates at the maximum application rate.

Research on fish reports the lowest 96-hour LC_{50} for clopyralid is 103 mg a.e./L in trout (Dow Chemicals 1980 as cited in SERA 1999). Research on *Daphnia magna* reported the lowest LC_{50} for technical clopyralid as 232 mg/L, about a factor of 2.2 higher than the lowest reported LC_{50} in fish (Dow AgroSciences 1998 *cited in* SERA 1999).

There is no chronic data available for fish, however, work on *Daphnia magna* shows the NOAEL is 23.1 mg a.e./L (SERA 2004b). This NOAEL is substantially higher that the anticipated concentrations for acute or chronic exposures and could be used as the basis for asserting that no adverse effects are plausible in fish and aquatic invertebrates. As a result, the toxicity of clopyralid is relatively low to aquatic species.

Glyphosate

Glyphosate is a non-selective systemic aquatic herbicide. It can be applied as a broadcast, spot, or wipe application, and is effective in controlling purple loosestrife, giant reed, cat-tail, and in some situations, saltcedar. In general, glyphosate is very immobile in soil, being readily adsorbed by soil particles and subject to microbial degradation (Norris et al. 1991). This immobility reduces the potential of glyphosate to enter waterbodies during runoff. Glyphosate was applied to an agricultural watershed at rates of 0.98, 3.06, and 8.12 lbs/ac (Edwards et al. 1980).

Based on bioassays, the USEPA OPP has classified technical grade glyphosate as non-toxic to practically non-toxic in freshwater fishes (USEPA OPP 1993). Some formulations are more toxic to fish than technical grade glyphosate. Studies showed that the 96-hour LC_{50} values for in freshwater fishes ranged from 1.1 to 16 mg/L in rainbow trout for a 41% glyphosate formulation to over 1,000 mg/L in rainbow trout and bluegill sunfish for 62.4% glyphosate formulation. At a typical rate of 2 lbs a.e./ac, the less toxic formulation of glyphosate results in little risk to fish and aquatic invertebrates except under accidental spill scenarios, which result in low to moderate risk to fish and low risk to aquatic invertebrates. At the typical application rate, the more toxic formulation of glyphosate poses high risk to fish and aquatic invertebrates in accidental spill scenarios and low risk under routine acute exposure scenarios (moderate risk to sensitive fish species). At a maximum rate of 7 lbs a.e./ac, the less toxic formulation of glyphosate poses a low risk to fish and aquatic invertebrates in acute exposure scenarios resulting in peak EECs in the impacted stream and pond, and accidental spills pose moderate to high risk to fish and low risk to aquatic invertebrates. At this same application rate, the more toxic formulation of glyphosate results in high risk to fish and aquatic invertebrates under accidental spill scenarios and moderate risk to fish and low risk to aquatic invertebrates under acute exposure to peak EECs. Based on these data, the USEPA classified glyphosate formulation as moderately toxic to practically non-toxic to freshwater fishes (SERA 2003b).

Hexazinone

Hexazinone is an s-triazine herbicide that inhibits photosynthesis and the synthesis of RNA, proteins, and lipids. This herbicide degrades rapidly in water exposed to sunlight. For hexazinone, the BLM modeled a typical application rate of 1 lb a.i./ac and a maximum rate of 8 lbs a.i./ac. Within this application range, hexazinone poses no risk to fish and aquatic invertebrates in acute and chronic exposure scenarios in the impacted stream and pond (accidental spill scenarios were not modeled).

Hexazinone does not tend to bioaccumulate and the clearance rate from tissue of exposed animals is rapid once exposure ceases (Norris et al. 1991). Rhodes (1980) exposed bluegill sunfish to hexazinone for 4 weeks at concentrations up to 1.0 mg/L. Hexazinone residues reached maximum values of 2.1 mg/kg in the carcass and 6.7 mg/kg in the viscera. However, after 2 weeks of clean water, Rhodes did not detect any hexazinone in these fish.

Bioassays on hexazinone and commercial formulations indicate commercial formulations are substantially less toxic than hexazinone, even when exposures are normalized for hexazinone levels (Wan et al. 1988). Wan et al. found commercial formulas much less toxic than hexazinone in rainbow trout. At a subchronic level, results on early life stages of fathead minnow showed a NOEL of 17 mg/L (Pierson 1990 *cited in* SERA 1997). Overall, studies indicate hexazinone is only slightly toxic to fish, with LC_{50} greater than 100 mg/L in all studies reported (Norris et al. 1991).

Some aquatic invertebrates, such as daphnids and glass shrimp, are thought to be slightly more sensitive to hexazinone than fish, with 48-hour LC_{50} values ranging from 100 to 150 mg/L (SERA 1997). At a subchronic level, in a life cycle study using *Daphnia magna*, the NOEL for survival was 29 mg/L. When hexazinone pellets were applied, at a rate of 3.1 lbs/ac, in four watersheds in mixed pine stands, no effects on stream macroinvertebrates at water concentrations of 8 to 44 μg/L.

Reasonable levels of acute exposure in standing water and streams range from approximately 0.3 mg/L at an application rate of 1 lb a.i./acre to 1.2 mg/L at an application rate of 4 lb a.i./acre. Over these ranges, no effects to fish or the most sensitive aquatic invertebrates are expected (SERA 1997). In standard laboratory bioassays, the lowest reported effect level for any aquatic animal is 81 mg/L for *Daphnia magna* (SERA 1997). This level is over 60-fold higher than the maximum anticipated water concentration at the highest anticipated application rate.

Imazapyr

Imazapyr is an ALS-inhibiting herbicide used in the control of a variety of grasses, broadleaf weeds, vines, brush species, and aquatic vegetation. It is effective in the control of saltcedar, which dominates many riparian systems in the West. Imazapyr is relatively non-toxic to fish and aquatic invertebrates, with fish generally showing LC_{50} values greater than 100 mg/L in most bioassays (SERA 2004e). At the modeled application rates of 0.45 lb and 1.5 lbs/ac, imazapyr poses no risk to fish and aquatic invertebrates in acute and chronic exposure scenarios in the impacted stream and pond. Moderate risk is predicted at the typical application rate for sensitive fish species as a result of accidental spills, and at the maximum application rate, accidental spills result in high risk to sensitive fish and low risk to tolerant fish and aquatic invertebrates.

Three studies suggest no substantial differences between the acute and chronic toxicity of imazapyr. The first study, a full-life cycle study in fathead minnow showed a no observable effect concentration (NOEC) of 118 mg/L; the second, an early life-stage study in fathead minnow, showed an NOEC of 120 mg/L; and the third study, on early life-stage in the rainbow trout, showed an NOEC of 43.1 mg/L (SERA 2004e).

Aquatic invertebrates do not appear to be anymore sensitive to imazapyr than fish. Based on two studies using *Daphnia magna*, no mortality was observed at 24 or 48 hours of exposure of up to 100 mg/L of imazapyr; with the second study showing a NOEC after 48 hours at 180 mg/L (SERA 2004e). This NOEC determination was based on the lack of mortality and abnormal effects. As with fish, the chronic toxicity of imazapyr for daphnids is no greater than the acute toxicity, with the NOEC of 97.1 mg/L basically equal to the acute NOEC of 100 mg/L for fish (Manning 1989 *cited in* SER 2004a).

No adverse effects to fish and other aquatic organisms appear to be likely at either the typical application rate of 0.45 lb/acre or the maximum application rate of 1.25 lb/acre for a normal exposure. Peak concentrations of imazapyr in surface water is, with the highest HQ of 0.01, below the level of concern at the typical application rate (LOC=1.0) by a factor of 100, and below the level of concern at the highest application rate (LOC=0.36) by a factor of 36. Sensitive fish mortality is plausible if an accidental spill of a large amount of imazapyr occurs in a relatively small body of water, although this scenario is very arbitrary and dependent on the concentration of imazapyr and the size of the water body. This conclusion is based on modeling for accidental spills, ranging from approximately 2 mg/L to 8 mg/L. These concentrations are in the range of the reported LC_{50} values for sensitive species of fish (i.e., 3 to 4 mg/L; SERA 2004e).

Metsulfuron Methyl

Metsulfuron methyl is a selective ALS-inhibiting herbicide used pre- and post-emergence in the control of many annual and perennial weeds and woody plants. It is not registered for use in aquatic situations, but can be applied in riparian areas if the herbicide does not come into contact with water. The typical application rate considered in this risk assessment, 0.03 lb a.i./ac, is over 800 times higher than the NOEC in the vegetative vigor (direct spray) assay of the most sensitive non-target species (i.e., 0.000037 lb/ac) and approximately 8 times higher than the NOEC for the most tolerant species in

TABLE 4-18
Risk Categories Used to Describe Forest Service-evaluated Herbicide Effects on Fish and Aquatic Invertebrates According to Exposure Scenario[1]

Application Scenario	2,4-D		Clopyralid		Glyphosate[2]		Hexazinone		Imazapyr		Metsulfuron Methyl		Picloram[3]		Triclopyr[4]	
	Typ[5]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Acute/Accidental Exposures																
Fish (sensitive species) – accidental spill	L[6]	M	L	L	H	H	NE	NE	M	H	0	L	H	H	L/H	M/H
Fish (tolerant apecies) – accidental spill	NE	NE	0	0	H	H	NE	NE	0	L	0	0	L	L	NE/NE	NE/NE
Fish (sensitive apecies) – acute exposure, peak EEC	0	0	0	0	M	M	0	0	0	0	0	0	L	L	0/M	0/H
Fish (tolerant species) – acute exposure, peak EEC	NE	NE	0	0	L	M	0	0	0	0	0	0	0	0	NE/NE	NE/NE
Aquatic Invertebrates – accidental spill	L	M	L	M	M	H	NE	NE	0	L	0	0	L	M	L/M	H/H
Aquatic Invertebrates – acute exposure, peak EEC	0	0	0	0	L	L	0	0	0	0	0	0	0	0	0/L	0/M
Chronic Exposures																
Fish – chronic exposure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0/0	0/0
Aquatic invertebrates – chronic exposure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0/0	0/0

[1] Risk levels are presented for the maximum application rate in aquatic applications.
[2] Risk levels for the more toxic glyphosate formulation are presented here.
[3] Sensitive and tolerant aquatic invertebrates were evaluated for picloram. Information is presented for sensitive aquatic invertebrates.
[4] Fist value is for triclopyr acid formulation (TEA) and second value is for triclopyr butoxythel formulation (BEE).
[5] Typ = typical application rate; and Max = maximum application rate.
[6] Risk categories: 0 = No risk (HQ < LOC); L = Low risk (HQ = 1 to 10 x LOC); M = Moderate risk (HQ = 10 to 100 x LOC); H = High risk (HQ > 100 LOC); and NE = Not evaluated. Risk categories are based on upper estimates of hazard quotients and the BLM LOCs of 0.1 for acute scenarios and 1.0 for chronic scenarios. The reader should consult the text of this section of the individual Forest Service risk assessments to evaluate risks at central estimates of hazard quotients.
Fish sensitive species include coldwater fish, such as trout and salmon, while fish tolerant species include warmwater fish, such as fathead minnows.

the same assay (i.e., 0.0039 lb/ac). The maximum application rate modeled in the risk assessment (0.15 lb/ac) is over 4,000 times the NOEC in sensitive species and a factor of about 40 above the NOEC in tolerant species (SERA 2004f). At both typical and maximum rates, metsulfuron methyl poses almost no risk to fish and aquatic invertebrates in accidental, acute, and chronic exposure scenarios in the impacted stream and pond (accidental spill at the maximum application rate results in low risk to sensitive fish species).

Values from 96-hour LC_{50} values for acute toxicity in bluegill sunfish and rainbow trout ranged from approximately 150 mg/L to 1,000 mg/L for both species (SERA 2004f). In rainbow trout, signs of sublethal toxicity include erratic swimming behavior, lethargy, and color change at concentrations around 100 mg/L, with a NOEC of 10 mg/L (SERA 2004f). One investigation did not observe any effects on rainbow trout hatching, larval survival, or larval growth over a 90-day exposure period, at a NOEC of up to 4.5 mg/L (Kreamer 1996 *cited in* SERA 2004f). The NOEC of 10 mg/L for sublethal effects in rainbow trout is approximately 100 times more sensitive than bluegill sunfish that has a NOEC of 1,000 mg/L.

Metsulfuron methyl is relatively non-toxic to aquatic invertebrates. Based on acute bioassays in daphnids, metsulfuron methyl is relatively non-toxic, with an acute EC_{50} value for immobility ranging from over 150 mg/L to 720 mg/L and acute NOEC values for immobility ranging from over 150 mg/L to 420 mg/L (SERA 2004f). Typically, the endpoint for aquatic invertebrates when exposed to high concentrations of metsulfuron methyl is a decrease in growth rate.

Overall, metsulfuron methyl appears to have a very low potential to cause any adverse effects in aquatic animals. Peak concentrations of metsulfuron methyl associated with runoff or percolation are estimated to be very low (less than 0.0003 mg/L [3e-04]), whereas all HQs for aquatic animals are very low (3e-10 mg/L to 3e-05 mg/L).

Picloram

Picloram is a pyridine herbicide that acts as a plant growth regulator. This herbicide mimics naturally occurring plant auxins (plant growth hormones) in a manner that leads to uncontrolled and abnormal growth that can in turn lead to gross signs of toxicity or death (SERA 2003c). It would not be used to control aquatic vegetation.

At the typical rate (0.35 lb a.e./ac) and maximum rate (1.0 lb/ac), picloram poses low risk to sensitive fish species from acute exposure scenarios at the peak EEC. Accidental spill scenarios result in high risk to sensitive fish and low risk to tolerant fish at the typical and maximum rates, low risk to aquatic invertebrates at the typical rate, and moderate risk to aquatic invertebrates at the maximum rate.

The acute and chronic toxicity of picloram to aquatic organisms has been assayed in various species of fish and invertebrates. An acute LC_{50} value for trout ranges from 0.8 mg/L to 19.3 mg/L, while some warmwater species, such as bluegill sunfish and fathead minnow, appear to be less sensitive to picloram, with LC_{50} values ranging from 15 mg/L to 55 mg/L.

Other differences involving the nature of the form of picloram (acid versus potassium salt) have been observed, however, toxicity of picloram in various forms is not substantial. Based on studies, the USEPA classified picloram acid as moderately toxic to freshwater fish based on the LC_{50} of 5.5 mg/L in trout and also classified the potassium salt of picloram as moderately toxic to freshwater fish based on the LC_{50} of 13 mg/L in trout (SERA 2003c).

Research on *Daphnia magna* showed an acute (48-hour) LC_{50} value ranged from 63 mg/L to 75 mg/L and chronic studies identified a NOEL at 11.8 mg/L and the LOEL at 18.1 mg/L (SERA 2003c).

Triclopyr

Triclopyr is a selective, systemic herbicide used on broadleaf and woody species, including woody species found in riparian and aquatic areas, such as saltcedar, willows, and purple loosestrife. Triclopyr mimics auxin, a plant growth hormone, thus disrupting the normal growth and viability of plants. Commercial formulations of triclopyr may contain the acid formulation (TEA) or the BEE formulation; these triclopyr derivatives are evaluated separately in the Forest Service risk assessment. The BLM application rates used in the risk assessment were an average rate of 1 lb a.e./ac and a maximum rate of 10 lb a.e./ac. At the typical rate (1.0 lb/ac) and maximum rate (10.0 lb/ac), triclopyr acid poses no risk to fish and aquatic invertebrates in acute and chronic exposure scenarios in the impacted stream and pond; the accidental spill scenario results in low risk to fish and aquatic invertebrates. At the same typical rate, triclopyr BEE poses moderate risk to fish and low risk to aquatic invertebrates in acute exposure scenarios at peak EECs, and high risk to fish and moderate risk to aquatic invertebrates as a result of accidental spill in the impacted stream and pond. At the maximum application rate triclopyr acid poses moderate risk to fish and high risk to aquatic invertebrates under the accidental spill scenario. At the same maximum rate, triclopyr BEE poses high risk to fish and moderate risk to aquatic invertebrates in acute exposure scenarios at peak EECs, and high risk to fish and risk aquatic invertebrates in accidental spill scenarios in the impacted stream and pond.

Some effects may be anticipated for fish and aquatic invertebrates under certain conditions. While there is a major difference in the potential hazards posed by triclopyr TEA formulations (which are registered for aquatic use; e.g., Garlon 3A®) and triclopyr BEE formulations (which are not registered for aquatic use; e.g., Garlon 4®) to fish, there are no significant differences among species in terms of sensitivity to the various agents. Sublethal effects of Garlon 4 on salmonids occur at concentrations between 0.32 and 0.43 mg/L, where fish were lethargic, while behavioral changes to Garlon 3A® would occur at 200 mg/L. Subchronic toxicity in fathead minnows (at the embryo-larval stages) was observed when the fish were subjected to 140 mg/L of triclopyr TEA for 28 days (Mayes et al. 1984; Mayes 1990, as cited in SERA 2003d). This study found that survival of these minnows was greatly reduced at this toxicity level.

Based on acute lethality, aquatic invertebrates are equally sensitive as fish to the various forms of triclopyr (SERA 2003d). For triclopyr acid, an acute LC_{50} value of 132.9 mg/L (about the same as 199 ppm a.e. value used for fish) is used by the USEPA (USEPA OPP 1998).

No significant effects have been noted on frog embryos with the application of Garlon 3A® and Garlon 4®. Studies on embryos and tadpoles of three frog species using Garlon 4®, exposure to 0.6, 1.2, and 4.6 ppm a.e. caused no effect on hatching success, malformations, or subsequent avoidance behavior of embryos, although the two higher concentrations were associated with mortality or immobility in tadpoles (SERA 2003d).

The risk characterizations for aquatic animals differ for triclopyr TEA and triclopyr BEE. For triclopyr TEA, the risks to aquatic species are low at all applications rates; even at 10 lbs a.e./acre, the risk to aquatic animals remains below the level of concern. Although triclopyr BEE is more toxic than triclopyr TEA, the risk of triclopyr BEE to aquatic animals is low, as this formulation will rapidly hydrolyze to triclopyr acid, lowering risk to aquatic animals.

Impacts of Other Herbicides Currently Available for Use

Asulam, atrazine, 2,4-DP, fosamine, mefluidide, and simazine were approved for use in the earlier BLM EISs. Research shows asulam, fosamine, mefluidide, and simazine are practically nontoxic to cold- and warmwater fish (rainbow trout and bluegill sunfish, respectively) while asulam is slightly toxic to aquatic invertebrates (*Daphnia magna*; Extension Toxicology Network 1993; USEPA 1995b, d; English Nature 2003). Data shows atrazine may cause reductions in phytoplankton, zooplankton, aquatic invertebrate, and fish populations, but in general, is not acutely toxic (USEPA 2003c). 2,4-DP may be toxic to aquatic organisms. The 2,4-DP butoxy ethyl ester (technical) is highly toxic to fish, but practically nontoxic to freshwater invertebrates (Wan et al. 1990). The BLM has not used any of these herbicides, except fosamine (< 50 acres annually) since 1997.

Impacts by Alternative

Important invasive species that would be treated by the BLM using herbicides include hydrilla and milfoils, which are found in ponds, lakes, and streams, and perennial pepperweed, saltcedar, knapweed and thistles that are found in riparian habitats. These species displace native vegetation and decrease species diversity. Dense concentrations of aquatic plants can lower the concentration of dissolved oxygen in the water and can upset the balance of the fish community by providing too much cover for small fish (Payne and Copes 1986). Invasive riparian plants form monocultures that crowd out more desirable native plant species.

The BLM proposes to treat aquatic and riparian vegetation to improve habitat for fish and aquatic organisms on public lands. However, herbicide treatments can also lead to the harm or even death of fish and aquatic organisms. The following discusses the habitat benefits and health risks to fish and aquatic organisms under each alternative.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue its ongoing vegetation treatment programs in 14 western states, and would be able to use 20 herbicides previously approved under earlier RODs. Herbicide use under the No Action Alternative would impact target and non-target vegetation over an estimated 305,000 acres annually, including approximately 2,250 acres of riparian and aquatic habitat. Herbicides used to manage aquatic and riparian vegetation under this alternative could include select formulations of 2,4-D, glyphosate, and imazapyr, and certain formulations of triclopyr in riparian areas where contact with water can be avoided. The BLM would not be able to use herbicides to treat public lands in Alaska, Nebraska, and Texas under this alternative.

The nature of impacts to fish and aquatic invertebrates (positive and negative) would be similar to those that have occurred in recent years. Negative impacts to fish and aquatic invertebrates would be lower than the other herbicide treatment alternatives (B, D, and E) because far fewer acres would be treated. However, long term positive impacts to riparian and aquatic vegetation communities and resulting positive impacts on fish and aquatic invertebrates would also be lower under this alternative. These positive long-term impacts would be beneficial to fish and aquatic invertebrates by improving riparian and instream habitat, including eradication of aquatic weeds that dominate a water system and a resulting increase in dissolved oxygen content, and a regrowth of native riparian vegetation and a resulting increase in shade habitat.

In addition, because the new herbicides proposed in this EIS (Overdrive®, diquat, fluridone, and imazapic) would not be used, risks to fish and aquatic invertebrates would be different under this alternative. Because the No Action Alternative would not use the new herbicides, which have low risks to aquatic wildlife, per area risks to fish and aquatic invertebrates from accidental and drift scenarios may be greater than under the other herbicide-use alternatives. Furthermore, fluridone is specifically indicated for aquatic use, whereas none of the other previously-approved herbicides are strictly aquatic herbicides. Diquat and select formulations of 2-4-D would be used in the aquatic vegetation treatment program, and both have shown to be effective in the control of milfoils and hydrilla. The other herbicides registered for aquatic use, glyphosate and triclopyr, are not as effective in controlling these species.

Under this alternative, the BLM would be able to continue to use asulam, atrazine, 2,4-DP, fosamine, mefluidide, and simazine on public lands, although these chemicals have not been used, or used sparingly (fosamine) since 1997. These chemicals are not approved for use in riparian and aquatic habitats, except for 2,4-DP, which could be used to treat bracken fern in riparian habitats Except for 2,4-DP, these herbicides are practically nontoxic to slightly toxic to freshwater fish.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

The Preferred Alternative would result in the herbicide treatment of approximately 932,000 acres annually across 17 western states, of which about 10,100 acres would consist of aquatic and riparian habitat. The BLM would only be allowed to use 14 previously-approved herbicides, six fewer than under the No Action Alternative, but the BLM would be able to use the four new herbicides evaluated in this PEIS. In addition, the BLM would be able to treat vegetation using herbicides in Alaska, Texas, and Nebraska, although it is anticipated that few or no herbicide treatments would occur in Alaska.

As this alternative proposes to treat the most acres of all the alternatives (more than four times the acreage proposed under the No Action Alternative), this alternative could result in the most extensive impacts to fish and aquatic invertebrates. The potential for acute and chronic toxic effects to fish and other aquatic organisms could be 4 times greater under this alternative than the other alternatives due to the increased acreages that would be considered under this alternative.

The BLM's ability to use four new chemicals (fluridone and diquat for aquatic applications, and imazapic and Overdrive® for terrestrial applications), could reduce the risks to fish and other aquatic organisms. For example, fluridone shows no risks to aquatic organisms at normal application rates and could replace other aquatic herbicides currently used by the BLM on public lands. It appears to be effective in the control of milfoil and hydrilla, and can be used instead of diquat in states where diquat is not legal for use in aquatic systems, such as California (Bossard et al. 2000).

Overdrive® and imazapic would primarily be used on rangelands, but could still provide benefits relative to the No Action Alternative. Overdrive® would be used to treat thistles and knapweeds, while imazapic could be used to control downy brome. These invasive plant species degrade riparian and rangeland habitats and can lead to shortened fire cycles, followed by soil erosion and sedimentation. Under accidental direct spray and spill and off-site drift scenarios, Overdrive® and imazapic present very low or no risks to fish and aquatic invertebrates, similar to chlorsulfuron, diflufenzopyr, and sulfometuron methyl, but less than risks associated with other herbicides currently being used. For the surface runoff scenarios that were evaluated, risks to fish and aquatic invertebrates were not predicted for any of the new herbicides, whereas some of the other herbicides do present risk to these organisms under some surface runoff scenarios. Each of the currently available and new herbicides evaluated in this PEIS has different properties (e.g., mode of action), is suggested for different uses, and is most effective/least risky in different scenarios, suggesting that the more herbicides available for use, the easier it is to select one or more that would result in the least risk to fish and aquatic invertebrates for specific aquatic applications or terrestrial applications near waterbodies.

The BLM would be able to use new herbicides approved in the future under the Preferred Alternative. If these chemicals are used because they require lower application rates and/or are less toxic than currently-used and proposed herbicides, fish and aquatic organisms would benefit. The more herbicides available for use, the easier it would be for the BLM to select one or more that would result in the least risk to fish and aquatic invertebrates for specific aquatic applications or terrestrial applications near waterbodies.

Alternative C – No Use of Herbicides

Under Alternative C, fish and aquatic invertebrates would not be affected by herbicide use. Primary effects would stem from other vegetation treatment methods (see the accompanying PER). Positive ecosystem benefits as a result of vegetation management may be reduced under this alternative as there are certain invasive species for which herbicide use is the only effective method of treatment or for which other methods are impractical due to cost, time, accessibility, or public concerns. For example, rough terrain that may not allow treatment by methods requiring terrestrial vehicle and foot access could potentially be treated using herbicides applied by aircraft. Other treatment methods, such as mechanical, fire, and biological, can result in soil disturbance and sedimentation of aquatic bodies, and may not adequately treat the pest plant.

In addition, it is often difficult to eradicate some species, such as aquatic species and those that resprout from rhizomes, by means other than herbicide application. These include milfoils and hydrilla, which form dense mats of aquatic vegetation that crowd out native plants and degrade fish habitat (Bossard et al. 2000), and where chemical treatments, including the use of 2,4-D, diquat, and fluridone, are more effective than other treatments, such as mechanical harvesters that tend to fragment and spread the weed. This treatment alternative would likely leave many aquatic areas untreated, and this would result in continued negative impacts to the aquatic species that are native to these areas.

Alternative D – No Aerial Applications

Alternative D would allow the use of the same herbicides in the same areas as under the Preferred Alternative, and would have similar benefits resulting from the increased availability of new and future herbicides. However, this alternative would not allow the use of aerial application methods, thereby reducing the total acreage possible for treatment (530,000 total acres). However, this alternative would have little impact on treatment of aquatic and riparian habitats as compared to the Preferred Alternative. Nearly all (98%) of acres proposed for treatment in aquatic and riparian habitats under the Preferred Alternative would be treated using ground-based methods and could also be treated under Alternative D. This alternative would substantially reduce the impacts of off-site drift to waterbodies from application on upland habitats. Drift is a major route of unintended damage to waterbodies and resident fish and aquatic invertebrates, with aerial application the primary cause of off-site drift. Therefore, per area impacts would also be much lower under this alternative than under the No Action Alternative and Preferred Alternative and would be similar to or less than per area impacts from Alternative E. However, without the use of aerial spraying, large areas of vegetation would not be able to be treated under Alternative D, which may lead to continued or future degradation of upland habitats to the detriment of nearby streams and other aquatic habitats.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Approximately 466,000 acres would be treated under Alternative E, which is slightly less than the acreage that would be treated under Alternative D, and less than half of the acreage that would be treated under the Preferred Alternative. In addition, the BLM would not be able to use ALS-inhibiting active ingredients (i.e., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl).

Of the herbicides that would be unavailable to the BLM under this alternative, imazapyr is the only herbicide that could be used in riparian and aquatic habitats, where it has been shown to be very effective against saltcedar. Imazapyr posed little risk to fish and aquatic organisms at typical application rates. Without imazapyr, the BLM would likely treat larger stands of saltcedar using prescribed fire followed by a foliar application of triclopyr, and smaller stands by cutting the stem and applying triclopyr, less effective treatments than use of imazapyr.

Chlorsulfuron, imazapic, and sulfometuron methyl do not pose risks to fish or aquatic invertebrates. Metsulfuron methyl may pose a low risk to aquatic invertebrates in a stream if the stream was accidentally directly sprayed at the maximum application rate (an unlikely scenario). Therefore, disallowing use of these four herbicides would be unlikely to benefit fish and aquatic organisms.

Alternative E incorporates other management practices (i.e., the BLM would not use sulfonylurea and other ASL-inhibiting active ingredients approved in the earlier RODs, including chlorsulfuron, imazapyr, metsulfuron methyl, and sulfometuron methyl) that would be likely to have positive effects on fish and aquatic invertebrates. In addition, herbicides would not be used in riparian conservation areas, which would protect aquatic species and attendant ecosystem functions in these key habitats.

Mitigation for Herbicide Treatment Impacts

The following recommended general management practices are designed to reduce potential unintended impacts to non-TES fish and aquatic invertebrates from the application of herbicides in the BLM vegetation management program. Mitigation appropriate for TES species is later in this section under Special Status Fish and Other Aquatic Organisms.

- Limit the use of diquat in waterbodies that have native fish and aquatic resources.
- Limit the use of terrestrial herbicides (especially diuron) in watersheds with fish-bearing streams during periods when fish are in life stages most sensitive to the herbicide(s) use.
- Establish appropriate herbicide-specific buffer zones to waterbodies, habitats, or fish species of interest (Table 4-19).

These practices would help minimize impacts to fish, aquatic invertebrates, and aquatic ecosystems on public lands to the extent practical.

Special Status Fish and Other Aquatic Organisms

Introduction

As discussed in Chapter 3, public lands in the western U.S. support over 150 species of aquatic animals that have been given a special status based on their rarity or sensitivity. Included are 76 species of fish, and 7 species of aquatic arthropods that are federally-listed as threatened or endangered, or are proposed for federal listing. Populations of non-native aquatic species and riparian weeds may alter aquatic habitats, making them less suitable for special status fish and aquatic invertebrates. The *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* (USDI BLM 2005b) provides a description of the distribution, life history, and current threats for each federally-listed animal species, as well as species proposed for listing.

Impacts Assessment Methodology

Beginning in spring 2002, the BLM participated in an Ad Hoc Interagency Team to address the effects of invasive vegetation and noxious weed treatments on humans, plants, and animals. This team consisted of ecologists and toxicologists of the BLM, USEPA, NOAA Fisheries, and USFWS.

In May 2002, the BLM began the process of developing the assessment procedures that would be followed while conducting ERAs. This process involved close coordination with NOAA Fisheries, the USFWS, and the USEPA; representatives of these agencies participated in weekly telephone calls with the BLM and its contractor who prepared the ERAs. These agencies also provided information they felt was necessary to meet their requirements for consultation under the ESA, and reviewed draft work products prepared by the BLM contractor. In November 2002, the BLM submitted a draft *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* to the USEPA, NOAA Fisheries, and USFWS. Comments from these agencies were used in the development of the final ERA protocol (ENSR 2004). Risk assessments for 10 chemicals were completed in May 2005 (ENSR 2005b-k). Information from the ERAs is included in the BA and in this section,

TABLE 4-19
Buffer Distances to Minimize Risk to Non-TES Fish and Aquatic Invertebrates from Off-site Drift of BLM-evaluated Herbicides from Broadcast and Aerial Treatments

Application Scenario	BROM[1]	CHLR	DICA	DIFLU	DIQT	DIUR	FLUR	IMAZ	OVER	SULF	TEBU
Minimum Buffer Distance (feet) from Fish and Aquatic Invertebrates											
Typical Application Rate											
Aerial	NA	0	NA	NA	NA	NA	NA	0	NA	0[c]	NA
Low boom	0	0	0	0	NA	0	NA	0	0	0	0
High boom	0	0	0	0	NA	0	NA	0	0	0	0
Maximum Application Rate											
Aerial	NA	0	NA	NA	NA	NA	NA	0	NA	0	NA
Low boom	0	0	0	0	NA	100	NA	0	0	0	0
High boom	0	0	0	0	NA	100	NA	0	0	0	0

[1] BROM = Bromacil; CHLR = Chlorsulfuron; DICA = Dicamba; DIFLU = Diflufenzopyr; DIQT = Diquat; DIUR = Diuron; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.
NA = Not applicable.
Boom height = The Tier I ground application model allows selection of a low (20 inches) or a high (50 inches) boom height.

including information on likely risks to TES fish and other aquatic resources, and on SOPs that should be followed to minimize these risks.

The BLM also reviewed the literature and findings from ERAs conducted by the Forest Service to assess the impacts to sensitive fish and aquatic invertebrate species from the use of eight herbicides currently used by the BLM (2,4-D, clopyralid, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, and triclopyr; SERA 2005a). The ERA methods are summarized earlier in this section. Methods used by the BLM are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C; methods used by the Forest Service are available at http://www.fs.fed.us/r6/invasiveplant-eis/.

As discussed earlier in this section, the USEPA has defined various LOCs for use in assessing risks to different organisms. As far as risks to aquatic animals are concerned, the LOC for acute risks to endangered species is the most conservative. However, there is only one LOC to determine chronic risks. Risk assessments completed by the BLM used the USEPA's chronic LOC and the acute endangered species LOC when documenting risks to fish and aquatic invertebrates (i.e., both sensitive and "secure"). In order to achieve consistency between the two sets of risk assessments, Forest Service ERAs were interpreted using the same LOCs for acute and chronic risks identified in BLM ERAs.

Herbicide use does create potential risks to sensitive fish and aquatic invertebrate species; however, these risks can be minimized by following certain SOPs, which can be implemented at the local level according to specific conditions (see Table 2-6). These include 1) surveying for TES fish and aquatic invertebrate species before treating an area; 2) using drift reduction agents to reduce the risk of drift hazard; 3) using the typical application rate, rather than the maximum application rate where practical; 4) selecting herbicide products carefully to minimize additional impacts from degradates, adjuvants, inert ingredients, and tank mixtures; 5) ensuring appropriate buffer zones between treatment areas and areas with TES fish and aquatic invertebrates are maintained; and 6) minimizing treatments near water bodies during periods when fish and aquatic invertebrates are in the life stage most sensitive to the herbicide used.

Summary of Herbicide Effects to Special Status Fish and Aquatic Invertebrates

The invasion and spread of non-native plant species into aquatic and riparian habitats may affect certain populations of special status fish and aquatic invertebrates. An overview of the ways in which non-native aquatic and riparian plants may affect aquatic habitats is presented earlier in this section. As discussed in the BA, numerous TES fish species are threatened by changes in water quality and flow, which may result from weed infestations. Salmon, for example, require a high level of dissolved oxygen, which is reduced when aquatic weeds such as Eurasian watermilfoil and hydrilla invade an aquatic system. A decrease in dissolved oxygen associated with the encroachment/excessive growth of vegetation has also been listed as a threat to the Foskett specked dace in south-central Oregon (USFWS 1985) and the unarmored threespine stickleback in southern California (NatureServe Explorer 2001). For species such as these, herbicide treatments to reduce coverage of non-native plant species in aquatic and riparian habitats would likely improve habitat over the long term.

Numerous special status aquatic animals, however, are most threatened by changes in water levels and quality associated with development, upslope land use practices, and groundwater pumping, and the expansion of non-native fish populations. For most of the TEP aquatic animals discussed in the BA, invasions of non-native plant species into riparian and aquatic habitats were not listed as threats to the species' survival. For these animals, health risks and increased inputs of chemicals into the water associated with herbicide spraying could outweigh any habitat improvements resulting from minimized weed infestations. In addition, some herbicide treatments could have short-term adverse effects on special status fish and aquatic invertebrates by killing non-target native vegetation and reducing the overall cover of riparian vegetation that regulates water temperature through shading. It is also likely, however, that the weed infestations (if present) in or near the aquatic habitats that support some of these species do not currently require herbicide treatments under the BLM's vegetation management programs.

A more conservative LOC of 0.05 was used to determine risks to TES fish and aquatic invertebrates. The potential effects of herbicides on special status aquatic animals could be greater than for effects on non-TES fish and other aquatic organisms (a LOC of 0.1 was used for non-TES species), as shown in Table 4-20 for BLM-evaluated herbicides. Aquatic herbicides with the greatest likelihood of impacting special status fish and aquatic invertebrates during a normal application to an aquatic habitat include diquat and the more toxic formulation of glyphosate. Normal applications of 2,4-D and imazapyr would not pose a risk to special status fish or aquatic invertebrates.

Terrestrial herbicides with the greatest likelihood of impacting special status aquatic animals as a result of a spill, drift, accidental direct spray into an aquatic habitat, or surface runoff are diuron, picloram, and the more toxic formulation of glyphosate. According to ERAs, there would be no risks to fish or aquatic invertebrates associated with chlorsulfuron, dicamba, diflufenzopyr, imazapic, Overdrive®, or sulfometuron methyl.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under this alternative, approximately 2,300 acres of aquatic and riparian habitats and 302,700 acres of upland habitats on public lands would be treated with herbicides annually. Considering acreage alone, it is likely that special status fish and aquatic invertebrates would be exposed to herbicides less under this alternative than under the other herbicide-use alternatives. Adverse health risks associated with herbicide exposure should be less extensive as well. Risks to TES species would also be lower, although mitigation would be required to protect these species and their habitat from harm under all alternatives, which should minimize differences in risk to TES species.

Control of weed infestations in aquatic and riparian areas would be less extensive under the No Action Alternative than under the other herbicide-use alternatives. Therefore, the degree of benefit to special status aquatic animals, particularly species that are currently threatened by infestations of non-native plants, would likely be lower than under the other herbicide-use alternatives. However, short-term adverse impacts to habitats that support special status aquatic animals (such as increased water temperatures) would be lower as well. The degree of benefits versus impacts to these habitats from treatments would largely depend on where the treatments occurred.

Under this alternative, only those herbicides currently used by the BLM would be used to treat vegetation. 2,4-D, glyphosate, imazapyr, and triclopyr acid would be used in aquatic and riparian habitats. Certain herbicides that are not registered for aquatic use (i.e., dicamba and clopyralid) could also be used in riparian areas, provided the herbicide did not contact the water. Of these herbicides, only glyphosate is likely to pose toxicological risks to special status fish and aquatic invertebrates during a normal application, but only if the more toxic formulation is used, or the less toxic formulation is applied at the maximum application rate. Although risks associated with an accidental spill would be greater, continuing use of these herbicides to treat riparian and aquatic vegetation should continue to pose a low risk to special status aquatic animals.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Under the Preferred Alternative, approximately 10,000 acres of aquatic and riparian habitats and 922,000 acres of upland habitats on public lands would be treated with herbicides annually. Based on acreage, this alternative would entail the greatest amount herbicide exposure to special status fish and aquatic invertebrates. Although a greater amount of herbicides would be used in aquatic and riparian habitats than under the other alternatives, risks to aquatic animals from their normal use would remain minimal, provided glyphosate was only applied at typical application rates, and only the less toxic formulation was used. However, since more terrestrial herbicides would be used under this alternative as well, risks associated with accidental spill of those herbicides near a water body, and accidental direct spray into a water body, would also be greater than under the other alternatives.

The most extensive control of weed infestations in aquatic and riparian areas would occur under this alternative. Therefore, the degree of benefit to special status aquatic animals over the long term (through habitat improvements) would potentially be greater than under the other alternatives. As under the other alternatives, the degree of benefits versus impacts to these habitats from treatments would largely depend on where the treatments occurred.

Under the Preferred Alternative, the BLM would be able to use 14 of the 20 currently-approved herbicides that are currently available for use under the No Action Alternative, as well as four new herbicides and other new herbicides that become available in the future. One of the two new aquatic herbicides that could be used under this alternative, diquat would pose low to high risks to fish, and moderate to high risks to aquatic invertebrates during a normal application, depending on the application rate and type of aquatic habitat. Fluridone would pose no to moderate risks to fish and aquatic invertebrates, depending on the application rate and type of aquatic habitat. Use of diquat or fluridone in place of safer aquatic herbicides under the Preferred Alternative would likely increase the incidence of adverse health effects to aquatic organisms per area treated, relative to the No Action Alternative. Dicamba, Overdrive®, and imazapic pose no risk to fish or aquatic invertebrates. Therefore, these herbicides would provide the BLM with increased safe options for treating riparian areas under the Preferred Alternative. Herbicides that become available in the future could allow the BLM even more flexibility to develop effective treatment programs in and near aquatic habitats, while minimizing risks to special status aquatic organisms.

Alternative C – No Use of Herbicides

Under this alternative, no public lands would be treated with herbicides. Therefore, there would be no impacts to special status aquatic animals as a result of herbicide exposure during vegetation treatments. The BLM would likely be less effective at controlling weed infestations than under the other alternatives, so there would be fewer habitat benefits to special status fish and aquatic invertebrate habitat that is degraded by non-native species. In addition, if other treatment methods were used to control weeds in riparian areas in lieu of herbicides, the disturbance to habitat could be greater. Mechanical methods and containment using domestic animals, for example, can result in greater sedimentation into aquatic habitats and more extensive removal of riparian vegetation, as compared to herbicide treatments, which would affect water quality.

Alternative D – No Aerial Applications

Under this alternative, approximately 530,000 acres would be treated with herbicides annually, more than under all other alternatives except the Preferred Alternative. However, the amount of riparian and aquatic habitat treated would be similar to the amount that would be treated under the Preferred Alternative, since ground-based methods would be used to apply herbicides to 98% of the treated acreage in these habitats. Therefore, the risks to aquatic animals from exposure to herbicides would potentially be somewhat lower, but not substantially different, than under the Preferred Alternative. It is likely that riparian and aquatic habitats that support special status fish and aquatic invertebrates would be exposed to less off-site drift than under the No Action and Preferred alternatives, since aerial spraying would not occur in adjacent upland areas.

The amount of long-term benefit, as well as the short-term adverse impacts, to riparian and aquatic habitats associated with herbicide applications would be much the same as under the Preferred Alternative. In addition, the herbicides available for use by the BLM would be the same as those discussed for the Preferred Alternative. The risks associated with using diquat and fluridone, and the benefits associated with flexibility in selecting herbicides, and in using new herbicides that become available in the future, would be the same as those discussed under the Preferred Alternative.

Alternative E – No Use of Acetolactate Synthase-Inhibiting Active Ingredients

Under this alternative, approximately 466,000 acres would be treated with herbicides annually, more than under the No Action alternative, but fewer than under the other herbicide-use alternatives. In addition, herbicide use in riparian and aquatic habitats would be minimized by prohibiting their use in riparian conservation areas and limiting the use of broadcast applications. These management practices would help minimize the risk that special status fish and aquatic invertebrates would be exposed to herbicides. Risks to special status aquatic animals from herbicide exposure would be lower than under the Preferred Alternative and Alternative C, and in some areas would be lower than under No Action Alternative.

The limited number of acres treated, and the additional restrictions on herbicide treatments in and near aquatic habitats would reduce some opportunities for using herbicides to make long-term habitat improvements. Accordingly, the associated short-term adverse impacts to habitats that support aquatic animals would be minimized in certain areas as well. The degree of effect to special status fish and aquatic invertebrates would depend on where herbicide applications were allowed to occur, and whether the BLM would use manual treatment methods, or a different type of vegetation treatment, in place of broadcast treatments in habitats that support special status species.

Under this alternative, the BLM would not be able to use chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl, or any other ALS-inhibiting herbicides that are made available in the future. Of these, imazapyr is registered for use in riparian areas, and the other four herbicides can be used in riparian areas, providing no herbicide is allowed to enter adjacent water bodies. None of these herbicides pose toxicity risks to special status fish or aquatic invertebrates during a direct spray into an aquatic habitat, even at the maximum application rate. Eliminating the use of ALS-inhibitors would reduce the BLM's choices when developing treatment programs, and could result in greater risks to special status aquatic animals if other more toxic herbicides were used in their place.

Mitigation for Herbicide Treatment Impacts

The following mitigation is recommended to reduce the likelihood of impacts to special status fish and aquatic invertebrates from herbicide applications. This mitigation should be implemented in addition to the SOPs and mitigation designed to protect aquatic animals presented earlier in this section.

- To protect TES fish and other aquatic organisms, implement all mitigation measures for aquatic animals presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* (USDI BLM 2005b).
- Establish appropriate herbicide-specific buffer zones to waterbodies, habitats, or fish or other aquatic species of interest as shown in Table 4-21.
- At the local level, consider effects to special status fish and other aquatic organisms when designing treatment programs.

These practices would help minimize impacts to fish, aquatic invertebrates, and aquatic ecosystems on public lands to the extent practical.

Wildlife Resources

Introduction

The nearly 262 million acres of public lands sustain an abundance and diversity of wildlife resources. Public lands provide a permanent or seasonal home for more than 3,000 species of amphibians, reptiles, birds, and mammals. An important activity of the BLM is managing vegetation to improve wildlife habitat—areas where basic needs (e.g., food, shelter, water, reproduction, movement) are met. Plants are an important component of habitat, providing food and cover for wildlife. Food is a source of nutrients and energy, while good cover prevents the loss of energy by providing shelter from extremes in wind and temperature. Cover also affords protection from predators. The eight ecoregions encompassed by public land in the western states support different wildlife species and habitats: these characteristics are described further in Chapter 3. Areas that have been impacted by an influx of invasive plants may support fewer native wildlife species, as invasive plants can change habitat conditions and vital ecosystem functions, which some native species cannot adapt to. These areas may also

TABLE 4-20
Risk Categories Used to Describe BLM-evaluated Herbicide Effects on TES Fish and Aquatic Invertebrates According to Exposure Scenario

Application Scenario	BROM[1]		CHLOR		DICAMBA		DIFLU		DIQUAT		DIURON		FLUR		IMAZ		OVER		SULFM		TEBU	
	Typ[2]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Direct Spray																						
Fish pond	L[3]	L	0	0	0	0	0	0	L	H	M	H	0	M	0	0	0	0	0	0	0	0
Fish stream	M	M	0	0	0	0	0	0	M	M	H	H	0	L	0	0	0	0	0	0	0	0
Aquatic invertebrates pond	0	0	0	0	0	0	0	0	M	H	M	M	0	H	0	0	0	0	0	0	L	L
Aquatic invertebrates stream	0	L	0	0	0	0	0	0	H	H	M	H	0	L	0	0	0	0	0	0	L	M
Accidental Spill to Pond																						
Fish pond	NE	M	NE	0	NE	L	NE	0	NE	H	NE	H	NE	M	NE	0	NE	0	NE	0	NE	M
Aquatic invertebrates pond	NE	M	NE	0	NE	M	NE	0	NE	H	NE	H	NE	H	NE	0	NE	0	NE	0	NE	L
Off-Site Drift																						
Fish pond	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Fish stream	0	M	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates pond	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates stream	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Surface Runoff																						
Fish pond	0	0	0	0	0	0	0	0	NE	NE	0	L	NE	NE	0	0	0	0	0	0	0	0
Fish stream	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates pond	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0
Aquatic invertebrates stream	0	0	0	0	0	0	0	0	NE	NE	0	0	NE	NE	0	0	0	0	0	0	0	0

[1] BROM = Bromacil; CHLOR = Chlorsulfuron; DIFLU = Diflufenzopyr; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.

[2] Typ = Typical application rate; and Max = Maximum application rate.

[3] Risk categories: 0 = No risk (majority of RQs < most conservative LOC for non-TES species); L = Low risk (majority of RQs 1-10x most conservative LOC for non-TES species); M = Moderate risk (majority of RQs 10-100x most conservative LOC for non-TES species); H = High risk (majority of RQs >100 most conservative LOC for non-TES species); and NE = Not evaluated. The risk category is based on the risk level of the majority of risk quotients observed in any of the scenarios for a given exposure group and receptor type. The reader should consult the risk tables in Chapter 4 of the ERAs (ENSR 2005b-k) to determine the specific scenarios that result in the displayed level of risk for a given receptor group.

TABLE 4-21
Buffer Distances to Minimize Risk to TES Fish and Aquatic Organisms from Off-site Drift of BLM-evaluated Herbicides from Broadcast and Aerial Treatments

Application Scenario	BROM[1]	CHLR	DICA	DIFLU	DIQT	DIUR	FLUR	IMAZ	OVER	SULF	TEBU
Minimum Buffer Distance (feet) from Fish and Aquatic Invertebrates											
Typical Application Rate											
Aerial	NA	0	NA	NA	NA	NA	NA	0	NA	0	NA
Low boom	0	0	0	0	NA	0	NA	0	0	0	0
High boom	0	0	0	0	NA	100	NA	0	0	0	0
Maximum Application Rate											
Aerial	NA	0	NA	NA	NA	NA	NA	0	NA	0	NA
Low boom	0	0	0	0	NA	100	NA	0	0	0	0
High boom	0	0	0	0	NA	900	NA	0	0	0	0

[1] BROM = Bromacil; CHLR = Chlorsulfuron; DICA = Dicamba; DIFLU = Diflufenzopyr; DIQT = Diquat; DIUR = Diuron; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive[R]; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.
NA = Not applicable.
Boom height = The Tier I ground application model allows selection of a low (20 inches) or a high (50 inches) boom height.

support an increased number of non-native wildlife species, which compete with native wildlife for available resources.

This section begins with an assessment of risks to general wildlife, including insects, birds, and small and large mammals, and is followed by an assessment of risks to TES wildlife species. Initial discussion in this section focuses on the risks to wildlife health from the use of herbicides, followed by an assessment of the risks and benefits to wildlife from treating vegetation in each ecoregion, followed by an assessment of impacts to wildlife under each alternative.

Scoping Comments and Other Issues Evaluated in the Assessment

Some respondents felt that the BLM should manage for biodiversity and identify specific sites that have high wildlife value. Other respondents wanted the EIS to address the habitat requirements of different wildlife species and the ways in which vegetation treatments would influence these habitats. Considering treatment effects to ground-nesting birds was also mentioned as an important issue to consider. Numerous comments also promoted the idea that wildlife habitat improvement efforts should be directed at restoring habitat and natural ecological processes.

The protection of sage-grouse and their habitat was advised. It was noted that carefully applied herbicides may improve sage-grouse habitat. One respondent noted that aggressive saltcedar removal efforts in the Mojave River have killed wildlife in the past. Numerous comments encouraged the BLM to use this PEIS process as an opportunity for recovering of the full range of native species and ecosystems across the western states, including species such as white-tailed and black-tailed prairie dogs, black-footed ferret, Columbia spotted frog, Washington ground squirrel, desert yellowhead, and wolves.

Standard Operating Procedures

Herbicide use poses a potential risk to wildlife; however, risk can be minimized by following certain standard operating procedures, which can be implemented at the local level according to specific conditions. The following general procedures, which are designed to reduce potential unintended impacts to wildlife from the application of herbicides in the BLM vegetation management program, were taken into consideration when evaluating risks to wildlife from herbicide use (also see Table 2-6):

- Review, understand, and conform to the “Environmental Hazards” section on the herbicide label. This section warns of known pesticide risks to the environment and provides practical ways to avoid harm to organisms or to the environment.
- Use herbicides of low toxicity to wildlife.

- Avoid accidental direct spray and spill conditions to reduce the largest potential impacts.
- Use the typical application rate, rather than the maximum application rate, to reduce potential risk to most species for most herbicides.
- Use spot applications or low-boom broadcast applications where possible to limit the probability of contaminating of non-target food and water sources, especially vegetation over areas larger than the treatment area.
- Minimize application areas where possible.
- Include pre-treatment surveys for sensitive habitat and TES species within or adjacent to proposed treatment areas.
- Use timing restrictions (e.g., do not treat during critical wildlife breeding or staging periods) to minimize impacts to wildlife.
- Notify adjacent landowners prior to treatment.

Impacts Assessment Methodology

The BLM reviewed the literature and findings from Ecological Risk Assessments (ERAs) conducted by the BLM and Forest Service to assess the impacts to wildlife from the use of herbicides (ENSR 2005b-k; USDA Forest Service 2005). The methods presented here are a brief overview of the ERA process to determine the risks of herbicide applications to wildlife species. The ERA methods are presented in detail in Appendix C and in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004).

BLM Methodology

Problem Formulation

Wildlife receptors, representing different categories of terrestrial animal species, were evaluated to determine the effects of herbicide exposure in terms of certain assessment endpoints and associated measures of effect. The essential biological requirements for each of these groups of organisms are the endpoints to be protected from herbicide exposure. These endpoints include mortality, growth, reproduction, or other ecologically-important sublethal processes. These assessment endpoints, for the most part, reflect direct effects of an herbicide on these organisms, but indirect effects were also considered. Measures of effect are measurable changes in an attribute of an assessment endpoint (or its surrogate, as discussed below) in response to a stressor to which it is exposed (USEPA 1998a). For the screening-level ERA, the quantitative measures of effect associated with the assessment endpoints generally consisted of acute and chronic toxicity data (from pesticide registration documents and from the available scientific literature) for the most appropriate surrogate species.

Exposure Characterization

The BLM uses herbicides in a variety of programs (e.g., maintenance of rangeland and recreational sites) with several different application methods (e.g., application by aircraft, vehicle, backpack). In order to assess the potential ecological impacts of these herbicide uses to terrestrial wildlife, the following exposure scenarios and receptor types were considered as routes of the most plausible acute and chronic (short- and long-term) impacts that would occur under a variety of conditions. These receptors represent a range of wildlife receptors that could be extrapolated to the typical wildlife species found on public lands. These receptors also represent different feeding guilds (herbivore, omnivore, and carnivore). The exposure scenarios include:

Direct spray of terrestrial wildlife:

- Small mammal – 100% absorption
- Pollinating insect – 100% absorption
- Small mammal – 1st order dermal absorption (absorption occurs over 24 hours, taking into consideration the potential for some herbicide to not be absorbed)

Indirect contact with foliage after direct spray:

- Small mammal – 100% absorption
- Pollinating insect – 100% absorption
- Small mammal – 1st order dermal absorption

Ingestion of food items contaminated by direct spray:

- Small mammalian herbivore – acute and chronic exposure
- Large mammalian herbivore – acute and chronic exposure
- Small avian insectivore – acute and chronic exposure

- Large avian herbivore – acute and chronic exposure
- Large mammalian carnivore – acute and chronic exposure

Exposure scenarios resulting from off-site drift, surface runoff, and wind erosion were not modeled for terrestrial wildlife because the direct spray scenarios were more conservative than scenarios involving wind erosion or runoff. Risk from consumption of food directly sprayed by an herbicide would be much greater than if the herbicide drifted or was carried by water onto the food item.

Effects Characterization

In the majority of cases, toxicological data do not exist for the specific wildlife species of concern. Consequently, toxicological data for surrogate wildlife receptors, obtained from a literature review, were evaluated and used to establish quantitative benchmarks (i.e., toxicity reference values for the ecological species of concern). Data from acceptable studies were used to compile statistical endpoints into a matrix for each chemical and for each receptor. Data were further subdivided into acute adverse-effect-levels, chronic adverse-effect-levels, and no-observed-adverse-effect-levels. For each chemical, receptor, and route of exposure, the lowest reported herbicide level resulting in an identified acute statistical endpoint was selected as the acute TRV. Chronic TRVs, based on longer exposure periods and associated endpoints such as growth and reproduction, were developed, when possible, to provide supplementary data to the risk assessment. Before the chronic NOAEL TRV was determined, a chronic lowest-observed-adverse-effect-level was identified, which was the lowest herbicide level that was found to cause significant adverse effects in a chronic study. Once a LOAEL was selected, the chronic NOAEL TRV was established as the highest NOAEL value that was less than both the LOAEL and the acute TRV. Once developed, TRVs were compared with predicted environmental concentrations (estimated exposure concentrations of the herbicide to evaluate the likelihood of adverse effects to ecological receptor).

Risk Characterization

In order to address potential risks to wildlife receptors from exposure to herbicides, risk quotients (RQs) were calculated by dividing the estimated exposure concentration for each of the previously described scenarios by the appropriate herbicide-specific TRV. To facilitate the translation of RQs into readily applicable estimates of risk, the calculated RQs were compared to levels of concern defined by the USEPA for screening the potential risk of pesticides. Distinct USEPA LOCs were used for acute and chronic impacts, as well as to assess potential increased risks to threatened, endangered, and sensitive species. The ecological risk implications of various exposure estimates can be readily determined by noting which RQs exceed the corresponding LOCs.

Forest Service Methodology

Forest Service risk assessment methodology was similar to that used by the BLM (see SERA [2001a] for a complete description of the current methodology). The steps involved in the Forest Service risk assessments were classified as hazard identification (analogous to BLM problem formulation), exposure assessment, dose response assessment (analogous to BLM effects characterization), and risk characterization.

Hazard identification involved the review of existing data with a focus on the dose-response and dose-severity relationships to determine the effect levels (e.g., NOAEL, LOAEL) and assessment endpoints (e.g., acute toxicity, subchronic or chronic systemic toxic effects, reproductive effects) that are most relevant for the herbicide risk assessments.

In the exposure assessment phase, the Forest Service developed several general and accidental/incidental exposure scenarios: direct spray, ingestion of contaminated media (via grooming activities, vegetation, prey species, or water), and indirect contact with contaminated vegetation. Actual exposure scenarios and receptors depended on the available herbicide toxicity data. The Forest Service also uses an allometric approach to model exposure for different sizes of animals; however exposure assessments were only as specific as the available toxicity data. For example, if the hazard identification process suggested that large mammals would be more sensitive than small mammals, or birds more sensitive than mammals, then exposure levels were modeled separately. Exposures also varied depending on the application method and the chemical and toxicological properties of the given herbicide.

Dose response assessment described the degree or severity of risk as a function of dose. A dose was derived—usually from a series of experimental doses—that was associated with a negligible, or at least a defined, level of risk. These dose levels are generally referred to as reference values, or more specifically as "reference doses" (RfDs). To derive the reference value, the experimental threshold was divided by an uncertainty factor used to account for discrepancies between experimental exposure conditions and the actual conditions the receptor might experience during Forest Service exposure. Often, reference values are standard across government agencies.

The risk characterization process then compared the exposure assessment to the dose response assessment to develop hazard quotients for risk determination. HQs are analogous to the RQs developed in the BLM risk assessments—they are calculated as the projected level of exposure (i.e., EEC) divided by an index of an acceptable level of exposure or otherwise defined level of exposure (e.g., a NOAEL divided by an uncertainty factor). In addition, the herbicides were all compared based on their selectivity, potency, persistence in the environment, and ability to move off-site.

As with the BLM risk assessments, information on effects to native species is incomplete, so impacts were extrapolated from the risk assessment or herbicide labels. Using herbicide labels to identify close relatives of native or desirable species does help to reduce uncertainty.

Summary of Herbicide Impacts

While some field studies suggest that appropriate herbicide use is not likely to directly affect wildlife (e.g., Cole et al. 1997, Sullivan et al. 1998), there is the potential for herbicides (used properly or improperly) to harm wildlife individuals, populations, or species (USDA Forest Service 2005). Harm at the population or species level is unlikely for non-TES species because of the size and distribution of treatment areas relative to the dispersal of wildlife populations and the foraging area and behavior of individual animals.

Possible adverse direct effects to individual animals include death, damage to vital organs, change in body weight, decrease in healthy offspring, and increased susceptibility to predation. Adverse indirect effects include reduction in plant species diversity and consequent availability of preferred food, habitat, and breeding areas; decrease in wildlife population densities within the first year following application as a result of limited regeneration; habitat and range disruption (as wildlife may avoid sprayed areas for several years following treatment), resulting in changes to territorial boundaries and breeding and nesting behaviors; and increase in predation of small mammals due to loss of ground cover (USEPA 1998b).

In the absence of prominent direct effects, it can be said that the main risk to wildlife from herbicide use is habitat modification. In forests, for example, herbicide use may result in minor and temporary effects on plant communities and wildlife habitats following single applications to young stands or stands following harvest, including some beneficial effects, but usually result in a significant drop in forage the season following treatment. However forage species and wildlife use of treated areas are likely to recover two to several years after treatment (Escholz et al. 1996; McNabb 1997; Miller and Miller 2004).

The extent of direct and indirect impacts to wildlife would vary by the effectiveness of herbicide treatments in controlling target plants and promoting the growth of native vegetation, as well as by the extent and method of treatment (e.g., aerial vs. ground) and chemical used (e.g., toxic vs. non-toxic; selective vs. non-selective), the physical features of the terrain (e.g., soil type, slope), and weather conditions (e.g., wind speed) at the time of application. The impacts of herbicide use on wildlife would depend directly on the sensitivity of each species to the particular herbicides used (and the pathway by which the individual animal was exposed to the herbicide) and indirectly on the degree to which a species or individual was positively or negatively affected by changes in habitat. Species that reside in an area year round and have a small home range (e.g., insects, small mammals), would have a greater chance of being directly adversely impacted if their home range was partially or completely sprayed because they would have greater exposure to herbicides—either via direct contact upon application or indirect contact as a result of touching or ingesting treated vegetation.

In addition, species feeding on animals that have been exposed to high levels of herbicide would be more likely to be impacted, particularly if the herbicide bioaccumulates in their systems. Although these scenarios were not modeled, wildlife could also experience greater impacts in systems where herbicide transport is more likely, such as areas where herbicides are aerially sprayed, dry areas with high winds, or areas where rainfall is high and soils are porous. Wildlife that inhabit subsurface areas (e.g., insects, burrowing mammals) may also be at higher risk if soils are non-porous and herbicides have high soil-residence times. The degree of vegetation interception, which depends on site and application characteristics, would also affect direct spray impacts. The impacts of herbicide use on wildlife would be site- and application-specific, and as such, site assessments would have to be performed, using available impact information, to determine an herbicide-use strategy that would minimize impacts to wildlife, particularly in habitat that supports TES species.

The BLM and Forest Service risk assessments suggested several common impacts of herbicides to wildlife. Birds or mammals that eat grass that has been sprayed with herbicides have relatively greater risk for harm than animals that eat other vegetation or seeds because herbicide residue is higher on grass (Fletcher et al. 1994; Pfleeger et al. 1996); this phenomenon is apparent with large mammalian herbivores in the BLM risk assessments. Grass foragers might include deer, elk, rabbits and hares, chukar, quail, and geese (USDA Forest Service 2005). However, harmful doses of herbicide are not likely unless the animal forages exclusively within the treatment area for an entire day. For example, studies of white-tailed deer have reported an average home range of about 400 acres (Fowler 2005), which would be about the size of the typical application area (two-thirds of herbicide treatments would be 400 acres or less), and less than half the size of the of a large application area of 1,000 acres (20% of treatments would be 1,000 acres or larger). Scenarios of chronic consumption of contaminated vegetation would also be unlikely if vegetation were to show signs of damage (these signs may not occur immediately after spraying). In addition, insect foragers (e.g., bats, shrews, and numerous bird species) would be at risk from herbicide applications because of the small size of insects and their correspondingly large surface area.

Impacts of BLM-Evaluated Herbicides

Risks from direct spray and spills, indirect contact with foliage after direct spray, and ingestion of food items contaminated by direct spray are generally low or non-existent for terrestrial fauna, with a few exceptions, particularly for mammalian herbivores and pollinating insects. Specific risks to wildlife from each individual herbicide are presented below. See the tables and figures in Section 4 of the ERAs for each herbicide for risk information on ecological receptor groups according to herbicide application method. Also, see Table 4-22, and Appendix C, for a summary of the typical degree of risk each of the BLM herbicides poses to different receptor categories under different routes of exposure.

Bromacil

Direct spray of the pollinating insect posed low risk at both the typical and maximum application rates. This is a conservative scenario that assumes the insect absorbs 100% of the herbicide with no degradation or limitations to uptake. Low acute and chronic risks were predicted for small mammalian herbivores ingesting food sprayed at the maximum application rate. No acute risk and low chronic risks were predicted for large mammalian herbivores ingesting vegetation sprayed at the typical application rate, and moderate acute and chronic risks were predicted at the maximum application rate. Therefore, direct spray of bromacil poses a risk to pollinating insects and large mammalian herbivores, as well as to small mammalian herbivores and large mammalian carnivores at the maximum application rate. Chronic risks to large mammalian herbivores were moderate to high, suggesting caution is needed when applying this herbicide in forage areas; however, it is unlikely that large mammals would obtain food solely within the application area, as assumed by ERAs. Because bromacil is a non-selective herbicide and is registered for non-cropland uses, it is not likely to be used in rangelands or wildlife grazing areas where some vegetative cover is desired—this would limit its exposure to large mammalian herbivores. If typically foraged rangeland plants were protected from off-site transport of bromacil, such as with the use of appropriate buffer zones (see Vegetation section in this chapter), then large mammalian herbivores would not likely be at risk from off-site drift or surface runoff of bromacil (these scenarios were not modeled). Risks to birds and small mammals in any modeled scenario are unlikely. Use of bromacil in spot applications or over small areas would be unlikely to adversely impact wildlife populations and could have positive effects through beneficial habitat modification.

Chlorsulfuron

Risk quotients for terrestrial wildlife were all below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray of chlorsulfuron is not likely to pose a risk to terrestrial animals. Therefore, use of chlorsulfuron would primarily affect wildlife through habitat modification. Its use in forested rangeland and other wildlife habitat areas could benefit wildlife over the long term by controlling invasive plant species and promoting the establishment and growth of native plant species that may provide more suitable wildlife habitat and forage.

Dicamba

Overdrive® is a formulation of dicamba and diflufenzopyr, and an analysis of risks to wildlife for dicamba was conducted during preparation of the Overdrive® ERA. However, an ERA report for dicamba was not done by the BLM as part of this PEIS, although some information on dicamba is included in the Overdrive® ERA. The Forest Service conducted an ERA for dicamba, and the reader is encouraged to review this document (available at http://www.fs.fed.us/foresthealth/pesticide/risk.shtml).

Accidental direct spray of pollinating insects poses low risk at the maximum application rate. The ingestion of food items contaminated by direct spray of dicamba resulted in low acute risk to the small avian insectivore and large mammalian carnivore at the typical application rate. The ingestion of food items contaminated by direct spray of dicamba resulted in moderate acute risk to the small avian insectivore, low acute and chronic risk to large mammalian herbivores, and low chronic risk to small mammalian herbivores at the maximum application rate. Because dicamba is proposed for use in rangelands and forestlands and does have moderate residual activity, insects and wildlife could be at risk from the application of this chemical, particularly if it is sprayed throughout the range area. The use of dicamba in rangeland could benefit wildlife by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more suited for forage.

Diflufenzopyr

Risk quotients for terrestrial wildlife were all below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray of diflufenzopyr is not likely to pose a risk to terrestrial animals. Therefore, use of diflufenzopyr would primarily affect (positively or negatively) wildlife through habitat modification. Its use in forested rangeland and other wildlife habitat areas would benefit wildlife by controlling invasive plant species and promoting the establishment and growth of native plant species that may provide more suitable wildlife habitat and forage. Loss of vegetation due to treatments would impact wildlife short-term, especially for species that use knapweeds, thistles, and other target vegetation for food and cover.

Diquat

Risk quotients for terrestrial wildlife were above the most conservative LOC of 0.1 (acute endangered species) for several scenarios. Accidental direct spray of pollinating insects poses low risk at the typical and maximum application rates, respectively. No risks to small mammals were predicted due to direct spray or indirect contact with foliage. Both of these scenarios conservatively assumed 100% absorption.

Risk assessments predicted acute and chronic risks to nearly all of the receptor types as a result of ingesting food items contaminated by direct spray, with the greatest risk predicted for large mammalian and large avian herbivores. For large mammalian herbivores, no acute and low chronic risks and moderate acute and chronic risks were predicted as a result of ingesting vegetation sprayed at the typical and maximum application rates, respectively. For large avian herbivores, no acute and low chronic risks were predicted for the typical application rate, and low acute and high chronic risks were predicted at the maximum application rate. In addition, ERAs predicted: low chronic risks to small mammalian herbivores for the typical application rate, and low acute and moderate chronic risks for the maximum application rate; moderate acute and chronic risks for the maximum application rate; and low acute risks to large mammalian carnivores for the maximum application rate.

Diuron

Acute RQs for terrestrial wildlife were above the most conservative LOC of 0.1 (acute endangered species) for several scenarios. Direct spray of pollinating insects resulted in low and moderate risk at the typical and maximum application rates, respectively. In addition, at the maximum application rate, low risk was predicted for the pollinating insect from indirect contact with foliage impacted by direct spray.

Risk assessments predicted acute and/or chronic risks to all of the receptor types as a result of ingesting food items contaminated by direct spray, with the greatest risk predicted for large mammalian herbivores (moderate chronic risk for ingestion of food sprayed at the typical application rate, and low acute and high chronic risks for the maximum application rate). In addition, ERAs predicted: low chronic risks to small mammalian herbivores for the typical application rate, and low acute and moderate chronic risks for the maximum application rate; low acute and chronic risks to small avian insectivores for the maximum application rate; low acute and moderate chronic risks to large avian herbivores for the maximum application rate; and low chronic risks to large mammalian carnivores for the typical and maximum application rates.

Fluridone

Risk quotients for terrestrial animals were below the most conservative LOC of 0.1 (acute endangered species) for all scenarios, except in the case of a small mammalian herbivore ingesting vegetation sprayed by fluridone at the maximum application rate (low chronic risk). These results indicate that accidental direct spray or drift of this aquatic herbicide would be unlikely to pose a risk to terrestrial wildlife.

Imazapic

Risk quotients for terrestrial wildlife were all below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray of imazapic is not likely to pose a risk to terrestrial animals. Therefore, use of imazapic would primarily affect wildlife through habitat modification. Its use in forested rangeland and other wildlife habitat areas could benefit wildlife by controlling invasive plant species and promoting the establishment and growth of native plant species that provide more suitable wildlife habitat and forage.

Overdrive®

Most of the RQs for terrestrial wildlife were below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray of Overdrive® is not likely to pose a risk to terrestrial animals. However, there would be low chronic risk to large mammalian herbivores consuming plants contaminated by direct spray at the typical application rate and moderate chronic risk at the maximum application rate. Because Overdrive® is proposed for use in rangeland and wildlife habitat, large mammalian herbivores could be particularly at risk from the application of this chemical; however, it is unlikely that these large animals would do all of their foraging within or immediately adjacent to application areas. The use of Overdrive® would primarily affect (positively or negatively) wildlife through habitat modification. Its use in wildlife habitat areas could benefit most wildlife by controlling invasive plant species and promoting the establishment and growth of native plant species that provide more suitable wildlife habitat and forage.

Sulfometuron Methyl

Risk quotients for terrestrial wildlife were all below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray of sulfometuron methyl is not likely to pose a risk to terrestrial animals. Because this herbicide is relatively non-selective, it is not likely to be used in wildlife habitat areas, and therefore, should result in few negative or positive impacts on wildlife. Long-term positive impacts could result if sulfometuron methyl was used to clear former wildlife grazing habitat of an aggressive invasive, such as downy brome, and native forage was able to reestablish once this area was cleared.

Tebuthiuron

Risk quotients for the pollinating insect were above the most conservative LOC of 0.1 (acute endangered species) for direct spray of insects (low risk at the typical and maximum application rates) and indirect contact with foliage after direct spray (low risk at the maximum application rate).

The ingestion of food items contaminated by direct spray poses a risk to mammalian herbivores at the maximum application rate. Low acute risk and chronic risk were predicted for the small and large mammalian herbivores. The strength of this herbicide is its use as a habitat modifier in the BLM shrub reduction program—it is relatively non-selective, but tends to harm grasses present. At low rates of application, tebuthiuron is used to thin shrubs, creating a more favorable habitat for shrub-dependent species. Because this application often takes place on land with a low concentration of grass forage, risks to mammalian herbivores associated with its use might be lower than those predicted under the ingestion scenarios, and wildlife forage and habitat could be enhanced by these applications. Birds and mammalian carnivores should not be adversely impacted by direct spray of tebuthiuron under any application scenarios.

Impacts of Forest Service-evaluated Herbicides

The following information for eight herbicides proposed for use by the BLM is taken from ERAs performed by the Forest Service to support assessment of the environmental consequences of using these herbicides in Forest Service vegetation management programs. As part of these ERAs, the Forest Service developed worksheets (see USDA Forest Service 2005) that allowed the BLM to assess risks for BLM typical and maximum application rates and LOCs (rather than the Forest Service rates and LOCs). Thus, the risk assessments process for the Forest Service-evaluated herbicides parallels the BLM process as much as possible. However, some Forest Service modeled risk scenarios for terrestrial animals may be different than

TABLE 4-22
Risk Categories Used to Describe BLM-evaluated Herbicide Effects on Non-TES Wildlife According to Exposure Scenario

Application Scenario	BROM[1]		CHLOR		DICAMBA		DIFLU		DIQUAT		DIURON		FLUR		IMAZ		OVER		SULFM		TEBU	
	Typ[2]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Direct Spray of Terrestrial Wildlife																						
Small mammal – 100% absorption	0[3]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pollinating insect – 100% absorption	L	L	0	0	0	L	0	0	L	L	L	M	0	0	0	0	0	0	0	0	0	0
Small mammal – 1st order dermal absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Contact with Foliage After Direct Spray																						
Small mammal – 100% absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pollinating insect – 100% absorption	0	0	0	0	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0	0	L
Small mammal – 1st order dermal absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ingestion of Food Items Contaminated by Direct Spray																						
Small mammalian herbivore – acute	0	L	0	0	0	0	0	0	0	L	0	L	0	0	0	0	0	0	0	0	0	0
Small mammalian herbivore – chronic	0	L	0	0	0	L	0	0	L	M	L	M	0	0	0	0	0	0	0	0	0	L
Large mammalian herbivore – acute	0	L	0	0	0	L	0	0	0	M	0	L	0	0	0	0	0	0	0	0	0	L
Large mammalian herbivore – chronic	L	M	0	0	0	L	0	0	L	M	M	H	0	0	0	0	L	M	0	0	0	L
Small avian insectivore – acute	0	0	0	0	L	M	0	0	0	M	0	L	0	0	0	0	0	0	0	0	0	L
Small avian insectivore – chronic	0	0	0	0	0	0	0	0	0	M	0	L	0	0	0	0	0	0	0	0	0	0
Large avian herbivore – acute	0	0	0	0	0	0	0	0	0	L	0	L	0	0	0	0	0	0	0	0	0	0
Large avian herbivore – chronic	0	L	0	0	0	0	0	0	L	H	0	M	0	0	0	0	0	0	0	0	0	0
Large mammalian carnivore – acute	0	L	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0	0	0	0	0
Large mammalian carnivore – chronic	0	0	0	0	L	L	0	0	0	0	L	L	0	0	0	0	0	0	0	0	0	0

[1] BROM = Bromacil; CHLOR = Chlorsulfuron; DIFLU = Diflufenzopyr; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.
[2] Typ = Typical application rate; and Max = Maximum application rate.
[3] Risk categories: 0 = No risk (majority of RQs < most conservative LOC for non-TES species); L = Low risk (majority of RQs 1-10x most conservative LOC for non-TES species); M = Moderate risk (majority of RQs 10-100x most conservative LOC for non-TES species); and H = High risk (majority of RQs >100 most conservative LOC for non-TES species). The risk category is based on the risk level of the majority of risk quotients observed in any of the scenarios for a given exposure group and receptor type. The reader should consult the risk tables in Chapter 4 of the ERAs (ENSR 2005b-k) to determine the specific scenarios that result in the displayed level of risk for a given receptor group.

those used in the BLM ERAs, depending on the specificity of available toxicity data. The assessment of impacts below is presented using the Forest Service upper estimates of hazard quotients, to maximize the conservatism of the assessment. In addition, it should be noted that the development of HQs by the Forest Service (as well as the BLM) is already conservative for many reasons (e.g., assumption of 100% dermal absorption, assumption that 100% of diet is contaminated, use of most sensitive values for exposure and dose/response assessments). Risks to TEP species are specifically analyzed in the Biological Assessment accompanying this document (USDI BLM 2005b).

2,4-D

2,4-D presents risk to some terrestrial wildlife as a result of direct spray as well as ingestion of contaminated food (Table 4-23; SERA 1998). Direct spray of 2,4-D results in moderate risk to insects (bees) and small mammals at both the typical and maximum application rates, assuming 100% absorption of the herbicide. Small mammals face low risk from direct spray if assuming 1st order dermal absorption. In addition, mammals and large birds face risk from the consumption of vegetation contaminated by 2,4-D at the application site: large mammals and large birds face moderate acute and chronic risk at both the typical and maximum application rates (large birds face high acute risk at the maximum application rate), and small mammals face low acute risk at the typical and maximum application rates. Long-term consumption of contaminated vegetation would be unlikely if the vegetation were to show signs of damage. In other acute scenarios, small mammals face low risk from consumption of water contaminated by an accidental spill; small mammals face moderate to high risk and small birds face high risk from the consumption of contaminated insects; predatory birds face high risk from the consumption of fish contaminated by a spill; and carnivorous mammals and birds face low risk from the consumption of small mammals contaminated by direct spray of 2,4-D. The risk assessment indicates that insectivores and large herbivores eating large quantities of grass and other vegetation are at risk from routine exposure to 2,4-D, suggesting that 2,4-D should not be applied over large application areas where foragers would only consume contaminated food.

Clopyralid

According to the Forest Service risk assessment (SERA 2004b), clopyralid is not likely to result in risk to terrestrial animals; however there are several scenarios under which there would be low acute risk to a variety of receptors at the typical and maximum application rates (Table 4-23). At the typical application rate, small mammals are at risk from 100% absorption of direct spray and consumption of contaminated insects, and there are risks associated with the consumption of contaminated vegetation by these mammals. At the maximum application rate, the honey bee also is at risk from direct spray, the large bird is at risk from the consumption of contaminated vegetation, and the small bird faces risk from the consumption of contaminated insects. Application of clopyralid at the maximum application rate also poses low chronic risk to large mammals and large birds consuming on-site contaminated vegetation. The Forest Service asserts that use of clopyralid in Forest Service programs is not likely to result in adverse effects to terrestrial animals; risks identified all fall within the lowest risk category.

Glyphosate

Glyphosate applications pose low to moderate risk to several terrestrial wildlife receptors under multiple exposure scenarios at the typical and maximum application rates (Table 4-23; SERA 2003b). Direct spray of a small animal and a bee, both assuming 100% absorption, pose low risk at the typical application rate and a moderate risk at the maximum application rate. Consumption of vegetation contaminated by a spill poses low risk to small mammals at the maximum application rate only. A large mammal consuming contaminated vegetation would face low acute risk at the typical application rate, moderate acute risk at the maximum application rate, and low chronic risk at the maximum application rate; the large bird consuming contaminated vegetation would face low acute and chronic risk. Acute consumption of contaminated insects would pose a low risk to both small mammals and small birds if the herbicide was applied at the typical application rate. The herbicide would pose a moderate risk if applied at the maximum rate. Acute risks from glyphosate exposure are low at the typical application rate under all scenarios, and there are no chronic risks. Exposure scenarios with the greatest risk are direct spray and acute consumption of contaminated vegetation and insects. Glyphosate is non-selective, suggesting that spot applications in rangeland and wildlife habitat areas would be the most appropriate use of this herbicide. Spot applications would have lower risks associated with consumption of contaminated vegetation and insects than broadcast applications, as fewer non-target areas would be impacted by direct spray or spray drift.

Hexazinone

At the typical and maximum application rates, several exposure scenarios would result in low to moderate risk to wildlife receptors (Table 4-23; SERA 1997). Small mammals would face low to moderate risk if directly sprayed at the maximum application rate, assuming 1st order dermal absorption, and low to moderate risk assuming 100% dermal absorption. Similarly, 100% absorption of direct spray by insects would pose a low to moderate risk. Acute consumption of contaminated vegetation would pose low risk to the small mammal for treatments at the maximum application rate. Acute and chronic consumption of contaminated vegetation would pose a moderate risk to both large mammals and large birds. Acute consumption of contaminated insects would pose a moderate risk to small birds, and acute consumption of contaminated fish would pose a low to moderate risk to predatory birds. Also, acute consumption of contaminated water would pose a low risk to small mammals at the maximum application rate. It appears that wildlife, especially sensitive species, are at risk from the application of hexazinone (the effects of hexazinone on insects, birds, and soil microarthropods are less certain than the effects on mammals). If food and water sources were not contaminated, risks would be reduced. Contamination of food and water sources could be minimized by utilizing spot applications at the typical application rate. Because hexazinone is semi-selective, is used for woody species, and is typically only applied in spot applications, risks to wildlife under normal application could be lower than those predicted by the risk assessment.

Imazapyr

Imazapyr does not pose substantial risks to terrestrial animal species, but there are low risks associated with several exposure scenarios, mostly for herbicide applications at the maximum application rate (Table 4-23; SERA 2004e). At the typical application rate, the only scenario that would pose a risk (low risk) to wildlife is that of a small mammal consuming contaminated insects. At the maximum application rate, however, the following scenarios pose a low risk to wildlife receptors: direct spray of the small animals and insects, consumption of contaminated vegetation by large mammals and large birds, and consumption of contaminated insects by small mammals and small birds. Therefore, application of imazapyr at the typical application rate is not likely to result in adverse effects to terrestrial animals in the Forest Service or BLM programs, with the possible exception of small insectivorous mammals. The HQs for terrestrial invertebrates are based on a single study using mortality as the endpoint, so results for this receptor are less certain. Because imazapyr is primarily used for the management of saltcedar in riparian zones and is relatively costly to use in the management of upland vegetation, large-scale impacts to wildlife are unlikely, even at the maximum application rate. Wildlife that reside mostly within the riparian zone would be most at risk from application of imazapyr.

Metsulfuron Methyl

None of the HQs estimated for metsulfuron methyl exposure at the typical application rate indicate risk to any of the receptors (Table 4-23; SERA 2004f). At the maximum application rate, metsulfuron methyl would pose a low risk to small animals via 100% absorption of direct spray and consumption of contaminated insects, and to large mammals via consumption of contaminated vegetation. Therefore, application of metsulfuron methyl at the typical application rate should not result in any adverse effects to terrestrial animals in the Forest Service or BLM programs.

Picloram

Most of the HQs for the evaluated scenarios of picloram exposure were below the LOC for both the typical and maximum application rates (Table 4-23; SERA 2003c). Under three scenarios, low risk were predicted at the typical application rate: 100% absorption of direct spray by small animals, acute consumption of contaminated vegetation by large mammals, and acute consumption of contaminated insects by small mammals. At the maximum application rate, risk was somewhat elevated for these three scenarios (low to moderate risk), and two additional scenarios posed low risk: 100% absorption of direct spray by insects and chronic consumption of on-site contaminated vegetation by the large bird. Therefore, picloram applications at the typical rate would potentially have few adverse effects on terrestrial animals.

Triclopyr

Application of the two evaluated formulations of triclopyr, triclopyr acid and triclopyr butoxyethyl ester (BEE), presents risks to insects, mammals, and birds under several exposure scenarios (Table 4-23; SERA 2003d). Because risks calculated for these two formulas were the same, no differentiation will be made between triclopyr acid and triclopyr BEE in this section. The following scenarios pose a low risk for applications at the typical rate and moderate risk for applications at the maximum rate: first-order and 100% absorption of direct spray by small mammals, 100% absorption of direct spray by insects, acute consumption of contaminated vegetation by large mammals and large birds, acute consumption of contaminated insects by small birds and small mammals, and chronic consumption of on-site contaminated vegetation by large mammals and large birds. In addition, at the maximum application rate, there would be low risk associated with acute consumption of contaminated vegetation by small mammals following an accidental spill, acute consumption of contaminated small mammals by carnivorous mammals, and chronic consumption of off-site contaminated vegetation by large mammals. No risk is predicted for small mammals as a result of acute or chronic consumption of contaminated vegetation or water, or for predatory birds as a result of consumption of contaminated fish. In summary, acute or accidental direct spray scenarios would pose low to moderate risk to terrestrial mammals and insects, consumption of contaminated vegetation would pose low to moderate risk to large mammals and large birds, and consumption of contaminated insects would posed low to moderate risk for small birds.

Impacts of Other Herbicides Currently Available for Use

2,4-DP, asulam, atrazine, fosamine, mefluidide methyl, and simazine were approved for use in the earlier BLM EISs. 2,4-DP could be used in forested rangeland. It has low toxicity to mammals and is practically non-toxic to waterfowl and upland game birds. Asulam is of low toxicity to birds and mammals, and would primarily be used to control bracken fern on forested rangelands (Information Ventures, Inc. 1995a). Atrazine could be used for vegetation treatments in conifer plantations, but would not be used in forestlands or other rangelands. It is slightly toxic to non-toxic in birds, and slightly to moderately toxic to mammals (Information Ventures, Inc. 1995b; Extension Toxicology Network 1996). Fosamine is practically nontoxic to insects, birds, and mammals, although some chronic reproductive effects have been noted in mallards (USEPA 1995). Mefluidide is of low to moderate toxicity to birds and mammals (Information Ventures, Inc. 1995c). Simazine could be used by the BLM on Christmas tree plantations, but would likely not be used on rangeland. Simazine is almost non-toxic to birds and mammals, although sheep and cattle are more sensitive to simazine than other mammals, and a dose as low as 500 mg/kg can be fatal (Information Ventures, Inc. 1995d). The BLM has not used any of these herbicides, except fosamine (< 50 acres annually), since 1997, and does not plan to utilize them in the near future.

Impacts of Herbicide Treatments on Wildlife and Habitat by Ecoregion

Tundra and Subarctic

Herbicides have not been used on public lands in Alaska on Arctic tundra and in subarctic forests, and herbicide treatments have not been proposed for these regions. Use of herbicides in these habitats is discouraged because forbs valuable to many tundra and boreal forest wildlife species would be reduced substantially (Braun 1980).

Temperate Desert

The goal of most treatments in this ecoregion is to restore lands damaged by fires in the Great Basin, and to benefit sage-grouse and other wildlife that use sagebrush communities. In particular, efforts would be focused on improving existing sagebrush stands and replacing invasive annual grasses with native bunchgrasses and forbs (USDA Forest Service and USDI BLM 2000). Although few wildlife vertebrates depend solely on the sagebrush analysis region, the Great Basin alone provides habitat for about 100 bird, 70 mammal, and 23 amphibian and reptile species (USDI BLM 1999).

At mid-elevations and lower, long fire intervals have created decadent, climax sagebrush communities that dominate large areas of public land. These communities have lost their perennial herbaceous understory as a result of competition from sagebrush plants. Where perennial species have been lost, downy brome has replaced these grasses, to the detriment of wildlife habitat (Perryman et al. 2003). As downy brome and other annual grasses have replaced native sagebrush and other shrubs in the region, populations of mule deer, pronghorn antelope, bighorn sheep, Columbian sharp-tailed grouse, sage-grouse, and several species of raptors have declined due to loss of habitat and prey species that depend on shrub habitat (USDI BLM 1999). Vegetation treatments that promote a mixed sagebrush-grass-forb community benefit wildlife. Habitat in these communities is improved by creating openings in dense and crowded sagebrush and rabbitbrush stands, removing invasive species, and promoting production of perennial grasses and forbs (Paige and Ritter 1999, USDI BLM 1999, Sage Grouse Conservation Planning Team 2001).

TABLE 4-23
Risk Categories[1] Used to Describe Forest Service-evaluated Herbicide Effects on Wildlife According to Exposure Scenario

	2,4-D		Clopyralid		Glyphosate[2]		Hexazinone		Imazapyr		Metsulfuron		Picloram		Triclopyr[2]	
	Typ[3]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Acute/Accidental Exposures																
Direct spray, small mammal, 1st order absorption	L[4]	L	0	0	0	0	0	L	0	0	0	0	0	0	L	M
Direct spray, small animal, 100% absorption	M	M	L	L	L	M	L	M	0	L	0	L	L	L	L	M
Direct spray, bee, 100% absorption	M	M	0	L	L	M	L	M	0	L	0	0	0	L	L	M
Consumption of contaminated fruit, small mammal	L	L	0	0	0	L	0	L	0	0	0	0	0	0	0	0
Consumption of contaminated grass, large mammal	M	M	L	L	L	M	L	M	0	L	0	L	L	M	L	M
Consumption of contaminated grass, large bird	M	H	0	L	L	L	L	M	0	L	0	0	0	0	L	M
Consumption of contaminated water, small mammal, spill	L	L	0	0	0	L	0	L	0	0	0	0	0	0	0	L
Consumption of contaminated water, small mammal, stream	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated insects, small mammal	M	H	L	L	L	M	0	0	0	L	0	L	L	M	L	M
Consumption of contaminated insects, small bird	H	H	0	L	L	M	M	M	L	L	0	0	0	0	L	M
Consumption of contaminated small mammal, predatory mammal	L	L	0	0	0	0	0	0	0	0	0	0	0	0	0	L
Consumption of contaminated small mammal, predatory bird	L	L	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated fish, predatory bird, spill	H	H	0	0	0	0	L	M	0	0	0	0	0	0	0	0
Chronic Exposures																
Consumption of contaminated vegetation, small mammal, on-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated vegetation, small mammal, off-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated vegetation, large mammal, on-site	M	M	0	L	0	L	L	M	0	0	0	0	0	0	L	M
Consumption of contaminated vegetation, large mammal, off-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L
Consumption of contaminated vegetation, large bird, on-site	M	M	0	L	0	L	L	M	0	0	0	0	0	L	L	M
Consumption of contaminated vegetation, large bird, off-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated water, small mammal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated fish, predatory bird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Risk categories are based on upper estimates of hazard quotients and the BLM LOCs of 0.1 for acute scenarios and 1.0 for chronic scenarios. The reader should consult the text of this section of the individual Forest Service risk assessments to evaluate risks at central estimates of hazard quotients.
[2] Risk categories are the same for both evaluated formulations.
[3] Typ = Typical application rate; and Max = maximum application rate.
[4] Risk categories: 0 = No risk (HQ < LOC); L = Low risk (HQ = 1 to 10 x LOC); M = Moderate risk (HQ = 10 to 100 x LOC); and H = High risk (HQ > 100 LOC).

Treatments can improve habitat structure, complexity, and layering to the benefit of species that rely on a diversity of plant types and cover to meet their daily needs. Several studies have shown that densities of songbirds and small mammals are greater in mixed communities than in pure sagebrush or grassland stands (USDI BLM 1991a).

Sagebrush rangelands are often treated with herbicides to increase herbaceous plants, with herbicides that remove broad-leaved plants without harming grasses being the most widely used. As noted in the Vegetation section, 2,4-D, glyphosate, picloram, and tebuthiuron are important herbicides for control of sagebrush, rabbitbrush, and other woody species. Olson et al. (1994) used low rates of tebuthiuron to thin big sagebrush stands and enhance wildlife habitat in Wyoming. Glyphosate can be applied to sagebrush in winter months to kill only sagebrush above the snow.

Herbicide treatments and fire use may be the only effective ways to control large areas of annual weeds and other invasive vegetation in this ecoregion. For smaller areas, however, mechanical treatments are recommended over herbicides for improving sage-grouse habitat. Mechanical methods often do less damage to the understory and are more effective than herbicides for sagebrush control (USDI BLM 1991a). Studies have shown that nesting and brood habitat can be depleted by spraying, and in Wyoming, Johnson (1969) found that it can take sagebrush 14 to 17 years to recover from spraying. Past efforts to reduce sagebrush habitat has been implicated as contributing to the decline in sage-grouse populations throughout the West (Robinson and Bolen 1989). Braun et al. (1977) recommended that sagebrush control not occur within a 2-mile radius of sage-grouse leks, nesting areas, wintering grounds, or breeding grounds. However, Urness (1979) believed that herbicides could be used to prevent shrub invasion onto leks and alter the size and density of sagebrush to more closely approximate nesting requirements.

Herbicidal control of sagebrush can reduce populations of some birds, such as Brewer's sparrow and vesper's sparrow, and can reduce the production of forbs and seeds that are important to nesting birds and their young for food and cover. Thus, sagebrush treatments must be carefully designed to ensure that large stands of sagebrush are not lost.

Response by mammals varies with herbicide treatment. Deer mice seem unaffected, northern pocket gophers and least chipmunks can decrease, badgers might decrease initially should gophers or ground squirrels be affected negatively, and mountain voles usually increase (Cooperrider et al. 1986; Payne and Bryant 1998). Once preferred forbs return to an area, small mammals apparently return to pretreatment levels.

Elk benefit from conversion of sagebrush to bunchgrass-dominated sites. Elk use increased 89% on chemically treated versus untreated sites in Wyoming (Wilbert 1963, Severson and Medina 1983). Mule deer used sagebrush less in Colorado after it was sprayed with 2,4-D. Loss of forbs associated with herbicide treatments of sagebrush stands can be detrimental to white-tailed deer, as forbs can comprise 60% or more of the deer's diet (Robinson and Bolen 1989).

Pronghorns rely heavily upon browse diets during fall and winter, but forbs are important in spring and summer. Herbicide treatments that thin dense stands of tall sagebrush and improve forb and grass understories can benefit pronghorns (Urness 1979).

In general, treating large units of sagebrush with herbicides to increase grass for livestock is not recommended for wildlife habitat management. For optimum wildlife habitat, herbicide applications to thin sagebrush should be limited to 7-acre or smaller patches, with 80-acre areas of untreated sagebrush to serve as a buffer between treated sites and to retain untreated areas for interior species. Based on current knowledge, total treatment should be less than 20% of an area (Back et al. 2002). Howard and Wolfe (1976) recommended patterned treatments of small tracts, instead of large tracts, for species such as ferruginous hawks because such treatments improve the prey base. Leaving strips of untreated vegetation between strips of treated vegetation also affords wildlife the opportunity to find food and cover resources while treated stands recover. Spraying areas with over 39% big sagebrush cover can benefit sage-grouse as long as treatments are in small blocks, strips, or patches (Holecheck et al. 1989). Spraying should be conducted before forbs emerge. Little benefit from any habitat modification can be expected unless livestock grazing is closely regulated after treatment (Payne and Bryant 1998).

Subtropical Desert

Herbicides such as 2,4-D, picloram, tebuthiuron, and dicamba are used to control woody species such as mesquite, creosotebush, and snakeweed in Subtropical Desert habitats. Mesquite has invaded millions of acres of shortgrass and mixed-grass prairies of the Southwest. The invasion of woody species has occurred at the expense of native grassland species, and has reduced the carrying capacity of much of the nation's rangelands. In Texas, woody shrubs infest over 80% of the state's rangelands (Robinson and Bolen 1989). Brush removal may help to conserve water when the foliage of the moisture-demanding brush is removed. However, in some areas, the expanded range of mesquite has increased the distribution and abundance of white-tailed deer, doves, quail, and cottontail (McCormick 1975 *cited in* USDI BLM 1991a).

Where dense canopies are a problem, treatment with triclopyr and clopyralid might be needed to thin woody vegetation. Stem application of triclopyr is a desirable method of mesquite control because it promotes quick removal of mesquite with minimal damage to native plants and wildlife (Waggoner et al. 2003). In general, no more than 60% of a mesquite-dominated habitat should be treated, and treatments should be in strips or as a patchwork of openings. Germano (1978 *cited in* USDI BLM 1991a) observed that jackrabbits, antelope, quail, and lizards favored openings in mesquite stands. Except for mockingbirds and golden-fronted woodpeckers, most nongame birds in northern Texas were unaffected by herbicide-treated areas designed to improve habitat for mourning doves and bobwhite quail, as long as stems and tree skeletons were left standing. Total density of nongame birds increased 54% on managed versus unmanaged sites; species diversity and richness were similar (Payne and Bryant 1998). Where soil is disturbed in the fall by disking to promote forbs and grasses, herbicides such as diuron and 2,4-D can be cost-effective to enhance production of foods for northern bobwhite quail and mourning doves.

As long as cover is maintained, white-tailed deer appear to adapt to reduction in browse species associated with herbicide treatments of mesquite. Spraying large blocks of cover habitat adversely affects deer, but treating woodlands in alternating bands can benefit deer (USDI BLM 1991a, Payne and Bryant 1998). Herbicide treatments of upland habitat should be acceptable for most wildlife as long as 20% of an area is left as old, mature woodland and tree skeletons remain as screening cover.

Herbicides have also been targeted for plants such as burroweed, creosotebush, tarbush, cholla, yucca, and pricklypear. In creosotebush communities, tebuthiuron treatments were more effective than mechanical treatments in killing these plants, but changes in grass and forb densities were the same whether creosotebush was chemically or mechanically treated (Morton and Melgoza 1991). In Arizona, Smith (1984 *cited in* USDI BLM 1991a) compared bird use in creosotebush treated with tebuthiuron and found that birds used openings created through treatment for nesting and foraging sites. After 3 years, rodent abundance was 71% higher on creosotebush areas treated with tebuthiuron than control plots in southeastern Arizona (Standley and Smith 1988).

Cautious and guarded use of herbicides in hot desert communities is recommended. Aside from the semidesert grasslands, herbicides probably have limited value, particularly in the Sonoran and Mojave deserts. Plant control by chemical means usually must be followed by revegetation, which may be unsuccessful due to low and erratic precipitation. In addition, because of the sparse vegetation over much of the desert, removal of vegetation can have substantial impacts on native wildlife that rely on affected plants for food and cover and that cannot readily find new habitat (Payne and Bryant 1998).

Temperate Steppe

The BLM administers between 10 and 15 million acres of short- and mixed-grass prairie grasslands that support 136 species of wildlife, including lesser prairie chicken, mountain plovers, and prairie dogs. Over three-quarters of treatments in the Temperate Steppe Ecoregion would be focused on annual and perennial grasses and forbs, including downy brome, leafy spurge, and several species of knapweeds and thistles. Much of this work would be done in support of the BLM's Conservation of Prairie Grasslands initiative.

Control of broadleaf plants by selective herbicides, such as 2,4-D, usually increases grass production. 2,4-D is also effective in controlling weedy forbs, such as bull, musk, and Scotch thistle. 2,4-D can be tank mixed with other herbicides, such as glyphosate, dicamba, picloram, and triclopyr to enhance the activity of these herbicides. Applications of picloram may damage sensitive grasses as well as broadleaf plants, and can substantially alter the composition of grassland communities and affect wildlife diets (USDI BLM 1991a). For example, Fagerston et al. (1977) found that the prairie dog diet changed significantly from forbs to grass after their habitat was treated with 2,4-D, which significantly reduced the abundance of forbs on the site. Despite the diet change, the 2,4-D treatment appeared to have little detrimental effect on prairie dogs.

Leafy spurge can be controlled with picloram, dicamba, and glyphosate (Hickman et al. 1990). Because forbs and other broadleaved plants are important to many wildlife species, patchwork treatments of herbicides should be applied when treating large areas of leafy spurge.

Prairie threeawn is an herbaceous invader on degraded, tallgrass prairie range sites; it colonizes bare soil and maintains dominance for many years, and its value to wildlife is minimal. Atrazine effectively controls prairie threeawn (Engle et al. 1990).

Herbicide treatments have also been used to reduce the cover of woody shrubs, such as mesquite and Eastern redcedar, which encroach upon prairie grasslands. While these woody species can benefit some wildlife species (see Wildlife Resources section in Chapter 3), they can also crowd out grassland and forb species, reducing the value of habitat for some species (Engle et al. 1987; Payne and Bryant 1998). Woody shrubs should be controlled where canopy cover reduces the amount of understory vegetation used for food and cover. Picloram and tebuthiuron are effective in controlling woody shrubs.

Herbicides such as 2,4-D have been used in evergreen and deciduous forests at higher elevations to thin sagebrush, snowbrush ceanothus, chokecherry, snowberry, and other shrubs (Vallentine 1989). After treatment, plants often resprout from the crown, producing palatable forage. Whisenant (1987) successfully treated big sagebrush with clopyralid, leaving bitterbrush and serviceberry relatively unharmed. Treating bitterbrush areas with 2,4-D in Idaho resulted in plants that were unharmed or only slightly damaged (Vallentine 1989). Damage to bitterbrush could be reduced if an area targeted for sagebrush control was treated early, before bitterbrush twigs elongated or began to flower (Payne and Bryant 1998). Bitterbrush plants less than 12 inches tall and those that are flowering will be severely damaged or killed by 2,4-D.

Subtropical Steppe Ecoregion

Over three-quarters of treatments in the Subtropical Steppe Ecoregion would be focused on sagebrush and other evergreen shrublands, while 12% would focus on pinyon-juniper and other evergreen woodland species. Healthy pinyon-juniper woodlands, with a full complement of understory grasses, forbs, and shrubs, provide excellent wildlife habitat. However, in many areas, pinyon-juniper has increased in density to the point that understory vegetation is excluded, to the detriment of wildlife (USDA Forest Service and USDI BLM 2000).

Broad-scale herbicide use in pinyon-juniper woodlands has not been popular over the past several decades, especially when used to open up pinyon-juniper stands. The possibility of destroying midstory shrubs that are important food sources is a major disadvantage to herbicide use (Payne and Bryant 1998). As noted in Chapter 3, avian species diversity is often greater in pinyon-juniper woodlands than in adjacent grasslands (Sieg 1991), as leaves and berries are important food items for birds and mammals.

Picloram and tebuthiuron are the main herbicides used to treat pinyon-juniper woodlands. Both picloram and tebuthiuron may persist in the soil for several years and may injure understory grasses, shrubs, and forbs. Individual tree treatments with these herbicides are often more effective in controlling trees and less injurious to understory species than broadcast applications. Using picloram on some sites can also result in dominance by annual grasses, such as downy brome or medusahead, if these species become resistant to picloram (USDI BLM 1991a).

Studies of wildlife use of treated pinyon-juniper habitats have shown that mule deer use was greater in a chemically treated plot than on a mechanically treated plot because herbicide treatment resulted in more openings in the woodlands and a greater retention of screening cover (Severson and Medina 1983). Over 85% of treatments would be conducted using aircraft under the Preferred Alternative. If used properly, aerial broadcasts could create numerous, small, irregularly-shaped openings in terrain that is too rough for mechanical operations (Short and McCulloch 1977).

Herbicides could be used with mechanical treatment to manipulate pinyon-juniper (Evans et al. 1975). Small trees that escape chaining, cabling, or dozing could be treated effectively with picloram to ensure that the opening created is free of trees. Unwanted invaders of mechanically prepared openings, including downy brome, could be controlled with atrazine or glyphosate. Glyphosate could be used to desiccate leaves or needles, rendering them more susceptible to prescribed burning.

Tebuthiuron has been used to control shinnery oak to improve habitat for lesser prairie chickens in areas where shinnery oak forms a dense canopy cover. In a study in Oklahoma, tebuthiuron effectively controlled shinnery oak and increased grass production, yet did not reduce the abundance and diversity of forbs required by lesser prairie chickens (Doerr and Guthery 1983).

Mediterranean and Marine Ecoregions

Approximately 11,000 acres would be treated annually using herbicides in the Marine and Mediterranean ecoregions under the proposed action, primarily using ground-based methods. Over three-quarters of treatments in the Mediterranean and Marine ecoregions would occur in evergreen forestlands. Much of these efforts would be focused on integrated weed management and forest health. The objectives of forest health treatments would be to stem the decline in old-forest habitats primarily due to fire exclusion, to restore more natural fire regimes and reduce hazardous fuels to reduce the potential for catastrophic wildfires, and to restore forests recently burned by wildfires. Fire exclusion has resulted in a gradual shift in stand composition from shade-intolerant tree species such as ponderosa pine, to dense stands of shade-tolerant species such as Douglas-fir and grand fir (Wisdom et al. 2000). High stand densities can make foraging difficult for Lewis' woodpecker, and reduce the vigor of oaks used by western grey squirrels for foraging. The loss of large trees and snags can limit the abundance of nesting and foraging sites for woodpeckers, bats, and other wildlife.

Herbicides are an important tool for improving forest productivity in the Marine Ecoregion, and studies suggest that the range of wood volume gains from effectively managing forest vegetation (primarily using herbicides) is 30 to 450% for Pacific Northwest forests (Wagner et al. 2004). Herbicides can be effective in improving forest wildlife habitat by 1) reducing populations of invasive exotic plants, 2) creating snags and downed woody material, 3) maintaining patches of early-successional vegetation within late-successional communities, and 4) maintaining woody and herbaceous plant communities for browsing species (Lautenschlager et al. 1995; Wagner et al. 2004).

Herbicide use in the forest, however, has often been perceived by the public as inconsistent with the ecological aspects of forest management. As discussed above, under typical application scenarios, herbicides evaluated by the BLM pose negligible chronic or acute toxicity hazards to wildlife, and most are rapidly eliminated from animal systems once ingested or absorbed (Tatum 2004; Wagner et al. 2004). Response by wildlife to herbicide-induced habitat alteration is highly variable. Black-tailed deer readily browse Douglas-fir seedlings treated with 2,4-D, atrazine, and fosamine, but reduce use of seedlings treated with glyphosate (Bovey 2001). Because herbicides can alter habitat and successional patterns, they may be useful to restore desirable habitat conditions, especially for early-successional plant communities (see review in Guynn et al. 2004).

Due to abundant rainfall along the Pacific Coast, amphibians are common in habitats west of the Cascade Range. As noted above, ERAs did not assess risks to amphibians from herbicide treatments. Also noted above, the USEPA found that data are inconclusive regarding the risks to amphibians from atrazine. A study of herbicides sprayed for pest control in Canada showed that risks to amphibian embryos and larvae from hexazinone, glyphosate, triclopyr, and three other herbicides that are not used by the BLM, were similar to those found in freshwater fish when herbicides were applied at typical application rates; high concentrations did cause paralysis and death in some tadpoles (Berrill et al. 1997).

Herbicides can often be more selective than mechanical or fire treatments and just as selective as manual treatments in forestlands (Payne and Bryant 1998). Common herbicides used in forest wildlife management include asulam, atrazine, 2,4-D, glyphosate, simazine, and tebuthiuron; however, the BLM has not used atrazine or asulam on public lands since at least 1997. Spraying herbicides over conifer plantations eliminates competing shrubs and hardwood sprouts, but also reduces the value of these forests to wildlife (Rutske 1969). If treatments are done in patches or strips, important refuge areas can be created for amphibians, reptiles, birds, and small mammals (Payne and Bryant 1998); staggering treatments over several years can achieve the same effect.

Weed management in forestlands would reduce or eliminate weed populations that displace native plants that are generally more desirable to wildlife. Plant species of concern include knapweeds, yellow starthistle, toadflaxes, downy brome, and several species of thistle. Several studies have shown that elk use of forest habitats was substantially lower on sites dominated by knapweeds than on sites dominated by native grasses (Sheley et al. 1999a). Yellow starthistle forms dense stands that provide limited value to wildlife, and it is poisonous to some animals (Sheley et al. 1999b). Knapweeds are effectively controlled by picloram, clopyralid, dicamba, and 2,4-D; these herbicides, along with glyphosate, can also be used to control yellow starthistle. Dalmatian and yellow toadflax displace existing plant communities and associated wildlife. Although deer have been observed to browse Dalmatian toadflax, the seeds are eaten by some species of birds and small mammals, and the vegetation can provide some cover for smaller wildlife, toadflaxes are not known to be heavily used by any native species (Lajeunesse 1999). Toadflaxes are often controlled using picloram. Thistle spines make then unpalatable to some wildlife and often create effective barriers to movement (Beck 1999). Several herbicides, including chlorsulfuron, clopyralid, 2,4-D, dicamba, imazapic, metsulfuron methyl, and picloram, are used to control thistles.

Phenoxy herbicides (2,4-D, 2,4-DP) have been used in the California chaparral to stimulate shrub regrowth and increase production of grass and forbs (USDI BLM 1988a). Dense, decadent chaparral provides minimal value to deer and other large mammals, but does provide good food and cover for reptiles, small mammals, and birds, such as mountain quail, thrashers, and wrentits. In one study, species composition, population size, and relative abundance of birds did not change 2 years after herbicide treatment of chaparral (Beaver 1976). Sites of dense chaparral treated as a patchwork mosaic should benefit most edge wildlife.

Glyphosate treatments during fall have been used to improve the success of perennial grass seedings in grasslands dominated by invading annuals in California (Vallentine 1989). Herbicides can also be a valuable tool to improve elk habitat by toppling oak in areas where dense stands occur. Elk use increased dramatically after Gambel oak was sprayed with herbicides (Kufeld 1977); mule deer response was minimal. Small areas of 12 acres or less should be treated to create habitat diversity and feeding sites. Tebuthiuron and triclopyr are effective for treating almost all oak species. Large trees should be protected for their mast-producing potential because acorns are relished by turkey, bear, deer, elk, and other wildlife species (Payne and Bryant 1998).

Impacts by Alternative

The following sections detail the expected effects of each of the five alternatives on terrestrial wildlife, and compare these effects to those expected under the other alternatives. These effects may vary depending on the percentage of acres treated using different application methods and different herbicides, as well as the size of treatment events. Earlier in this section, SOPs were described that would reduce some of the impacts described below.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue its ongoing vegetation treatment programs in 14 western states. Based on the information gathered from BLM field offices in 2002, approximately 3.4% of acres would be treated specifically to benefit wildlife and their habitats, although all treatments would be likely to provide long-term benefit to wildlife.

Under this alternative, the BLM would be able to use the 20 herbicides previously approved in earlier EIS RODs. However, based on the recent pattern of BLM herbicide use, it is likely that approximately three fourths of the area treated would involve the use of only four herbicides: 2,4-D, glyphosate, picloram, and tebuthiuron (Table 2-4). Herbicide use under the No Action Alternative would impact wildlife on approximately 305,000 acres. Public lands in Alaska, Nebraska, and Texas would not be eligible for herbicide treatments under this alternative.

The nature of wildlife impacts (positive and negative) would be similar to those that have occurred in the past 10 years. Negative impacts to wildlife could be lower than under the other herbicide-use alternatives, based on the relative number of acres treated. Impacts would include loss of non-target vegetation used by wildlife, and effects to wildlife health from exposure to herbicides. Aerial applications have the greatest potential to affect wildlife because they typically cover the larger treatment areas (USDI BLM 1991a). However, long-term positive impacts on wildlife communities (i.e., improvements in habitat and ecosystem function) would be much less under this alternative than under the other alternatives. Invasive plant populations would likely continue to expand at the current rate or greater, increasing damage to native plant communities and wildlife habitat and inhibiting ecosystem functions associated with those communities.

In addition, because the new herbicides proposed in this PEIS (diquat, fluridone, imazapic, and Overdrive®) would not be used, risks to wildlife would be different under this alternative than under the other herbicide treatment alternatives. Imazapic does not present any risks to wildlife in modeled scenarios (similar to chlorsulfuron, dicamba, fluridone, metsulfuron methyl, and sulfometuron methyl), and Overdrive® poses a low to moderate risk to large mammalian herbivores under the chronic ingestion of contaminated vegetation scenario. Diquat is fairly toxic to terrestrial wildlife, particularly under food ingestion scenarios (similar to

2,4-D and diuron); however, diquat is an aquatic herbicide and frequent exposure to terrestrial animals would not be expected. Therefore, the No Action Alternative would prevent the use of a greater repertoire of herbicides that are not injurious to terrestrial animals, possibly increasing per area risks to wildlife if more injurious herbicides were used instead (e.g., 2,4-D, bromacil, diuron, tebuthiuron, triclopyr), as well as decreasing the possibilities of more effective wildlife habitat and native ecosystem improvements.

2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine were approved for use in the earlier BLM EIS RODs, but the BLM has not used any of these herbicides, except fosamine (< 50 acres annually), since 1997, and does not plan to utilize them in the near future. These six herbicides have low toxicity to wildlife, although atrazine could exhibit endocrine-disrupting effects via inhibition of androgen receptors in mammals, amphibians, and potentially reptiles (see review in Storrs and Kiesecker 2004). A review by USEPA (2003f), however, suggested that information about the effects of atrazine of amphibians was inconclusive. Under this alternative, the BLM would use other herbicides, including bromacil, diuron, sulfometuron methyl, and triclopyr, which are effective in controlling weeds and invasive vegetation, but have less risk to wildlife.

The BLM would not be able to use herbicides in Alaska, Nebraska, and Texas under the No Action Alternative, but would be able to conduct herbicide treatments in these states under the other herbicide-treatment alternatives. No herbicide treatments would occur for Alaska and Nebraska based on information provided by local field offices during 2002. Approximately 11,000 acres would be treated annually in Texas using herbicides under the other alternatives, which would benefit wildlife in the Subtropical Desert Ecoregion.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

The Preferred Alternative would result in the treatment of approximately 932,000 acres across the western BLM states. In addition to the 14 previously-approved herbicides, the BLM would be able to use the four new herbicides evaluated in this PDEIS. Based on the information provided by local field offices in 2002, approximately 6.8% of acres (6 times as many acres as under the No Action Alternative) would be treated specifically to benefit wildlife and their habitats, although all treatments would be likely to provide long-term benefits to wildlife.

This alternative would result in the most extensive effects to wildlife because it proposes the most acres for treatment (3 times the acreage proposed under the No Action Alternative). The amount of positive versus negative impacts would depend on the relative amount each herbicide used—the chance for negative impacts would be higher if diuron and/or diquat and possibly bromacil and 2,4-D were used extensively. If these herbicides were used only in restricted scenarios, as is proposed, positive impacts could outweigh negative impacts. The use of the four new herbicides and the ability to use future herbicides that become registered with the USEPA would allow BLM managers more options in choosing herbicides that best match treatment goals and application conditions, and are less toxic, and may therefore reduce overall per capita risk to wildlife (three of the four new herbicides present little to no risk to wildlife) and increase positive habitat and ecosystem benefits from treatment. In addition, the ability to use future registered herbicides would allow the BLM to employ the most technologically-advanced herbicides, which would likely reduce risk to wildlife and increase management benefits. This alternative would also reduce risk and negative impacts that might be created from other vegetation management methods (e.g., risk of escaped prescribed fires; see the PER).

Based on BLM patterns of use, 2,4-D, glyphosate, picloram, and tebuthiuron would comprise about 70% of the currently-available herbicides that would be used under this alternative. The risks and benefits of using these and other currently-available herbicides are discussed under the No Action Alternative. Approximately 10% of all treatment acres would be treated with the new herbicides, and approximately 8% would be treated using imazapic. Imazapic could be used in all areas except riparian and wetland areas. Imazapic would be used to control downy brome, hoary cress, leafy spurge, perennial pepperweed, and several other invasive species that are known to displace native vegetation and alter wildfire intensity and frequency. Much imazapic use would occur in the Great Basin where downy brome has replaced native shrubs after recent catastrophic fires. As noted above, several wildlife species populations have shown sharp declines in the Great Basin, apparently due to loss of sagebrush and other key habitat components.

About 2% of all treatment acres would be treated using Overdrive®. Overdrive® would be used on rangelands; ROW; oil, gas and mineral sites; and cultural and recreation sites. This herbicide is not effective in downy brome control, but does have activity on oak species that may be controlled to reduce hazardous fuels. It also provides activity on several annual broadleaf species, including kochia, pigweed, and Russian thistle; several biennial species, including bull, musk, and Scotch thistle, teasel, and diffuse knapweed; and several perennial species including spotted and Russian knapweed and field bindweed. As discussed earlier, these species displace native vegetation, which is more desirable to wildlife and can lead to conditions that foster wildfires that kill or harm wildlife, and destroy habitat.

In addition to being able to use four new herbicides under this alternative, the BLM would be able to use herbicides in Alaska, Nebraska, and Texas. Herbicides should be avoided in Arctic tundra and subarctic forests. At this time, the BLM does not propose to conduct herbicide treatments in Arctic and subarctic tundra and forest habitats, but could do so in the future should the need arise and the agency deem that treatments were safe for wildlife and their habitats. If used, herbicide weed treatments would likely be targeted for developed areas and ROWs. The ability to use herbicides in Nebraska and Texas would allow for more comprehensive weed management programs in these states, which should reduce the negative effects of invasive species on native vegetation and improve wildlife habitat.

Under this alternative, over 70% of treatment acres would be treated in the Temperate Desert Ecoregion, a much greater proportion than would be treated under the No Action or other alternatives. Fifteen percent of treatments would occur in the Temperate Steppe Ecoregion. As with the No Action Alternative, treatments in the Temperate Desert Ecoregion would be targeted primarily toward sagebrush, rabbitbrush, and other evergreen shrubland species, and annual grass and perennial forb weeds, while those in the Temperate Steppe Ecoregion would focus on control of invasive annual and perennial grasses and forbs. Much of the increase in treatment acreage in this region is associated with the Great Basin Restoration Initiative and related attempts to restore fire-damaged ecosystems and improve habitat for sage-grouse and other sagebrush-dependent species.

Alternative C – No Use of Herbicides

Under Alternative C, wildlife would not be affected by herbicide use. Primary effects would stem from other vegetation treatment methods (see the accompanying PER). Positive ecosystem and habitat benefits as a result of vegetation management could be reduced under this alternative, as there are certain invasive species for which herbicide use is the only effective method of treatment or for which other methods are impractical due to cost, time, accessibility, or public concerns (e.g., saltcedar in riparian areas). For example, rough terrain may prevent treatment by methods requiring terrestrial vehicle and/or foot access, while aerial treatment with herbicides would be possible. In addition, it is often difficult to eradicate some species, such as shrubs that resprout from rhizomes, by means other than herbicide application (e.g., rabbitbrush, honey mesquite, sand shinnery oak, cholla). Similarly, pre-emergent herbicides that persist in the soil are the most effective means of controlling invasive plants with seeds that remain viable for long periods of time.

Under this alternative, in the absence of herbicide treatments, invasive plant populations would likely continue to spread, possibly at increasing rates, and cause further damage to susceptible native vegetation communities and wildlife habitat, particularly in areas and for species where other treatment methods are not effective or possible (e.g., large tracts of rangeland or grassland dominated by invasive, resprouting shrubs or without enough fine fuels to carry prescribed fires). However, it is uncertain how potential negative impacts from this alternative (mostly indirect) would compare with negative direct and indirect impacts from herbicide use.

Alternative D – No Aerial Applications

Alternative D would allow the use of the same herbicides in the same areas as under the Preferred Alternative, and would have similar benefits resulting from the increased availability of new and future herbicides. However, this alternative would not allow the use of aerial application methods, thereby dramatically reducing the acreage on which treatments (530,000 acres) would be possible because some large and remote areas cannot be effectively treated by ground application methods.

Out of all herbicide application methods, aerial applications have the greatest potential to affect wildlife (USDI BLM 1991a). With larger treatment areas, more wildlife would be exposed to chemicals, potentially harming wildlife and other wildlife that may eat them. As discussed above, large areas of habitat could be adversely affected. Unlike manual and mechanical treatment scenarios, it would be difficult for most wildlife to avoid spray from aircraft by fleeing. It is also difficult to design aerial treatments to avoid patches of important wildlife habitat or use areas within the larger treatment area.

This alternative would result in fewer impacts to wildlife due to off-site drift than under the Preferred Alternative. This exposure scenario was not specifically modeled for most herbicides (consumption of contaminated vegetation off-site was modeled for most of the Forest Service herbicides, with no risk demonstrated for any of these herbicides, except triclopyr at the maximum application rate); however, off-site drift impacts to vegetation are somewhat common (see Vegetation section in this chapter), and could alter habitat as well as forage. Conversely, without aerial spraying, large areas of vegetation would not be able to be treated under Alternative D, which could negatively impact wildlife habitat in these areas over the long term.

Under this alternative, long-term negative impacts on wildlife habitat and ecosystems could be greater than any potential short-term negative effects to wildlife that would result from aerial applications. In addition, direct and indirect impacts from other vegetation treatment options could increase if these other treatments were used more extensively to compensate for the loss of acres able to be treated by herbicides (see the PER).

Prescribed fire and mechanical treatment would be substituted for aerial herbicide treatments as much as possible in large areas proposed for treatment. Fire would not be effective in areas with insufficient fuels to carry fire, and could kill or harm wildlife that were unable to flee, as well as substantially alter habitats. Fire could also result in substantial damage to sagebrush stands and enhance the development and spread of downy brome and other annual grasses (USDI BLM 1991a). Mechanical treatments might not be suitable in areas where sprouting species, such as rabbitbrush, might increase after mechanical treatment. This alternative would preclude treatment of large expanses of downy brome and other invasive annual grasses using imazapic and other herbicides.

Nearly all (91%) aerial treatments are proposed for the Subtropical Steppe and Temperate Desert ecoregions. Of these, two-thirds would occur in evergreen shrublands to thin sagebrush stands and remove invasive vegetation, such as downy brome. The remaining treatments would focus primarily on control of undesirable annual and perennial grasses and forbs.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Alternative E was developed based on a proposal for ecosystem-based vegetation management submitted by the American Lands Alliance, an alliance of several environmental and conservation groups (see Appendix G). Approximately 466,000 acres would be treated under Alternative E, which is slightly less than what would be treated under Alternative D and less than half of what would be treated under the Preferred Alternative. In addition to a relatively low impact to wildlife as a result of the low number of acres treated, per-treatment impacts under Alternative E would also be lower than under the other herbicide-use alternatives because of some of the standards detailed by this alternative (e.g., preferential use of spot rather than broadcast applications, preferential treatment of small versus large infestations).

Sulfonylurea herbicides and other ALS-inhibiting herbicides (e.g., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl) block the synthesis of amino acids that are required for protein production and cell growth; thereby resulting in plant death. ALS-inhibiting herbicides would not be used under this alternative because data suggest they have the potential to damage off-site native and crop plant species under the right conditions of environment and application. These herbicides are biologically active at small concentrations, and relatively small application rates are necessary to manage target plants. It is uncertain whether these smaller application rates would result in fewer cases of unintended damage to wildlife and the environment or more cases due to the high potency of the herbicides. In 1981, the Environmental Effects Division of the USEPA did recommend against registering sulfonylurea herbicides because they persist for long periods of time in the environment and they cannot be detected at low levels. However, in this assessment, the ALS-inhibiting herbicides mostly posed no risk to terrestrial wildlife (chlorsulfuron, imazapic, sulfometuron methyl), except for a few cases of low risk (imazapyr, metsulfuron methyl), suggesting that the elimination of use of these herbicides would not likely benefit wildlife and could indirectly harm wildlife if more toxic herbicides that are currently available to the BLM were used in their place.

Alternative E incorporates other management practices that would be likely to have positive impacts on wildlife communities and habitats. Alternative E would limit the use of broadcast applications, which would reduce the possible risks to wildlife associated with off-site drift and consumption of vegetation across large areas. However, these applications would be available for use in appropriate situations (i.e., where no other method was practical and susceptible non-target plant species and aquatic areas were distant from the application area), which would allow some positive ecosystem benefits from larger-scale herbicide applications. In addition, herbicides would not be used in National Riparian Conservation Areas, which would protect wildlife species that frequent the riparian zone and attendant ecosystem functions in these key areas. While per-treatment ecosystem benefits could be greater under Alternative E than under the other herbicide-use alternatives as a result of this ecosystem-based management approach, overall positive vegetation and ecosystem benefits across the 17 western states (that cannot be attained by other treatment methods) would be lower under this alternative because of the relatively low treatment acres and the inability to use certain practices in situations that might require their use (e.g., use of ALS-inhibitor herbicides on highly aggressive weeds).

Mitigation for Herbicide Treatment Impacts

The following actions would reduce the risks to wildlife with herbicide applications:

- Apply dicamba, diuron, glyphosate, hexazinone, tebuthiuron, and triclopyr at the typical application rate to minimize risks to terrestrial wildlife.
- Minimize the size of application areas, where practical, when applying 2,4-D, bromacil, diuron, and Overdrive® to limit impacts to wildlife, particularly through the contamination of food items.
- Where practical, limit glyphosate and hexazinone to spot applications in rangeland and wildlife habitat areas to avoid contamination of wildlife food items.
- Do not aerially apply diquat directly to wetlands and riparian areas.
- Do not apply bromacil and diuron in rangelands, and use appropriate buffer zones (see Vegetation section) to limit contamination of off-site vegetation, which may serve as forage for wildlife.

Special Status Wildlife Species

Introduction

As discussed in Chapter 3, public lands in the western U.S. support over 200 species of terrestrial wildlife (including birds, mammals, amphibians, reptiles, mollusks, and arthropods) that have been given a special status based on their rarity or sensitivity. Included are more than 75 species that are federally listed as threatened or endangered, or are proposed for federal listing. Some of these species have habitat requirements that have been or are being altered or reduced by invasions of non-native plant species. The *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* (USDI BLM 2005b) provides a description of the distribution, life history, and current threats for each federally-listed animal species, as well as species proposed for listing. The BA also discusses the risks to TEP terrestrial wildlife associated with each of the herbicides proposed for use by the BLM under the different alternatives.

Impacts Assessment Methodology

The BLM reviewed the literature and findings from ERAs conducted by the BLM and Forest Service to assess the impacts to sensitive wildlife species from the use of herbicides (ENSR 2005b-k; SERA 2005a). The ERA methods are summarized earlier in this section. Methods used by the BLM are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C; methods used by the Forest Service can be viewed at http://www.fs.fed.us/r6/invasiveplant-eis/.

As discussed earlier, the USEPA has defined various LOCs for use in assessing risks to different organisms. As far as risks to terrestrial wildlife are concerned, the LOC for acute risks to endangered species is the most conservative. However, there is only one LOC to determine chronic risks. Risk assessments completed by the BLM used the USEPA's chronic LOC and the acute endangered species LOC when documenting risks to all terrestrial TES wildlife (i.e., both sensitive and "secure"). In order to achieve consistency between the two sets of risk assessments, Forest Service ERAs were interpreted using the same LOCs for acute and chronic risks identified in BLM ERAs.

Herbicide use does create potential risks to sensitive wildlife species; however, these risks can be minimized by following certain SOPs, which can be implemented at the local level according to specific conditions (see Table 2-6). These include 1) surveying for TES wildlife species before treating an area; 2) using drift reduction agents to reduce the risk of drift hazard; 3) using the typical application rate, rather than the maximum application rate where practical; and 4) selecting herbicide products carefully to minimize additional impacts from degradates, adjuvants, inert ingredients, and tank mixtures.

Summary of Herbicide Effects to Special Status Wildlife Species

Non-native plant species reduce the suitability of some habitats to support special status wildlife species. For some species, particularly butterflies and moths, certain plant species must be present on a site to serve as larval host plants. Other species require, or at the very least prefer, certain plants as food sources. For example, lesser and Mexican long-nosed bats meet most of their dietary needs from agave and cactus (USFWS 1994b, 1995a), and the northern Idaho ground squirrel feeds on native bunchgrasses to fulfill a large portion of its dietary needs (USFWS 2000). Encroachment of non-native plant species, and displacement of native plant species that serve as important sources of food, reduces the suitability of the habitat for these wildlife species. Similarly, the risks to non-target plants associated with herbicide applications amount to indirect risks to these wildlife species through alteration of their habitat.

For some special status wildlife species, it is the structure, rather than the species composition of the habitat that makes it suitable. For example, the western snowy plover nests in areas where vegetation is sparse, the Yuma clapper rail is associated with dense marsh vegetation (USFWS 1997), the southwestern willow flycatcher occurs in riparian areas with dense growths of deciduous shrubs and trees (USFWS 1995b), and kangaroo rats require open, grassland conditions. In some cases, invasive plant species alter the structure of habitats, making them less suitable for supporting sensitive wildlife species (e.g., the encroachment of European beachgrass into western snowy plover habitat, or the exclusion of marsh vegetation by saltcedar and arrowweed in Yuma clapper rail habitat). For these species, use of herbicides to control weed infestations would likely provide a long-term benefit. In other cases, non-native plant species may invade an area without making drastic structural changes, and the suitability of the habitat, though not ideal, is maintained (e.g., thickets of saltcedar and Russian olive providing nesting habitat for the southwestern willow flycatcher, or kangaroo rats thriving in annual grasslands dominated by non-native plant species such as red brome). For these species, use of herbicides may result in some improvement of habitat, but the long-term benefits may not outweigh the short-term risks to the species associated with herbicide treatments.

Some special status wildlife species occupy a wide variety of plant community types, as long as they provide adequate food, cover, and breeding/nesting/denning habitat. These species tend to be larger animals that cover a larger geographic area and eat a wide variety of food items, such as gray wolves, grizzly bears, and bald eagles. Although these species could potentially benefit to some degree from weed control, and are typically at low risk for impacts from exposure to herbicide, they may be impacted through disturbances associated with herbicide treatments (e.g., presence of herbicide applicators, trucks/ATVs, and/or helicopters in their habitat).

The most conservative LOC of 0.1 was used to determine risks to TES terrestrial wildlife species. Terrestrial herbicides with the greatest likelihood of impacting special status wildlife species, via any exposure pathway, include 2,4-D, bromacil, diuron, and hexazinone, for which moderate to high risks to TES terrestrial wildlife were predicted at the typical application rate, under one or more exposure scenario (Table 4-24). Terrestrial herbicides with the least likelihood of impacting special status wildlife species include chlorsulfuron, diflufenzopyr, imazapic, and sulfometuron methyl, for which no risks to TES wildlife were predicted via any exposure pathway.

Although amphibians are considered terrestrial wildlife during their terrestrial phase, they do have an aquatic phase that is not represented by risk assessments for other terrestrial animals. For these species, ERAs assumed that risks to fish (see Fish and Other Aquatic Organisms section of this chapter) represent risks to aquatic amphibians. Aquatic herbicides with the greatest likelihood of impacting special status amphibian species during a normal application to an aquatic habitat are diquat and the more toxic formulation of glyphosate. Normal applications of 2,4-D and imazapyr would not pose a risk to aquatic amphibians. Terrestrial herbicides with the greatest likelihood of impacting special status amphibian species as a result of a spill, drift, accidental direct spray into an aquatic habitat, or surface runoff are bromacil, diuron, and picloram. The following herbicides would pose no risk to aquatic amphibians, according to ERAs: chlorsulfuron, diflufenzopyr, imazapic, Overdrive®, and sulfometuron methyl.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under this alternative, approximately 305,000 acres of public lands would be treated with herbicides annually. Based on the acreage that would be treated, it is likely that special status wildlife species would be exposed to herbicides less under this alternative than under the other herbicide-use alternatives. Adverse health effects associated with herbicide exposure should be less extensive as well. Risks to TES species would also be lower, although mitigation would be required to protect these species (as well as key plant food species) from harm under all alternatives, which should minimize differences in risk to TES species among the alternatives.

Out of the four herbicide-use alternatives, control of weed infestations would likely be the least extensive under this alternative, and weed populations would spread at a faster rate. Those wildlife species for which native plant communities provide the most suitable habitat would likely fare the worst under this alternative, as far as the quality of their habitat was concerned. For those wildlife species that can successfully utilize habitats comprised of non-native plant species, differences among alternatives would be less clear. Although control of weeds and encouragement of native conditions would typically benefit wildlife habitat in general, removal of species that provide key habitat components (such as saltcedar and Russian olive that support nesting southwestern willow flycatchers) could harm some special status species. There are also disturbances associated with herbicide applications that could temporarily impact some special status species. The degree of benefits and impacts to wildlife habitat from treatments would largely depend on where the treatments occurred.

Under this alternative, only those herbicides currently used by the BLM would be used to treat vegetation. The majority of the total acreage would continue to be treated with picloram, tebuthiuron, and 2,4-D. Out of all the herbicides currently used by the BLM, 2,4-D has the highest risk to wildlife, according to ERAs. Although it is likely that the BLM would continue to use 2,4-D extensively because it is inexpensive, alternatives that allow for the use of new herbicides (alternatives B, D, and E) may offer the BLM more options for substituting herbicides that are less toxic to wildlife where special status species occur. Picloram and tebuthiuron pose a low risk to wildlife if applied at the typical rather than the maximum application rate, so continued use of these herbicides would have little impact to special status wildlife species.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Under the Preferred Alternative, approximately 932,000 acres of public lands would be treated with herbicides annually. Based on this acreage, the incidence of special status wildlife exposure to herbicides would be greater than under the other alternatives. Adverse health effects associated with herbicide exposure would likely be greater as well. Risks to TES species would also be greater, although mitigation to protect these species and their habitats from harm, as identified in the BA, would be required under all alternatives, minimizing the differences in risk among alternatives.

Out of all the alternatives, the Preferred Alternative would likely result in the most extensive control of weed infestations, and it is expected that weed populations would spread at the lowest rate under this alternative. Positive and negative impacts to special status wildlife habitat resulting from herbicide treatments, as discussed under the No Action Alternative, would likely be in line with the amount of acreage treated under each alternative, and would therefore be greatest under this alternative.

Under the Preferred Alternative, the BLM would be able to use 14 of the 20 currently approved herbicides that are currently available for use under the No Action Alternative, as well as four new herbicides and other new herbicides that become available in the future. The two new terrestrial herbicides, imazapic and diflufenzopyr pose no risks to sensitive wildlife under all exposure scenarios analyzed in ERAs. Therefore, risks to special status wildlife could be reduced under this alternative, provided the BLM used these herbicides in place of herbicides with higher risks to sensitive wildlife, such as 2,4-D and diuron.

Of the two new aquatic herbicides, diquat poses low to high risks to aquatic amphibians, depending on the application rate. There are no risks to aquatic amphibians associated with fluridone usage at the typical application rate, but low to moderate risks if it is used at the maximum application rate. If diquat were used instead of another less toxic herbicide to treat vegetation in habitats that support special status amphibians, herbicide-related impacts would likely be greater under the Preferred Alternative than under the No Action Alternative. Under the Preferred Alternative, however, less than 1% of acres treated with herbicides would be treated with diquat.

Because a greater number of herbicides would be available for use under this alternative, the BLM would have more flexibility to develop treatment programs that are more effective at improving wildlife habitat while minimizing risks to special status wildlife species than under the No Action Alternative. Of particular benefit to special status wildlife would be a suitable, inexpensive replacement for 2,4-D, which poses a high risk to terrestrial animals.

Alternative C – No Use of Herbicides

Under this alternative, no public lands would be treated with herbicides. Therefore, there would be no impacts to special status wildlife species as a result of herbicide exposure during vegetation treatments. However, the BLM would likely be less effective at controlling weed infestations than under the other alternatives. Therefore, there would be fewer benefits to special status wildlife habitat under this alternative, as compared to the herbicide-use alternatives. In addition, if other treatment methods were used to control weeds in lieu of herbicides, the disturbance to wildlife habitat could be greater. Mechanical treatments, for example, would potentially be louder and more disturbing to wildlife, especially during the breeding season, and vegetation removal would potentially be more immediate and complete, with a greater likelihood of altering habitat characteristics and injuring small animals present on the site.

Alternative D – No Aerial Application of Herbicides

Under this alternative, approximately 530,000 acres would be treated with herbicides annually, more than under all other alternatives except the Preferred Alternative. Based on acreage treated, the likelihood that special status wildlife species would be exposed to herbicides and suffer adverse health effects would be second highest under this alternative as well. Because aerial methods would not be used to apply herbicides, there would potentially be less risk that special status wildlife species would be inadvertently sprayed during treatments, but an increased risk of disturbing wildlife and crushing or hitting animals with trucks/ATVs because there would be more ground applications.

Benefits to wildlife habitat associated with herbicide treatments would not be as great as under the Preferred Alternative, particularly in areas that are inaccessible by ground methods. The degree of impact to special status wildlife would depend on which species were present in areas that could not be treated, and whether non-native plant species are a threat to their habitat.

Under this alternative, the herbicides available for use by the BLM would be the same as those discussed for the Preferred Alternative. The benefits associated with flexibility in selecting herbicides, and in using new herbicides that become available in the future, would be the same as those discussed under the Preferred Alternative.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Under this alternative, approximately 466,000 acres would be treated with herbicides annually, more than under the No Action Alternative, but fewer than under the other herbicide-use alternatives. Considering only acres treated, special status wildlife species would be less likely to be exposed to herbicides, and therefore would experience fewer herbicide-related impacts than under the other action alternatives (with the exception of Alternative C). Impacts to special status amphibians and riparian species would be reduced under this alternative, since herbicide use would be discouraged in areas populated by amphibians, and would not occur in riparian conservation areas. Furthermore, the limit in broadcast applications under this alternative would decrease the likelihood that special status wildlife would be directly sprayed by herbicides.

Benefits to wildlife habitat associated with herbicide treatments would be minimized under this alternative, but would still be greater than those under the No Action Alternative and Alternative C. The increased emphasis on passive restoration under Alternative E would likely benefit some special status wildlife species by reducing disturbance and preventing the spread of weeds in some areas. With this type of management in place, it is possible that fewer vegetation treatments would be necessary in certain areas, minimizing risks to special status wildlife species.

Under this alternative, the BLM would not be able to use chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl, or any other ALS-inhibiting herbicides that are made available in the future. According to the ERAs, there are no risks to special status wildlife associated with exposure to chlorsulfuron, imazapic, or sulfometuron methyl under any exposure pathway, even when applied at the maximum application rate. In addition, there are no risks associated with exposure to imazapyr or metsulfuron methyl when applied at the typical application rate, except in the case of a small bird eating contaminated invertebrates (low risk). The risks associated with applying either of these two chemicals at the maximum application rate are none to low, depending on the exposure pathway. Since these ALS-inhibiting herbicides are among the most benign as far as risks to terrestrial animals are concerned, there would be no apparent benefit to special status wildlife from discontinuing their use. Furthermore, there could be increased risks to special status wildlife from exposure to herbicides under this alternative if more toxic herbicides (such as 2,4-D, diuron, or hexazinone) were used in place of ALS inhibitors.

The risks of ALS-inhibiting herbicides on special status amphibians are generally none or low, with the exception of an accidental spill exposure of imazapyr. Therefore, increased risks to special status amphibians could occur if the BLM substituted more toxic herbicides (e.g., bromacil, diuron, or glyphosate) in place of ALS inhibitors. However, since use of herbicides would be discouraged in areas populated by amphibians under this alternative, impacts to special status amphibians could still be lower under this alternative than under the other herbicide-use alternatives.

Since the BLM would be able to use new herbicides that are made available in the future under this alternative, there would be more flexibility for creating effective treatment programs that minimize risks to special status wildlife species than under alternatives A and C. However, the inability to use ALS-inhibiting herbicides would reduce this flexibility below the level offered under alternatives B and D.

Mitigation for Herbicide Treatment Impacts

The following mitigation is recommended to reduce the likelihood of impacts to special status terrestrial wildlife species from herbicide applications. This mitigation should be implemented in addition to the SOPs designed to protect wildlife and the general mitigation for wildlife.

- To protect TES wildlife species, implement all mitigation measures for terrestrial animals presented in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment.*
- Where feasible, implement the mitigation measures for terrestrial animals presented in the BA to minimize impacts to non-TES species, unless treatments are specifically designed to improve habitats for these species. Refer to mitigation for a similar size and type of species, of the same trophic guild as the non-TES species in question.
- At the local level, consider effects to special status terrestrial wildlife species when designing treatment programs.

Livestock

Introduction

Public lands provide an important source of forage for many ranches and help to support the agricultural component of many communities scattered throughout the west. Approximately 165 million acres of public lands are open to livestock grazing, with use levels established by the Secretary of the Interior and administered through the issuance of grazing permits/leases. The majority of the grazing permits issued by BLM involve grazing by cattle, with fewer and smaller grazing permits for other kinds of livestock, which would include primarily sheep and horses. Many allotments are managed according to an allotment management plan, which outlines how livestock grazing is managed to meet multiple-use, sustained-yield, and other needs and objectives, as determined through LUPs. Even if there is no allotment management plan, grazing is managed to ensure that 1) watersheds are in or are making significant progress towards properly functioning physical condition; 2) ecological processes including the hydrologic cycle, nutrient cycle, and energy flow are maintained; 3) water quality complies with state water quality standards; and 4) habitats are or are making significant progress towards being restored.

Scoping Comments and Other Issues Evaluated in the Assessment

This section aims to contribute to the understanding of the impacts of herbicides on non-target species, focusing on livestock. The evaluation of the direct impacts of herbicides to livestock would help in the selection of less-toxic herbicides where feasible, a scoping concern identified by numerous respondents.

TABLE 4-24
Risk Categories[1] Used to Describe BLM-evaluated Herbicide Effects on TES Wildlife According to Exposure Scenario

Application Scenario	BROM[1]		CHLOR[1]		DICAMBA		DIFLU[1]		DIQUAT		DIURON		FLUR[1]		IMAZ[1]		OVER[1]		SULFM[1]		TEBU[1]	
	Typ[2]	Max[2]	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Direct Spray of Terrestrial Wildlife																						
Small mammal – 100% absorption	0[3]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pollinating insect – 100% absorption	L	L	0	0	L	L	0	0	L	M	L	M	0	0	0	0	0	0	0	0	L	M
Small mammal – 1st order dermal absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Contact with Foliage After Direct Spray																						
Small mammal – 100% absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pollinating insect – 100% absorption	0	0	0	0	0	0	0	0	0	L	0	L	0	0	0	0	0	0	0	0	0	L
Small mammal – 1st order dermal absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ingestion of Food Items Contaminated by Direct Spray																						
Small mammalian herbivore – acute	0	L	0	0	0	L	0	0	0	L	0	L	0	0	0	0	0	0	0	0	0	M
Small mammalian herbivore – chronic	0	L	0	0	0	L	0	0	L	M	L	M	0	L	0	0	0	0	0	0	0	L
Large mammalian herbivore – acute	0	M	0	0	0	L	0	0	L	M	0	M	0	0	0	0	0	0	0	0	0	L
Large mammalian herbivore – chronic	L	M	0	0	L	M	0	0	L	M	M	H	0	0	0	0	L	M	0	0	0	L
Small avian insectivore – acute	0	0	0	0	0	0	0	0	L	M	0	L	0	0	0	0	0	0	0	0	0	0
Small avian insectivore – chronic	0	0	0	0	0	0	0	0	0	M	0	L	0	0	0	0	0	0	0	0	0	0
Large avian herbivore – acute	0	L	0	0	0	0	0	0	0	M	0	M	0	0	0	0	0	0	0	0	0	L
Large avian herbivore – chronic	0	L	0	0	0	0	0	0	L	H	0	M	0	0	0	0	0	0	0	0	0	0
Large mammalian carnivore – acute	0	L	0	0	0	0	0	0	0	L	0	L	0	0	0	0	0	0	0	0	0	0
Large mammalian carnivore – chronic	0	0	0	0	L	L	0	0	0	0	L	L	0	0	0	0	0	0	0	0	0	0

[1] BROM = Bromacil; CHLOR = Chlorsulfuron; DIFLU = Diflufenzopyr; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.
[2] Typ = Typical application rate; and Max = Maximum application rate.
[3] Risk categories: 0 = No risk (majority of RQs < most conservative LOC for non-TES species); L = Low risk (majority of RQs 1-10x most conservative LOC for non-TES species); M = Moderate risk (majority of RQs 10-100x most conservative LOC for non-TES species); H = High risk (majority of RQs >100 most conservative LOC for non-TES species); and NE = Not evaluated. The Risk Category is based on the risk level of the majority of risk quotients observed in any of the scenarios for a given exposure group and receptor type. The reader should consult the risk tables in Chapter 4 of the ERAs (ENSR 2005b-k) to determine the specific scenarios that result in the displayed level of risk for a given receptor group.

The alternatives present a variety of herbicide use levels (including no use) for evaluation of relative positive and negative effect on livestock; one of the alternatives will evaluate the relative impacts of aerial versus ground application on livestock—these were key issues identified in the scoping process. Evaluation of the effects of herbicide use on livestock is in concert with the goal identified by some respondents of improving the management of public lands for multiple use and public benefit.

Standard Operating Procedures

Herbicide use does create potential risks to livestock; however, these risks can be minimized by following certain SOPs, which can be implemented at the local level according to specific conditions. The following general procedures are designed to reduce potential unintended impacts to livestock from the application of herbicides in the BLM vegetation management program:

- Schedule treatments when livestock are not present in the treatment area.
- As directed by the herbicide label, remove livestock from treatment areas prior to herbicide application, where applicable.
- Design treatments to take advantage of normal livestock grazing rest periods, when possible.
- Review, understand, and conform to the "Environmental Hazards" section on the herbicide label. This section warns of known pesticide risks to the environment and provides practical ways to avoid harm to organisms or to the environment.
- Use herbicides of low toxicity to livestock.
- Avoid accidental direct spray and spill conditions to reduce the largest potential impacts (remove livestock from target sites before herbicide application).
- Use the typical application rate, rather than the maximum application rate where practical, to reduce risk to livestock for most herbicides.
- Take into account the different types of application equipment and methods to limit the probability of contamination of non-target food and water sources.
- Minimize application areas where possible.
- Notify permittees of proposed treatment and identify any needed livestock grazing or feeding restrictions (see below for restrictions associated with each herbicide).
- Notify adjacent landowners prior to treatment.

These procedures would help minimize impacts to livestock and rangeland on western BLM lands to the extent practical, and as a result of this, long-term benefits to livestock from the control of invasive species would likely outweigh any short-term negative impacts to livestock associated with herbicide use.

Impacts Assessment Methodology

The BLM reviewed the literature and findings from ERAs conducted by the BLM and Forest Service to assess the impacts to livestock from the use of herbicides (ENSR 2005b-k; SERA 2005a). Risks to livestock were not specifically evaluated in these documents, which focused on risks to plants, fish and wildlife; however, results from the evaluation of terrestrial animal species can be applied to livestock species (i.e., results for large herbivores [154 pound mule deer] are applied to evaluate risks to common grazing animals on BLM lands—cows, sheep, and horses). The ERA methods are summarized in the Wildlife section of this chapter. Methods used by the BLM are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C; methods used by the Forest Service can be viewed on the Internet at http://www.fs.fed.us/r6/invasiveplant-eis/.

Summary of Herbicide Impacts

The extent of direct and indirect impacts to livestock will vary by the effectiveness of herbicide treatments in controlling target plants (that are not used as forage) and promoting the growth of native vegetation (that is used as forage), as well as by the extent and method of treatment (e.g., aerial vs. ground) and chemical used (e.g., toxic vs. non-toxic, selective vs. non-selective), the physical features of the terrain (e.g., soil type, slope), and weather conditions (e.g., wind speed) at the time of application. Possible adverse direct effects to individual animals include death, damage to vital organs, change in body weight, decreases in healthy offspring, and increased susceptibility to predation. Adverse indirect effects include reductions in forage amount and preferred forage type. The impacts of herbicide use on livestock would depend directly on the sensitivity of each species to the particular herbicides used (and the pathway by which the individual animal is exposed to the herbicide) and indirectly on the degree to which a species or individual is positively or negatively affected by changes in rangeland conditions, including forage quality and availability.

Livestock individuals would have a greater chance of being directly adversely impacted by herbicide use if their range extent is partially or completely sprayed because they would have greater exposure to herbicides–either via direct contact with the herbicide upon application or indirect contact via dermal contact with vegetation or ingestion of vegetation. However, livestock can be specifically removed from an area during vegetation treatment, or treatments can be scheduled to occur when livestock are not present, reducing the potential risks. If livestock are removed from the area specifically to facilitate vegetation treatment, the grazing permittee would be adversely affected as a result of the area being unavailable for grazing purposes. The permittee would need to either find alternative pasture somewhere else, or modify their ranching operation to account for the unavailable forage, which would cause them to incur increased costs and/or a loss of income. Even though large treatments (e.g., aerial applications on rangelands) would usually occur when livestock are not in the treated pasture, some risk of indirect contact and consumption of contaminated vegetation over a large area would still exist. Spot treatments could be applied at any time, regardless of the presence of livestock. Livestock may also experience greater impacts in systems where herbicide transport is more likely, such as areas where herbicides are aerially sprayed adjacent to rangeland, dry areas with high winds, or areas where rainfall is high and soils are porous; however these scenarios are not modeled. The degree of vegetation interception, which depends on site and application characteristics, would also affect direct spray impacts. As is evident, the impacts of herbicide use on livestock would be site and application specific, and as such, site assessments would have to be performed, using available impact information, to determine an herbicide-use strategy that would minimize impacts to livestock at the individual level.

The BLM and Forest Service risk assessments suggested several possible common impacts of herbicides to livestock (ENSR 2005b-k; SERA 2005a). Livestock, which likely have high levels of grass consumption, have relatively greater risk for harm than livestock or wildlife that feed on other herbaceous vegetation or seeds and fruits because herbicide residue is higher on grass than it is on other plants (Fletcher et al. 1994, Pfleeger et al. 1996); this is especially evident when examining risk levels of large mammalian herbivores in the BLM risk assessments. However, harmful doses of herbicide are not likely unless the animal forages exclusively within the treatment area for an entire day, suggesting that smaller treatments may be more appropriate for rangelands in cases where an herbicide has demonstrated risk to herbivores from the consumption of contaminated vegetation.

In cases where herbicide treatments are able to reduce the cover of noxious and unpalatable weeds on grazed lands, this would create short- and long-term benefits to livestock by increasing the quality of forage. In some cases, herbicides are the most effective means of controlling or eradicating invasive plant species. Noxious weed infestations can greatly reduce the land's carrying capacity for domestic livestock, which tend to avoid most weeds (Olson 1999). Cattle, in particular, preferentially graze native plant species over weeds, which often have low palatability as a result of defenses such as toxins, spines, and/or distasteful compounds. Although goats and sheep are more likely to consume alien weeds than cattle, they also tend to select native or introduced forage species over weeds (Olsen and Wallander 1998, Olson 1999). In addition, some noxious weeds (e.g., common tansy, houndstongue, Russian knapweed, and St. Johnswort) are poisonous to livestock. The success of weed removal would determine the level of benefit of the treatments over the long term.

Treatments that reduce the risk of future catastrophic wildfire through fuels reduction would also benefit livestock (weeds of concern that could be found in rangelands include downy brome, Russian thistle, kochia, oak, and pinyon/juniper). Uncontrolled, high intensity wildfires can damage large tracts of rangeland, reducing its suitability for livestock grazing. Wildfires typically occur during drought conditions, when burning rangeland magnifies the drought stress of forage species and hampers their recovery. Some herbicides are approved for use in BLM programs for rangeland as well as fuels management (e.g., glyphosate).

Over the short term, there would be minor impacts to livestock rearing related to mandatory restrictions associated with the use of herbicides. Livestock owners would not be able to slaughter (for food) animals consuming forage that has been treated by certain herbicides within the time period specified on the herbicide label. In addition, dairy animals would not be allowed to graze on areas treated with certain chemicals for the time period specified on the label.

Impacts of BLM-evaluated Herbicides

BLM herbicide exposure scenarios of direct spray and spill and indirect contact with foliage after direct spray did not result in risk to small mammals (large mammals were not modeled, but have a smaller surface area to body weight ratio, so are less likely to be impacted by these scenarios than small mammals; Table 4-25). Several herbicides did result in risk to large mammalian herbivores with the scenario of ingestion of food items contaminated by direct spray. Specific estimated risks to livestock from each individual herbicide are presented below. See the tables and figures in Section 4 of the ERAs (ENSR 2005b-k) for each herbicide for risk information on applicable ecological receptor groups according to herbicide application method. Also, see Table 4-25 in this section for a summary of the typical degree of risk each of the BLM herbicides pose to possible livestock receptors under different routes of exposure. Large mammalian herbivores were evaluated for the ingestion of food items contaminated by direct spray scenario. The receptor chosen for the large mammalian herbivore was a 154 pound mule deer. Chlorsulfuron, imazapic, and Overdrive® are the BLM-evaluated herbicides that would be most likely to be used in rangeland situations with grazing livestock; however, it is possible that other herbicides used nearby could impact livestock if they are transported off site.

Bromacil

Bromacil does not present a risk to small mammals via direct spray or indirect contact with foliage after direct spray (Table 4-25; ENSR 2005b). These scenarios are very conservative because they assume 100% absorption and small mammals have a relatively larger surface area for absorption of herbicide; therefore, it may be unlikely that bromacil would affect larger livestock under these scenarios. No acute risk and low chronic risk were predicted for a large mammalian herbivore ingesting vegetation sprayed at the typical application rate, and moderate acute and chronic risks were predicted at the maximum application rate. Therefore, direct spray of bromacil onto rangeland could pose a risk livestock that consume sprayed vegetation; the presence of chronic risk to livestock suggests that caution is needed in applying this herbicide in forage areas, particularly over large areas. However, bromacil is a non-selective herbicide and is not registered for application on rangelands or other livestock grazing areas where some vegetative cover is desired, suggesting that under typical use bromacil would not impact livestock. Any risk would come from off-site transport of bromacil to livestock grazing areas–a situation that could be avoided by following SOPs, including the use of appropriate buffer zones to prevent drift to off-site vegetation (see Vegetation section). Use of bromacil in spot applications or over small areas is not likely to impact livestock. Based on label directions, there are no restrictions on livestock use of treated areas.

Chlorsulfuron

Risk quotients for mammalian receptors for all modeled scenarios were all below the conservative LOC of 0.1, indicating that direct spray of chlorsulfuron is not likely to pose a risk to livestock (ENSR 2005c). Therefore, as chlorsulfuron is likely to be used in rangelands, this herbicide would primarily affect (positively or negatively) livestock through changes in the quality and abundance of forage. If used properly, its use in range and pasture areas could benefit livestock over the long term by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more desirable for forage. Based on label directions, there are no restrictions on livestock use of treated areas.

Dicamba

Overdrive® is a formulation of dicamba and diflufenzopyr, and an analysis of risks to livestock for dicamba was conducted during preparation of the Overdrive® ERA. However, an ERA report for dicamba was not done by the BLM as part of this PEIS, although some information on dicamba is included in the Overdrive® ERA. The Forest Service conducted an ERA for dicamba, and the reader is encouraged to review this document (available at http://www.fs.fed.us/foresthealth/pesticide/risk.shtml.

The ingestion of food items contaminated by direct spray of dicamba resulted in low acute and chronic risk to large mammalian herbivores at the maximum application rate. Because dicamba is proposed for use in rangelands and forestlands and does have moderate residual activity, livestock may be at risk from the application of this chemical, particularly if it is sprayed throughout the range area. The use of dicamba in rangeland could benefit livestock by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more suited for forage. However, because

TABLE 4-25

Risk Categories Used to Describe BLM-evaluated Herbicide Effects on Livestock and Wild Horses and Burros According to Exposure Scenario

Application Scenario	BROM[1]		CHLOR		DICAMBA		DIFLU		DIQUAT[2]		DIURON		FLUR[2]		IMAZ		OVER		SULFM		TEBU	
	Typ[3]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Direct Spray of Terrestrial Wildlife																						
Small mammal – 100% absorption	0[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small mammal – 1st order dermal absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Contact with Foliage After Direct Spray																						
Small mammal – 100% absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Small mammal – 1st order dermal absorption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ingestion of Food Items Contaminated by Direct Spray																						
Small mammalian herbivore – acute	0	L	0	0	0	0	0	0	0	L	0	L	0	0	0	0	0	0	0	0	0	L
Small mammalian herbivore – chronic	0	L	0	0	0	L	0	0	L	M	L	M	0	0	0	0	0	0	0	0	0	L
Large mammalian herbivore – acute	0	L	0	0	0	L	0	0	0	M	0	L	0	0	0	0	0	0	0	0	0	L
Large mammalian herbivore – chronic	L	M	0	0	0	L	0	0	L	M	M	H	0	0	0	0	L	M	0	0	0	L

[1] BROM = Bromacil; CHLOR = Chlorsulfuron; DIFLU = Diflufenzopyr; FLUR = Fluridone; IMAZ = Imazapic; OVER = Overdrive®; SULFM = Sulfometuron methyl; and TEBU = Tebuthiuron.

[2] Diquat and fluridone are aquatic herbicides that would not be used in terrestrial areas. Therefore, exposure of livestock via direct spray is less likely than with the other herbicides.

[3] Typ = Typical application rate; and Max = Maximum application rate.

[4] Risk categories: 0 = No risk (majority of RQs < most conservative LOC for livestock); L = Low risk (majority of RQs 1-10x most conservative LOC for livestock); M = Moderate risk (majority of RQs 10-100x most conservative LOC for livestock); and H = High risk (majority of RQs >100 most conservative LOC for livestock). The Risk Category is based on the risk level of the majority of risk quotients observed in any of the scenarios for a given exposure group and receptor type. The reader should consult the risk tables in Chapter 4 of the ERAs (ENSR 2005b-k) to determine the specific scenarios that result in the displayed level of risk for a given receptor group.

chlorsulfuron and imazapic are less risky to livestock and have similar target species, these herbicides could be considered for use instead of dicamba, where possible. Based on label directions, there are no restrictions on livestock use of treated areas, other than for lactating animals.

Diflufenzopyr

Risk quotients for terrestrial animals were all below the most conservative LOC of 0.1, indicating that direct spray of diflufenzopyr is not likely to pose a risk to livestock (ENSR 2005d). Diflufenzopyr is proposed for use with the active ingredient dicamba in the herbicide Overdrive®, which may be used in rangelands. Based on label directions, there are no restrictions on livestock use of treated areas.

Diquat

No risks to the small mammal were predicted due to direct spray or indirect contact with foliage (ENSR 2005e). Ingestion of food items contaminated by direct spray by the large mammalian herbivore resulted in low chronic risk at the typical application rate and moderate acute and chronic risk at the maximum application rate. This suggests that livestock could be at risk from the short- and long-term consumption of vegetation contaminated by diquat. Although registered for non-cropland and aquatic applications, use with public lands would be limited to aquatic applications. Thus, the likelihood of exposure of livestock to diquat is very minimal. Of most concern would be livestock that feed exclusively in riparian areas, where drift might impact riparian grasses, and livestock could also drink water from ponds treated with diquat however, these unlikely scenarios were not directly modeled.

Diuron

Ingestion of food items contaminated by direct spray by the large mammalian herbivore resulted in no acute risk and high chronic risk at the typical application rate, and moderate acute risk and moderate chronic risk as the maximum application rate (ENSR 2005f). However, because diuron is a non-selective herbicide, it is not likely to be used in rangelands where some vegetative cover is desired; this would limit its exposure to livestock. If typically foraged rangeland plants are protected from off-site transport of diuron, such as with appropriate buffer zones (see Vegetation section), then livestock would not likely be at risk from off-site drift or surface runoff of diuron. Based on label directions, there are no restrictions on livestock use of treated areas.

Fluridone

Risk quotients for large terrestrial animals were below the most conservative LOC of 0.1 for all scenarios (ENSR 2005g). These results indicate that accidental direct spray or drift of this aquatic herbicide would not likely pose a risk to livestock.

Imazapic

Risk quotients for terrestrial animals were all below the most conservative LOC of 0.1, indicating that direct spray of imazapic would not likely pose a risk to livestock (ENSR 2005h). Therefore, as imazapic would likely be used in rangelands, this herbicide would primarily affect (positively or negatively) livestock through changes in the quality and abundance of forage. If used properly, its use in range and pasture areas could benefit livestock over the long term by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more desirable for forage. Based on label directions, there are no restrictions on livestock use of treated areas.

Overdrive®

Overdrive® poses low chronic risk to large mammalian herbivores that consume plants contaminated by direct spray at the typical application rate and a moderate risk as the maximum application rate (ENSR 2005i). Because Overdrive® is proposed for use in rangelands and does have moderate residual activity, livestock may be at risk from the application of this chemical, particularly if it is sprayed throughout the range area. The use of Overdrive® in rangeland could benefit livestock by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more suited for forage. However, because chlorsulfuron and imazapic are less risky to livestock and have similar target species, these herbicides could be considered for use instead of Overdrive®, where possible. Based on label directions, there are no restrictions on livestock use of treated areas.

Sulfometuron Methyl

Risk quotients for terrestrial animals were all below the most conservative LOC of 0.1, indicating that direct spray of sulfometuron methyl would not likely pose a risk to livestock (ENSR 2005j). This herbicide is relatively non-selective, and is not registered for sites that are grazed. Thus, it should not impact livestock.

Tebuthiuron

The ingestion of food items contaminated by direct spray of tebuthiuron resulted in low acute and chronic risk to large mammalian herbivores at the maximum application rate (ENSR 2005k). The strength of this herbicide is its use as a habitat modifier in the BLM shrub reduction program—it is relatively non-selective but does not tend to harm grasses present. Therefore, impacts to livestock would be unlikely with intended use of this herbicide. According to the label for Spike 80DF, which has tebuthiuron as an active ingredient, if a treated area is to be used for haying or grazing, no more than 5 pounds per acre of Spike 80DF should be applied, and the product should not be applied more than once per year.

Impacts of Forest Service-evaluated Herbicides

The following information for eight herbicides proposed for use by the BLM is taken from ERAs performed by the Forest Service to support assessment of the environmental consequences of using these herbicides in Forest Service vegetation management programs (risk assessment results available at SERA [2005a]). Because the Forest Service completed these ERAs prior to completion of the PEIS, the BLM would use these ERAs to assess the potential ecological impacts of using these herbicides in future BLM vegetation management activities. The BLM previously evaluated and approved these eight herbicides in an earlier EIS—*Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a). As part of their risk assessments (see USDA Forest Service 2005), the Forest Service developed worksheets (see SERA 2005b), which allowed the BLM to assess risks of the herbicides using their own maximum application rates and LOCs (rather than the Forest Service rates and LOCs), allowing the risk assessments process for the Forest Service-evaluated herbicides to parallel the BLM process as much as possible. However, modeled risk scenarios for terrestrial animals may be different than used for the BLM-evaluated herbicides, depending on the specificity of available toxicity data. The assessment of impacts below is presented using the Forest Service upper estimates of HQs, to maximize the conservatism of the assessment. In addition to this, it should be noted that the development of HQs by the Forest Service (as well as the BLM) is already conservative for many reasons (e.g., assumption of 100% dermal absorption, assumption of 100% of diet contaminated, use of most sensitive values for exposure and dose/response assessments). 2,4-D, clopyralid, glyphosate, metsulfuron methyl, and triclopyr are the Forest Service-evaluated herbicides that are most likely to be used in rangeland situations with grazing livestock however, it is possible that other herbicides used nearby could impact livestock if they are transported off site.

2,4-D

2,4-D does present risk to some livestock as a result of direct spray as well as ingestion scenarios (Table 4-26; SERA 1998). Direct spray of 2,4-D results in moderate risk to small mammals at both the typical and maximum application rates, assuming 100% absorption of the herbicide. Small mammals face low risk from direct spray if assuming 1st order dermal absorption (i.e., absorption of herbicide through the skin over 24 hours, taking into consideration the potential for some of the herbicide not to be absorbed, so this results in less risk than 100% absorption).

Large livestock may face less risk of direct spray than small livestock because they have a smaller surface area to volume ratio over which to absorb the herbicide. Direct spray impacts to livestock can largely be prevented if animals are removed from target areas before spraying 2,4-D. Small mammals, and perhaps smaller livestock, face low risk from the consumption of water contaminated by a spill. In addition, livestock face risk from the consumption of vegetation contaminated by 2,4-D at the application site: large mammals face moderate acute and chronic risk at both the typical and maximum application rates and small mammals face low acute risk at the typical and maximum application rates. Large livestock that primarily consume grasses are particularly susceptible to risk from the vegetation consumption scenarios. However, long-term consumption of contaminated vegetation may be unlikely if the vegetation shows signs of damage. The risk assessment suggests that because large livestock eating large quantities of grass and other vegetation are at risk from routine exposure to 2,4-D and because 2,4-D is considered for use in rangeland, this herbicide should not be applied over large application areas where foragers would only consume contaminated food.

According to label directions for one formulation, dairy animals should be kept out of areas treated with 2,4-D for 7 days. Grass for hay should not be harvested for 30 days after treatment. Meat animals should be removed from treated areas 3 days prior to slaughter. Similar restrictions may be in place for other formulations, but users of 2,4-D should consult label directions before applying formulations of 2,4-D.

Clopyralid

According to the Forest Service risk assessment (SERA 2004b), clopyralid is not likely to result in risk to terrestrial animals; however, there were a few scenarios that resulted in potential low acute risk to livestock at the typical and maximum application rates. Small mammals are at risk from 100% absorption of direct spray and consumption of contaminated insects, and large mammals face risk from the consumption of contaminated vegetation. Application of clopyralid at the maximum application rate also poses low chronic risk to large mammals consuming on-site contaminated vegetation. The most likely livestock risk scenario would be the consumption of contaminated grass across large areas by large livestock, and this scenario can likely be avoided by restricting access of livestock to sprayed areas. In addition, all risks identified fall within the lowest risk category.

According to label directions, there are no restrictions on grazing or hay harvest following application at labeled rates, and livestock should not be transferred from treated grazing areas to sensitive broadleaf crop areas with first allowing for 7 days of grazing livestock on untreated pasture.

Glyphosate

Livestock face some risk from the use of glyphosate in rangelands. Direct spray of a small animal, assuming 100% absorption, results in low risk at the typical application rate and moderate risk at the maximum application rate (SERA 2003b). Smaller livestock, such as sheep and goats, are likely to experience greater risk from direct spray than larger livestock, such as cattle and horses, because of their larger surface area to body weight ratios. Direct spray impacts can largely be prevented if livestock are removed from the target area before spraying glyphosate. The large mammal consuming contaminated vegetation faces low acute risk at the typical application rate, moderate acute risk at the maximum application rate, and low chronic risk at the maximum application rate; and the small mammal faces low risk from consumption of contaminated vegetation (fruit) at the maximum application rate. The most likely risk scenario is the acute consumption of contaminated vegetation, which is particularly risky for cattle because they consume large amounts of grasses, which contain higher herbicide residue levels than herbaceous vegetation or seeds. Glyphosate is used in rangelands for the management of grasses and broadleaves, including woody species, and it is non-selective, suggesting that spot applications in rangeland would be the most appropriate use of this herbicide, which would reduce risks of consumption of contaminated vegetation as fewer non-target areas would be impacted by direct spray or spray drift. Based on label directions, there are no restrictions on livestock use of treated areas.

Hexazinone

At the typical and maximum application rates, several scenarios potentially result in low to moderate risk to livestock (SERA 1997). Small mammals face low risk of direct spray at the maximum application rate, assuming 1st order dermal absorption, and low to moderate risk assuming 100% dermal absorption. Acute consumption of contaminated vegetation results in low risk to the small mammal at the maximum application rate; and acute and chronic consumption of contaminated vegetation result in moderate risk to the large mammal. Also, acute consumption of contaminated water results in low risk to the small mammal at the maximum application rate. It appears that livestock are at risk from the application of hexazinone, but if food and water sources are not contaminated, risks are reduced, as direct spray can be avoided by removing livestock from the target area prior to applying hexazinone. Contamination of food and water sources could be minimized by utilizing spot applications of hexazinone at the typical application rate. Because hexazinone is used for woody species, it is not likely to be applied in rangelands where invasive plants are usually grasses or herbs. In addition, hexazinone is semi-selective, and is typically only applied in spot applications; therefore, risks to livestock under normal application may be lower than predicted by the risk assessment. According to label directions, livestock should not be grazed, nor forage or hay cut, on treated areas for 60 days.

Imazapyr

At the typical application rate, no scenarios are likely to result in risk to livestock, assuming that livestock consume primarily vegetation rather than insects (SERA 2004e). At the maximum application rate, however, a couple scenarios result in low risk to livestock: direct spray of the small animal and consumption of contaminated vegetation by the large mammal. Imazapyr is not registered for use in rangelands, therefore, it is unlikely that impacts via direct spray or consumption of contaminated vegetation would occur. The chance of this could be further minimized by

TABLE 4-26
Risk Categories Used to Describe Forest Service-evaluated Herbicide Effects on Livestock and Wild Horses and Burros According to Exposure Scenario

	2,4-D		Clopyralid		Glyphosate[1]		Hexazinone		Imazapyr		Metsulfuron		Picloram		Triclopyr[1]	
	Typ[2]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Acute/Accidental Exposures																
Direct spray, small mammal, 1st order absorption	L[3]	L	0	0	0	0	0	L	0	0	0	0	0	0	L	M
Direct spray, small animal, 100% absorption	M	M	L	L	L	M	L	M	0	L	0	L	L	L	L	M
Consumption of contaminated fruit, small mammal	L	L	0	0	0	L	0	L	0	0	0	0	0	0	0	0
Consumption of contaminated grass, large mammal	M	M	L	L	L	M	L	M	0	L	0	L	L	M	L	M
Consumption of contaminated water, small mammal, spill	L	L	0	0	0	L	0	L	0	0	0	0	0	0	0	L
Consumption of contaminated water, small mammal, stream	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chronic Exposures																
Consumption of contaminated vegetation, small mammal, on-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated vegetation, small mammal, off-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated vegetation, large mammal, on-site	M	M	0	L	0	L	L	M	0	0	0	0	0	0	L	M
Consumption of contaminated vegetation, large mammal, off-site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L
Consumption of contaminated water, small mammal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Risk categories are the same for both evaluated formulations.
[2] Typ = Typical application rate; and Max = maximum application rate.
[3] Risk categories: 0 = No risk (HQ < LOC); L = Low risk (HQ = 1 to 10 x LOC); M = Moderate risk (HQ = 10 to 100 x LOC); and H = High risk (HQ > 100 LOC). Risk categories are based on upper estimates of hazard quotients and the BLM LOCs of 0.1 for acute scenarios and 1.0 for chronic scenarios. The reader should consult the text of this section of the individual Forest Service risk assessments to evaluate risks at central estimates of hazard quotients.

removing livestock from areas nearby to application sites prior to spraying and by observing appropriate buffer zones from rangeland vegetation when applying imazapyr (see Vegetation section). Based on label directions, there are no restrictions on livestock use of treated areas.

Metsulfuron Methyl

Livestock face minimal risk from the application of metsulfuron methyl. None of the HQs estimated for metsulfuron methyl exposure at the typical application rate indicate risk to any of the terrestrial animal receptors (SERA 2004f). At the maximum application rate, metsulfuron methyl results in low risk to small animals via 100% absorption of direct spray and to large mammals via consumption of contaminated vegetation. Metsulfuron methyl is registered for use in rangeland, but impacts to livestock are unlikely if the typical application rate is used, and if the maximum application rate is used, impacts to livestock can be avoided by removing livestock from application areas prior to spraying metsulfuron methyl and by limiting the size of the application area or restricting access of livestock to recently sprayed areas to prevent consumption of large amounts of sprayed vegetation. Based on label directions, there are no restrictions on livestock use of treated areas for use rates of $1^2/_3$ ounces or less. If greater amounts of metsulfuron methyl are used, for age grasses may be cut for hay, fodder, or green forage and fed to livestock, including lactating animals, 3 days after treatment.

Picloram

Application of picloram is not likely to impact livestock. Most of the HQs for the evaluated scenarios of picloram exposure were below the LOC for both the typical and maximum application rates (SERA 2003c). Two scenarios were elevated above the LOC, resulting in low to moderate risk at the typical and maximum application rates: 100% absorption of direct spray by the small animal and acute consumption of contaminated vegetation by the large mammal. Picloram is registered for use in rangeland, and it could be applied over large areas as its primary targets are broadleaf and woody species; therefore it could be used to manage certain broadleaved plants without impacting native or desirable grasses. Impacts to livestock can be avoided by removing animals from application areas prior to spraying picloram and by limiting the size of the application area or restricting access of livestock to recently sprayed areas to prevent consumption of large amounts of sprayed vegetation.

Picloram has a number of restrictions on use in areas grazed by livestock or used for cutting hay. In general, livestock should not be grazed on treated areas, nor hay cut, for 2 weeks after treatment.

Triclopyr

Triclopyr presents some risk to livestock, particularly through the consumption of contaminated vegetation (SERA 2003d). Risk categories resulting from calculated HQs for the two evaluated formulas of triclopyr (triclopyr acid and triclopyr BEE) are the same, and therefore no differentiation will be made between these two formulas in this section. The following scenarios result in low risk at the typical application rate and moderate risk at the maximum application rate: first-order and 100% absorption of direct spray by the small mammal, and acute and chronic consumption of on-site contaminated vegetation by the large mammal. In addition, at the maximum application rate, low risk results from acute consumption of water contaminated by a spill by the small mammal and chronic consumption of off-site contaminated vegetation by the large mammal. No risk is predicted for small mammals as a result of acute or chronic consumption of contaminated vegetation or water. Triclopyr can be used in rangeland to selectively manage woody species without impacting native or desirable grasses. It also has low residual activity. Impacts to livestock can be avoided by removing animals from application areas prior to spraying triclopyr and by limiting the size of the application area or restricting access of livestock to recently sprayed areas to prevent consumption of large amounts of sprayed vegetation. Because large livestock are susceptible to impacts from long-term consumption of vegetation contaminated by triclopyr, it would be important to limit exposure of animals, particularly cattle and horses, to sprayed vegetation until residual activity has tapered off, particularly since sprayed grasses may not show signs of damage.

There are no grazing restrictions for triclopyr, except for lactating dairy cattle. Hay should not be harvested within 14 days of application.

Impacts of Other Herbicides Currently Available for Use

2,4-DP, asulam, atrazine, fosamine, mefluidide methyl, and simazine were approved for use in the earlier BLM EISs. 2,4-DP could be used in forested rangeland, but would not be used in areas where livestock graze. It has low toxicity to mammals. Asulam is of low toxicity to mammals, but livestock should not graze in treated areas or be fed forage from treated areas. It would primarily be used in the control of bracken fern on forested rangelands (Information Ventures, Inc. 1995a). Atrazine could be used for vegetation treatments in conifer plantations, but would not be used in forested or other rangelands where livestock might come in contact with the herbicide. It is slightly to moderately toxic to mammals (Information Ventures, Inc. 1995b; Extension Toxicology Network 1996e). Fosamine does not have a rangeland registration and would not be used where livestock graze. It is practically nontoxic to mammals (USEPA 1995). Mefluidide would not be cost effective to use on rangeland. It is of low to moderate toxicity to mammals (Information Ventures, Inc. 1995c). Simazine could be used by the BLM on Christmas tree plantations, but would likely not be used where livestock graze. Simazine has low toxicity to most mammals, although sheep and cattle are more sensitive to simazine than other mammals and a dose as low as 500 mg/kg can be fatal (Information Ventures, Inc. 1995d). The BLM have not used any of these herbicides, except fosamine (< 50 acres annually) since 1997, and does not plan to utilize them in the near future.

Impacts by Alternative

The following discusses the expected effects of each of the five alternatives on livestock, and compares the effects expected under each alternative with those expected under the other alternatives. These effects may vary depending on the percentage of acres treated using different application methods and different herbicides, as well as on the size of treatment events.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue its ongoing vegetation treatment programs in 14 western states, and would be able to use 20 herbicides previously approved under earlier RODs. Herbicide use under the No Action Alternative could impact livestock over an estimated 305,000 acres. The nature of impacts to livestock (positive and negative) would be similar to those that have occurred in the past 10 years. Negative impacts to livestock may be lower than under the other herbicide-use alternatives because fewer total acres would be treated using herbicides. However, long-term positive impacts on livestock communities (i.e., improvements in rangeland forage) could be greatly reduced under this alternative. Invasive plant populations would likely continue to expand at the current rate or more quickly, potentially increasing damage to desirable native forage, and the abundance of unpalatable or toxic plants.

Because the new herbicides proposed in this PEIS (diquat, fluridone, imazapic, and Overdrive®) would not be used under this alternative, risks to livestock would be different than under the other alternatives. Fluridone and imazapic do not present any risks to livestock in modeled scenarios (similar to chlorsulfuron, metsulfuron methyl, and sulfometuron methyl), and Overdrive® poses low to moderate risk to large livestock under a chronic exposure scenario in which the animal ingested contaminated vegetation over a long time period. Diquat is fairly toxic to livestock, particularly under food ingestion scenarios (similar to 2,4-D and diuron); however, diquat would be used by the BLM as an aquatic herbicide, and frequent exposure to livestock would not be expected. Therefore, the No Action Alternative would prevent the use of a greater repertoire of herbicides that are not injurious to terrestrial animals, possibly increasing per area risks to livestock if more injurious herbicides are used instead (e.g., 2,4-D, bromacil, diuron, tebuthiuron, triclopyr), as well as decreasing the possibilities of more effective rangeland improvements. However, elimination of diquat from use, particularly in rangeland riparian areas could somewhat decrease per area risk to livestock.

2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine were approved for use in the earlier BLM EISs, but the BLM has not used any of these herbicides, except fosamine (< 50 acres annually) since 1997, and does not plan to utilize them in the near future. None of these herbicides would normally be used in rangeland treatments where livestock might come into contact with the chemical. Instead, the BLM would use other herbicides, including triclopyr, sulfometuron methyl, bromacil, diuron, and Overdrive®, which are effective in controlling weeds and invasive vegetation, but have less risk to livestock.

The BLM would not be able to use herbicides in Alaska, Nebraska, and Texas under the No Action Alternative, but would be able to conduct herbicide treatments in these states under the other herbicide-treatment alternatives. No herbicide treatments are proposed for Alaska and Nebraska under this alternative, and it is unlikely that livestock would graze on public lands in Alaska. Approximately 11,000 acres would be treated annually in Texas using herbicides. These treatments could affect livestock.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

The Preferred Alternative would result in the treatment of approximately 932,000 acres in 17 western states. In addition to the 14 previously approved herbicides, the BLM would be able to use the four new herbicides evaluated in this PEIS. This alternative would result in the most extensive effects to livestock (both negative and positive) because it proposes the most acres for treatment (3 times the acreage that would be treated under the No Action Alternative). The extent of positive and negative impacts to livestock would depend on the relative amount each of the herbicides was used, and whether they would be applied in rangeland environments, and the method of application. The chance for negative impacts would be highest if diuron, diquat, bromacil and/or 2,4-D were used extensively. However, diquat would be used by the BLM as an aquatic herbicide, and bromacil and diuron, non-selective herbicides, are not likely to be used extensively in rangelands. If these herbicides were used in restricted scenarios, as is proposed, and other herbicides are used effectively to increase the abundance of native forage relative to unpalatable weeds, positive impacts to livestock could outweigh negative impacts. Furthermore, the ability to use the four new herbicides (diquat, fluridone, imazapic, and Overdrive®) as well as future herbicides that become registered with the USEPA would allow BLM managers more options in choosing herbicides that best match treatment goals and application conditions and are less toxic. As a result, there could be an increase per capita benefits and a reduction in overall per capita risks to livestock (three of the four new herbicides present little to no risk to livestock) and an increase in habitat and ecosystem benefits from treatment. This alternative would also reduce risks and negative impacts associated with other vegetation management methods (e.g., risk of escaped prescribed fires; see the PER).

Alternative C – No Use of Herbicides

Under Alternative C, livestock would not be affected by herbicide use. Primary impacts would stem from other vegetation treatment methods (see the accompanying PER; USDI BLM 2005a). Positive benefits to rangelands as a result of vegetation management could be reduced under this alternative, as certain invasive species are only effectively controlled by herbicides, and in some situations other methods are impractical due to cost, time, or public concerns. For example, mechanical and manual methods are impractical over large land areas, which are more effectively treated by broadcast herbicide applications. In addition, it is often difficult to eradicate some species (e.g., rabbitbrush, honey mesquite, sand shinnery oak, cholla), such as shrubs that resprout from rhizomes, by means other than herbicide application. Similarly, pre-emergent herbicides that persist in the soil are the most effective means of controlling invasive plants with seeds that remain viable for long periods of time.

Under this alternative, without the use of herbicides, invasive plant populations would likely continue to spread, possibly at increasing rates. The spread of invasive plant populations would cause further damage to susceptible native plant communities, including rangeland communities that provide forage for livestock, particularly in situations where other treatment methods would not be effective or feasible (e.g., large tracts of rangeland or grassland dominated by invasive, resprouting shrubs; or areas without enough fine fuels to carry prescribed fires). The spread of invasive plant populations would likely have deleterious effects on livestock. Rangeland that contains excessive or unpalatable brush cover is not useful for grazing and has reduced carrying capacity for domestic livestock. Capacity for cattle grazing decreases proportionately with loss of forage caused by weed infestation. Economic returns in terms of improved grazing value typically exceed herbicide treatment costs on lands where herbicides are used to control weeds (Olson 1999). In addition, acres infested by noxious weeds that are toxic to livestock, including common tansy, leafy spurge, Russian knapweed, St. Johnswort, tansy mustard, and yellow starthistles would increase; in contrast, these species would be targeted by the BLM for herbicide treatments under the other alternatives.

Alternative D – No Aerial Applications

Alternative D would be the same as the Preferred Alternative as far as herbicides that could be used, and areas that could be treated. Therefore, both alternatives would be equally likely to have both positive and negative effects on livestock and rangeland. The BLM would be able to choose from a suite of currently-approved herbicides and herbicides that could be approved under this PEIS, or in the future. However, this alternative would not allow the BLM to apply herbicides aerially. Fewer acres would be treated (540,040 acres) because some large areas, including rangelands, cannot be effectively treated by ground application methods. This alternative would substantially reduce the impacts of off-site drift to livestock, an exposure scenario that is not specifically modeled for most herbicides (consumption of contaminated vegetation off-site was modeled for most of the Forest Service herbicides, with no risk demonstrated to livestock for any of these herbicides, except triclopyr at the maximum application rate). Conversely, without the option to spray herbicides aerially, large areas of rangeland may remain untreated under Alternative D, and which could negatively impact livestock habitat and forage in these areas over the long term.

Under this alternative, long-term negative impacts to rangeland could be greater than any potential short-term negative effects to livestock that would result from aerial applications, particularly given that livestock would be removed from rangeland application areas before aerial spraying. Furthermore, most of the herbicides that are potentially damaging to livestock (e.g., bromacil, diquat, diuron, glyphosate, hexazinone, tebuthiuron) are not likely to be applied aerially in rangelands, and aerial spraying of other damaging herbicides (e.g., 2,4-D, Overdrive®) could be avoided. In addition, direct and indirect impacts from other vegetation treatment options could increase if these methods were used more extensively to compensate for the reduced number of acres treated by herbicides (see PER).

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Approximately 466,000 acres would be treated under Alternative E, which is slightly less than the acreage that would be treated under Alternative D, and less than half of the acreage that would be treated under the Preferred Alternative, but is still be an increase from the average annual treatment acreage that has occurred over the past 8 years and would likely occur under the No Action Alternative. Herbicide-related impacts to livestock would be lower under this alternative than under the Preferred Alternative because fewer acres would be treated with herbicides, and additional protective standards would be required during herbicide treatment (e.g., preferential use of spot rather than broadcast applications, preferential treatment of small versus large infestations).

Sulfonylurea herbicides and other ALS-inhibiting herbicides (e.g., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl) block the synthesis of amino acids that are required for protein production and cell growth, thereby resulting in plant death. ALS-inhibiting herbicides would not be used under this alternative because data suggest they have the potential to damage off-site native and crop plant species under the right conditions of environment and application. These herbicides are biologically active at low concentrations, and are applied at lower application rates than other herbicides to manage target plants. It is uncertain whether these lower application rates would result in fewer cases of unintended damage to livestock and rangeland or more cases due to the high potency of the herbicides and their persistence. In 1981, the Environmental Effects Division of the USEPA did recommend against registering sulfonylurea herbicides because they persist for long periods of time in the environment and they cannot be detected at low levels. However, in this assessment, none of the ALS-inhibiting herbicides resulted in risk to livestock at the typical application rate under any of the modeled scenarios, suggesting that the elimination of these herbicides would not benefit livestock and could indirectly harm livestock if more toxic herbicides were used in their place.

Alternative E incorporates other management practices that would be likely to have positive impacts on livestock and rangelands. Alternative E would limit the use of broadcast applications, which would reduce the possible risks to livestock associated with off-site drift and consumption of vegetation across large areas; however these applications would be available for use in appropriate situations (i.e., where no other method is practical and susceptible non-target plant species and aquatic areas are distant from the application area), which would allow some positive ecosystem benefits from larger-scale herbicide applications. While per-treatment ecosystem benefits may be greater under Alternative E than under the other herbicide-use alternatives as a result of this ecosystem-based management approach, overall positive vegetation and ecosystem benefits (that cannot be attained by other treatment methods) across the western states would be lower under this alternative because of the relatively low treatment acres and the inability to use certain practices in situations that might require their use (e.g., use of ALS-inhibitor herbicides on highly aggressive weeds). For example, imazapic, which has been shown to be effective in treating downy brome and leafy spurge, would be unavailable under this alternative. The BLM would also be unable to use chlorsulfuron and metsulfuron methyl to control yellow starthistles and several species of thistles that are harmful to livestock.

Mitigation for Herbicide Treatment Impacts

The following actions would greatly reduce the risk of herbicide applications to livestock:

- Apply diuron, glyphosate, hexazinone, tebuthiuron, and triclopyr at the typical, rather than maximum, application rate to minimize risks to livestock.
- Do not apply 2,4-D, bromacil, dicamba, diuron, Overdrive®, picloram, and triclopyr across large application areas, where feasible, to limit impacts to livestock, particularly through the contamination of food items, or remove livestock from application areas for an appropriate period of time, as specified on the product label.
- Where feasible, limit glyphosate and hexazinone to spot applications in rangeland to avoid contamination of food items.
- Do not aerially apply diquat directly to wetlands and riparian areas.
- Do not apply bromacil and diuron in rangelands and use appropriate buffer zones (see Vegetation section in this chapter) to limit contamination of off-site rangeland vegetation.

Wild Horses and Burros

Introduction

The BLM, in conjunction with the Forest Service, manages wild horses and burros on BLM- and Forest Service-administered lands through the Wild Free Roaming Horse and Burro Act of 1971. Animals are managed within 206 Wild Horse and Burro herd management areas, and are managed with the goal of maintaining the natural ecological balance of public lands as well as the ability to support multiple uses. Public lands inhabited by wild horses or burros are closed to grazing by domestic horses and burros under permit or lease. In FY 2003, wild horse and burro populations on public lands totaled over 37,000 animals, with nearly half of these animals living in Nevada. The population of wild horses and burros is approximately 13,000 animals above the appropriate management level. The appropriate management level is an estimate of the number of wild horses and burros that public lands can support while maintaining a thriving natural ecological balance.

The proposed herbicide vegetation management activities could affect wild horses and burros through exposure to chemicals that could harm their health, or through changes in vegetation that could positively or negatively alter the carrying capacity of the HMAs. Adverse impacts to wild horses and burros could include direct harm to wild horses and burros and a reduction in the availability or quality of forage in HMAs (decreasing the carrying capacity of the HMAs). Alternately, herbicide vegetation management activities could improve the amount and quality of forage, potentially increasing the carrying capacity of the HMAs.

Scoping Comments and Other Issues Evaluated in the Assessment

This section aims to contribute to the understanding of the impacts of herbicides on non-target species, focusing on wild horses and burros. The evaluation of the direct impacts of herbicides to wild horses and burros would help in the selection of less-toxic herbicides where feasible, a scoping concern identified by numerous respondents. The alternatives present a variety of herbicide use levels (including no use) for evaluation of relative positive and negative effect on wild horses and burros, and one of the alternatives will evaluate the relative impacts of aerial versus ground application—these were key issues identified in the scoping process. Evaluation of the effects of herbicide use on wild horses and burros is in concert with the goal identified by some respondents of improving the management of public lands for multiple use and public benefit.

Standard Operating Procedures

Herbicide use does create potential risks to wild horses and burros; however, these risks can be minimized by following certain SOPs, which can be implemented at the local level according to specific conditions (see Table 2-6). These include 1) using herbicides of low toxicity to wiid horses and burros; 2) avoiding accidental direct spray and spill conditions to reduce the largest potential impacts (exclude wild horses and burros from target sites before herbicide application, if feasible); 3) using the typical application rate, rather than the maximum application rate where practical, to reduce risk to wild horses and burros for most herbicides; and 4) taking into account the different types of application equipment and methods to limit the probability of contamination of non-target food and water sources.

These procedures would help to minimize impacts to wild horses and burros and rangeland on western public lands to the extent practical, and as a result of this, long-term benefits to wild horses and burros from the control of invasive species would likely outweigh any short-term negative impacts to these animals associated with herbicide use.

Impacts Assessment Methodology

The BLM reviewed the literature and findings from ERAs conducted by the BLM and Forest Service to assess the impacts to wild horses and burros from the use of herbicides (ENSR 2005b-k; SERA 2005a). Risks to wild horses and burros were not specifically evaluated in these documents, which focused on risks to plants, fish and wildlife; however, results from the evaluation of large terrestrial animal herbivores can be applied to wild horses and burros (i.e., results for large herbivores [154 pound mule deer] are applied to evaluate risks to common grazing animals on public lands, including wild horses and burros). The ERA methods are summarized in the Wildlife Resources section of this chapter. Methods used by the BLM are presented in detail in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol* (ENSR 2004) and in Appendix C; methods used by the Forest Service can be viewed on the Internet at http://www.fs.fed.us/r6/invasiveplant-eis/.

Summary of Herbicide Impacts

The extent of direct and indirect impacts to wild horses and burros would vary by the effectiveness of herbicide treatments in controlling target plants (that are not used as forage) and promoting the growth of native vegetation (that is used as forage); the extent and method of treatment (e.g., aerial vs. ground); the chemical used (e.g., toxic vs. non-toxic, selective vs. non-selective); the physical features of the terrain (e.g., soil type, slope); the weather conditions (e.g., wind speed); and the time of year (e.g., newborn horses and burros would be susceptible during foaling season, with March through June being a critical period) at the time of application. Adverse direct effects to individual animals as a result of exposure to herbicides include death, damage to vital organs, change in body weight, decreases in healthy offspring, and increased susceptibility to predation.

Adverse indirect effects could include reductions in forage amount and preferred forage type. Possible positive effects include improvement in the quality and amount of forage and improvement in general habitat conditions. The impacts of herbicide use on wild horses and burros would depend directly on the sensitivity of each species to the particular herbicides used (and the pathway by which the individual animal is exposed to the herbicide) and would depend indirectly on the degree to which a species or individual is positively or negatively affected by changes in herd management area conditions.

Wild horse and burro individuals would have a greater chance of exposure to herbicides—either via direct contact with the herbicide upon application or indirect contact via dermal contact with vegetation or ingestion of vegetation—if their range extent was partially or completely sprayed because they would have greater exposure to herbicides. However, it is unlikely that an animal's entire range would be sprayed, as these animals are wide ranging and herd management areas are often larger than 10,000 to 100,000 acres while most (77%) of treatments would be less than 1,000 acres.

On average, wild horses and burros use about 360 acres per animal, or about 3,600 acres for a herd of 10 animals. Wild horses and burros may also experience greater impacts in systems where herbicide transport is more likely, such as areas where herbicides are aerially sprayed adjacent to herd management areas, dry areas with high winds, or areas where rainfall is high and soils are porous; however these scenarios were not modeled.

The BLM and Forest Service risk assessments suggested several possible common impacts of herbicides to wild horses and burros (USDA Forest Service 2005; ENSR 2005b-k; SERA 2005a). Wild horses and burros, which likely have high levels of grass consumption, have relatively greater risk for harm than smaller wildlife or wildlife that feed on other herbaceous vegetation or seeds and fruits because herbicide residue is higher on grass than it is on other plants (Fletcher et al. 1994; Pfleeger et al. 1996); this is especially evident when examining risk levels of large mammalian herbivores in the BLM risk assessments. However, harmful doses of herbicide may not be likely unless the animal forages exclusively within the treatment area for an entire day, suggesting that smaller treatments may be more appropriate for herd management areas in cases where an herbicide has demonstrated risk to herbivores from the consumption of contaminated vegetation.

In cases where herbicide treatments are able to reduce the cover of noxious and unpalatable weeds on grazed lands and replace this with more palatable native plants, this would create short- and long-term benefits to wild horses and burros by increasing the availability and quality of forage. If the forage amount is increased within a given herd management area, this could increase the carrying capacity of the herd management area, many of which are currently overburdened with wild horse and burro populations that exceed the appropriate management level.

The use of herbicides or a combination of herbicide use and another treatment method may be the most effective means of controlling or eradicating some invasive plant species. Noxious weed infestations can greatly reduce the land's carrying capacity for domestic wild horses and burros, which tend to avoid weeds that have low palatability as a result of defenses such as toxins, spines, and/or distasteful compounds (e.g., thistle [Olson 1999]). In addition, some noxious weeds (e.g., horsetail, wild mustard, poison hemlock, tansy ragwort, yellow starthistle, and St. Johnswort) are poisonous to horses. Grazing may ultimately be an effective means of managing invasive plants in HMAs; however, if vegetation is overgrazed (e.g., as a result of HMAs supporting horses and wild burros in excess of the AML) another method, such as herbicide treatment, is required to return vegetation to a more desirable composition, followed by grazing within the carrying capacity of the HMA. The success of weed removal would determine the level of benefit of the treatments over the long term.

Treatments that reduce the risk of future catastrophic wildfire through fuels reduction would also benefit wild horses and burros. Weeds of concern that could be found in rangelands include downy brome, medusahead, halogeton, rabbitbrush, diffuse knapweed, Russian thistle, and perennial pepperweed, in particular, because much of the herd management area land for wild horses and burros occurs in drier habitats in Nevada. Uncontrolled, high intensity wildfires can damage large tracts of rangeland, reducing its suitability for wild horse and burro grazing. Wildfires typically occur during drought conditions, when burning rangeland magnifies the drought stress of forage species and hampers their recovery. Some herbicides are approved for use in BLM programs for rangeland as well as fuels management (e.g., glyphosate, imazapic, sulfometuron methyl).

Impacts of BLM-Evaluated Herbicides

BLM herbicide exposure scenarios of direct spray and spill and indirect contact with foliage after direct spray did not result in risk to small mammals (large mammals were not modeled, but have a smaller surface area to body weight ratio, so are less likely to be impacted by these scenarios than small mammals). Several herbicides did result in risk to large mammalian herbivores with the scenario of ingestion of food items contaminated by direct spray. Specific estimated risks to wild horses and burros from each individual herbicide are presented below. See the tables and figures in Section 4 of the ERAs (ENSR 2005b-k) for each herbicide for risk information on applicable ecological receptor groups according to herbicide application method. Also, see Table 4-25 for a summary of the typical degree of risk each of the BLM herbicides pose to possible wild horses and burros receptors under different routes of exposure. Small mammals are used in the direct contact with direct spray and indirect contact with directly sprayed foliage scenarios, but because small mammals have a relatively larger surface area for absorption of herbicide and because 100% absorption is assumed; it is unlikely that wild horses and burros would be at more risk than small mammals. Large mammalian herbivores were evaluated for the ingestion of food items contaminated by direct spray scenario. The receptor chosen for the large mammalian herbivore was a 154 pound mule deer. Chlorsulfuron, imazapic, and Overdrive® are the BLM-evaluated herbicides that are most likely to be used in rangeland situations with grazing wild horses and burros; however, it is possible that other herbicides used nearby could impact wild horses and burros if they are transported off site.

Bromacil

Bromacil does not present a risk to small mammals via direct spray or indirect contact with foliage after direct spray (ENSR 2005b). These scenarios are very conservative because they assume 100% absorption and small mammals have a relatively larger surface area for absorption of herbicide; therefore, it may be unlikely that bromacil would affect larger wild horses and burros under these scenarios. No acute risk and low chronic risk were predicted for a large mammalian herbivore ingesting vegetation sprayed at the typical application rate, and low acute and moderate chronic risks were predicted at the maximum application rate. Therefore, direct spray of bromacil onto rangeland could pose a risk to wild horses and burros that consume sprayed vegetation; the presence of chronic risk to wild horses and burros suggests that caution is needed in applying this herbicide in HMAs, particularly over large areas. However, because bromacil is a non-selective herbicide and is registered for non-cropland applications, it is not likely to be used in HMAs where vegetative cover is desired, suggesting that under typical use bromacil would not impact wild horses and burros. Any risk would come from off-site transport of bromacil to wild horses and burros grazing areas–a situation that could be avoided by following SOPs, including the use of appropriate buffer zones to prevent drift to off-site vegetation (see Vegetation section of this chapter). Use of bromacil in spot applications or over small areas would not likely impact wild horses and burros.

Chlorsulfuron

Risk quotients for mammalian receptors for all modeled scenarios were all below the most conservative LOC of 0.1, indicating that direct spray of chlorsulfuron would not likely pose a risk to wild horses and burros (ENSR 2005c). Therefore, as chlorsulfuron may be used in HMAs, this herbicide would primarily affect (positively or negatively) wild horses and burros through changes in the quality and abundance of forage. If used properly, its use in range and pasture areas could benefit wild horses and burros over the long term by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more desirable for forage.

Dicamba

Overdrive® is a formulation of dicamba and diflufenzopyr, and an analysis of risks to horses and burros for dicamba was conducted during preparation of the Overdrive® ERA. However, an ERA report for dicamba was not done by the BLM as part of this PEIS, although some information on dicamba is included in the Overdrive® ERA. The Forest Service conducted an ERA for dicamba, and the reader is encouraged to review this document (available at http://www.fs.fed.us/foresthealth/pesticide/risk.shtml.

The ingestion of food items contaminated by direct spray of dicamba resulted in low acute and chronic risk to large mammalian herbivores at the maximum application rate. Because dicamba is proposed for use in rangelands and forestlands and does have moderate residual activity, wild horses and burros may be at risk from the application of this chemical, particularly if it is sprayed throughout the range area. The use of dicamba in rangeland could benefit wild horses and burros by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more suited for forage. However, because chlorsulfuron and imazapic are less risky to wild horses and burros and have similar target species, these herbicides could be considered for use instead of dicamba, where possible.

Diflufenzopyr

Risk quotients for terrestrial animals were all below the most conservative LOC of 0.1, indicating that direct spray of diflufenzopyr would not likely pose a risk to wild horses and burros (ENSR 2005d). Diflufenzopyr is proposed for use with the active ingredient dicamba in the herbicide Overdrive®, which may be used in rangelands.

Diquat

No risks to the small mammal were predicted due to direct spray or indirect contact with foliage (ENSR 2005e). Ingestion of food items contaminated by direct spray by the large mammalian herbivore resulted in low chronic risk at the typical application rate and moderate acute and chronic risk at the maximum application rate. This suggests that wild horses and burros could be at risk from the short- and long-term consumption of vegetation contaminated by diquat. However, because diquat is an aquatic herbicide that is not proposed for use in terrestrial areas, the likelihood of exposure of wild horses and burros to diquat is very minimal. Of most concern would be wild horses and burros that feed exclusively in riparian areas, where drift might impact riparian grasses; however, this unlikely scenario was not modeled.

Diuron

Ingestion of food items contaminated by direct spray by the large mammalian herbivore resulted in no acute risk and moderate chronic risk at the typical application rate, and low acute risk and high chronic risk at the maximum application rate (ENSR 2005f). However, because diuron is a non-selective herbicide and is registered for non-cropland applications, it is not likely to be used in rangelands where some vegetative cover is desired; this would limit its exposure to wild horses and burros. If typically foraged rangeland plants are protected from off-site transport of diuron, such as with appropriate buffer zones (see Vegetation section in this chapter), then wild horses and burros are not likely to be at risk from off-site drift or surface runoff of diuron.

Fluridone

Risk quotients for large terrestrial animals were below the most conservative LOC of 0.1,for all scenarios (ENSR 2005g). These results indicate that accidental direct spray or drift of this aquatic herbicide would not likely pose a risk to wild horses and burros.

Imazapic

Risk quotients for terrestrial animals were all below the most conservative LOC of 0.1, indicating that direct spray of imazapic would not likely pose a risk to wild horses and burros (ENSR 2005h). If used properly, its use in range and pasture areas could benefit wild horses and burros over the long term by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more desirable for forage.

Overdrive®

Overdrive® poses low chronic risk to large mammalian herbivores that consume plants contaminated by direct spray at the typical application rate and a moderate risk at the maximum application rate (ENSR 2005i). Because Overdrive® is proposed for use in rangelands and does have moderate residual activity, wild horses and burros may be at risk from the application of this chemical, particularly if it is sprayed throughout the range area (an unlikely scenario). The use of Overdrive® in rangeland could benefit wild horses and burros by controlling unpalatable invasive plant species and promoting the establishment and growth of native plant species that may be more suited for forage. However, because chlorsulfuron and imazapic are less risky to wild horses and burros and have similar target species, these herbicides could be considered for use instead of Overdrive®, where possible.

Sulfometuron Methyl

Risk quotients for terrestrial animals were all below the most conservative LOC of 0.1, indicating that direct spray of sulfometuron methyl is not likely to pose a risk to wild horses and burros (ENSR 2005j). Because this herbicide is relatively non-selective, it is not likely to be used in HMAs, and therefore, should result in few negative or positive impacts on wild horses and burros.

Tebuthiuron

The ingestion of food items contaminated by direct spray of tebuthiuron resulted in low acute and chronic risk to large mammalian herbivores at the maximum application rate (ENSR 2005k). Tebuthiuron is not prominently used in rangeland habitat; the strength of this herbicide is its use as a habitat modifier, including thinning sagebrush to improve sage-grouse habitat. It is relatively non-selective but does not tend to harm grasses present. Therefore, impacts to wild horses and burros would be unlikely with intended use of this herbicide.

Impacts of Forest Service-evaluated Herbicides

The following information for eight herbicides proposed for use by the BLM is taken from ERAs performed by the Forest Service to support assessment of the environmental consequences of using these herbicides in Forest Service vegetation management programs (risk assessment results available at USDA Forest Service (2004) and SERA (2005a). Because the Forest Service completed these ERAs prior to completion of the PEIS, the BLM would use these ERAs to assess the potential ecological impacts of using these herbicides in future BLM vegetation management activities. The BLM previously evaluated and approved these eight herbicides in an earlier EIS—*Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a). As part of their risk assessments (see USDA Forest Service 2005), the Forest Service developed worksheets (see SERA 2005b), which allowed the BLM to assess risks of the herbicides using their own maximum application rates and LOCs (rather than the Forest Service rates and LOCs), allowing the risk assessments process for the Forest Service-evaluated herbicides to parallel the BLM process as much as possible. However, modeled risk scenarios for terrestrial animals may be different than used for the BLM-evaluated herbicides, depending on the specificity of available toxicity data. The assessment of impacts below is presented using the Forest Service upper estimates of HQs, to maximize the conservatism of the assessment. In addition to this, it should be noted that the development of HQs by the Forest Service (as well as the BLM) is already conservative for many reasons (e.g., assumption of 100% dermal absorption, assumption of 100% of diet contaminated, use of most sensitive values for exposure and dose/response assessments). 2,4-D, clopyralid, glyphosate, metsulfuron methyl, and triclopyr are the Forest Service-evaluated herbicides that are most likely to be used in rangeland situations with grazing wild horses and burros however, it is possible that other herbicides used nearby could impact wild horses and burros if they are transported off site.

2,4-D

2,4-D could present risk to some wild horses and burros as a result of direct spray as well as ingestion scenarios (Table 4-26; SERA 1998). Direct spray of 2,4-D results in moderate risk to small mammals at both the typical and maximum application rates, assuming 100% absorption of the herbicide. Small mammals face low risk from direct spray, assuming 1[st] order dermal absorption. Adult wild horses and burros may face less risk of direct spray than young wild horses and burros because they have a smaller surface area to volume ratio over which to absorb the herbicide. Direct spray impacts to wild horses and burros can largely be prevented if animals are removed from target areas before spraying 2,4-D. In addition, wild horses and burros face risk from the consumption of vegetation contaminated by 2,4-D at the application site: large mammals face moderate acute and chronic risk at both the typical and maximum application rates and small mammals face low acute risk at the typical and maximum application rates. Large wild horses and burros that primarily consume grasses are particularly susceptible to risk from the vegetation consumption scenarios. However, long-term consumption of contaminated vegetation may be unlikely if the vegetation shows signs of damage. The risk assessment suggests that because large wild horses and burros eating large quantities of grass and other vegetation could be at risk from routine exposure to 2,4-D and because 2,4-D is considered for use in rangeland, this herbicide should not be applied over large application areas where foragers would only consume contaminated food.

Clopyralid

According to the Forest Service risk assessment (SERA 2004b), clopyralid would not likely result in risk to terrestrial animals; however there were a few scenarios that resulted in potential low acute risk to wild horses and burros at the typical and maximum application rates. Small mammals are at risk from 100% absorption of direct spray and consumption of contaminated insects, and large wild horses and burros face risk from the consumption of contaminated vegetation. Application of clopyralid at the maximum application rate also poses low chronic risk to large wild horses and burros consuming on-site contaminated vegetation. The most likely risk scenario would be the consumption of contaminated grass across large areas by wild horses and burros, and this scenario can likely be avoided by restricting access of these animals to sprayed areas. In addition, all risks identified fall within the lowest risk category.

Glyphosate

Wild horses and burros would face some risk from the use of glyphosate in rangelands. Direct spray of a small animal, assuming 100% absorption, results in low risk at the typical application rate and moderate risk at the maximum application rate (SERA 2003b). Smaller wild horses and burros are likely to experience greater risk from direct spray than larger wild horses and burros, because of their larger surface area to body weight ratios. Direct spray impacts can largely be prevented if wild horses and burros are removed from the target area before spraying glyphosate. The large mammal consuming contaminated vegetation faces low acute risk at the typical application rate, moderate acute risk at the maximum application rate, and low chronic risk at the maximum application rate; and the small mammal faces low risk from consumption of contaminated vegetation at the maximum application rate. The most likely risk scenario is the acute consumption of contaminated vegetation, which is particularly risky for herbivores that consume large amounts of grasses, which contain higher herbicide residue levels than herbaceous vegetation or seeds. Glyphosate is used in rangelands for the management of grasses and broadleaves, including woody species. It is non-selective, suggesting that spot applications in rangeland would be the most appropriate use of this herbicide, which would reduce risks of consumption of contaminated vegetation as fewer non-target areas would be impacted by direct spray or spray drift.

Hexazinone

At the typical and maximum application rates, several scenarios could potentially result in low to moderate risk to wild horses and burros (SERA 1997). Small mammals face low risk of direct spray at the maximum application rate, assuming 1[st] order dermal absorption, and low to moderate risk assuming 100% dermal absorption. Acute consumption of contaminated vegetation results in low risk to the small mammal at the maximum application rate; and acute and chronic consumption of contaminated vegetation result in moderate risk to the large mammal. Also, acute consumption of contaminated water results in low risk to the small mammal at the maximum application rate. It appears that wild horses and burros would be at risk from the application of hexazinone, but if food and water sources are not contaminated, risks would be reduced, and direct spray could be avoided by removing wild horses and burros from the target area prior to applying hexazinone. Contamination of food and water sources could be minimized by utilizing spot applications of hexazinone at the typical application rate. Because hexazinone is used for woody species, it would not likely be applied in rangelands where invasive plants are usually grasses or herbs. In addition, hexazinone is semi-selective, and is typically only applied in spot applications; therefore, risks to wild horses and burros under normal application may be lower than predicted by the risk assessment.

Imazapyr

At the typical application rate, no scenarios would likely result in risk to wild horses and burros (SERA 2004e). At the maximum application rate, however, a couple scenarios result in low risk to wild horses and burros: direct spray of the small animal and consumption of contaminated vegetation by the large mammal. Imazapyr is not registered for use in rangelands; therefore, it is unlikely that impacts via direct spray or consumption of contaminated vegetation would occur. The chance of this could be further minimized by removing wild horses and burros from areas nearby to application sites prior to spraying and by observing appropriate buffer zones from HMA vegetation when applying imazapyr (see Vegetation section in this chapter).

Metsulfuron Methyl

Wild horses and burros would face minimal risk from the application of metsulfuron methyl. None of the HQs estimated for metsulfuron methyl exposure at the typical application rate indicate risk to any of the terrestrial animal receptors (SERA 2004f). At the maximum application rate, metsulfuron methyl results in low risk to small animals via 100% absorption of direct spray and to large mammals via consumption of contaminated vegetation. Metsulfuron methyl is registered for use in rangeland, but impacts to wild horses and burros would be unlikely if the typical application rate was used, and if the maximum application rate was used, impacts to wild horses and burros could be avoided by removing wild horses and burros from application areas prior to spraying metsulfuron methyl and by limiting the size of the application area or restricting access of wild horses and burros to recently sprayed areas to prevent consumption of large amounts of sprayed vegetation.

Picloram

Application of picloram would not likely impact wild horses and burros. Most of the HQs for the evaluated scenarios of picloram exposure were below the LOC for both the typical and maximum application rates (SERA 2003c). Two scenarios were elevated above the LOC, resulting in low to moderate risk at the typical and maximum application rates: 100% absorption of direct spray by the small animal and acute consumption of contaminated vegetation by the large mammal. Picloram is registered for use in rangeland, and it could be applied over large areas as its primary targets are broadleaf and woody species; therefore it could be used to manage certain broadleaved plants without impacting native or desirable grasses. Impacts to wild horses and burros could be avoided by removing animals from application areas prior to spraying picloram and by limiting the size of the application area or restricting access of wild horses and burros to recently sprayed areas to prevent consumption of large amounts of sprayed vegetation.

Triclopyr

Triclopyr presents some risk to wild horses and burros, particularly through the consumption of contaminated vegetation (SERA 2003d). Risk categories resulting from calculated HQs for the two evaluated formulas of triclopyr (triclopyr acid and triclopyr BEE) are the same, and therefore no differentiation will be made between these two formulas in this section. The following scenarios result in low risk at the typical application rate and moderate risk at the maximum application rate: 1st order and 100% absorption of direct spray by the small mammal, and acute and chronic consumption of on-site contaminated vegetation by the large mammal. In addition, at the maximum application rate, low risk results from acute consumption of water contaminated by a spill by the small mammal and chronic consumption of off-site contaminated vegetation by the large mammal. No risk is predicted for small mammals as a result of acute or chronic consumption of contaminated vegetation or water. Triclopyr can be used in rangeland to selectively manage woody species without impacting native or desirable grasses. It also has low residual activity. Impacts to wild horses and burros could be avoided by removing animals from application areas prior to spraying triclopyr and by limiting the size of the application area or restricting access of wild horses and burros to recently sprayed areas to prevent consumption of large amounts of sprayed vegetation. Because large wild horses and burros are susceptible to impacts from long-term consumption of vegetation contaminated by triclopyr, it would be important to limit exposure of wild horses and burros to sprayed vegetation until residual activity has tapered off, particularly since sprayed grasses may not show signs of damage.

Impacts by Alternative

The following discusses the expected effects of each of the five alternatives on wild horses and burros, and compares the effects expected under each alternative with those expected under the other alternatives. These effects may vary depending on the percentage of acres treated using different application methods and different herbicides, as well as on the size of treatment events.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue its ongoing vegetation treatment programs in 14 western states, and would be able to use 20 herbicides previously approved under earlier RODs. Herbicide use under the No Action Alternative could impact wild horses and burros over an estimated 300,000 acres. The nature of impacts to wild horses and burros (positive and negative) would be similar to those that have occurred in the past 10 years. Negative impacts to wild horses and burros may be lower than under the other herbicide-use alternatives because fewer total acres would be treated using herbicides.

Long-term positive impacts on wild horse and burro communities (i.e., improvements in rangeland forage) could be lower under this alternative than the other herbicide-treatment alternatives. Under the No Action Alternative, invasive plant populations would likely continue to expand at the current rate or more quickly, potentially increasing damage to desirable native forage, and the abundance of unpalatable or toxic plants.

Three-fourths of wild horses and burros are found in Nevada, Utah, and Wyoming (see Table 3-7), and about 82,000 acres of vegetation would be treated in these states using herbicides. Of these acres, over 40% would occur in evergreen shrublands (primarily sagebrush), 19% would occur in annual and perennial grasslands (e.g., meadows, grasslands, and prairies), 18% would occur in perennial forb communities (treatments associated with non-native forbs including knapweed, thistles, and leafy spurge), and 4% each would occur in evergreen woodlands (primarily pinyon-juniper and pine forest treatments) and in riparian/wetland habitats. The focus of these treatments would be to remove and control invasive vegetation and improve native shrubland and grassland communities, to the benefit of wild horses and burros. Wild horses favor native grasses, including bluebunch wheatgrass, western wheatgrass, Indian ricegrass and blue grasses, and riparian/wetland vegetation, including sedges. Wild burros feed on a variety of plants, including grasses, Mormon Tea, Palo Verde, and plantain. Treatments that improve range habitat should benefit the plant species.

Because the new herbicides proposed in this PEIS (diquat, fluridone, imazapic, and Overdrive®) would not be used under this alternative, risks to wild horses and burros would be different than under the other alternatives. Fluridone and imazapic do not present any risks to wild horses and burros in modeled scenarios (similar to chlorsulfuron, metsulfuron methyl, and sulfometuron methyl), and Overdrive® poses a low to moderate risk to large wild horses and burros under a chronic exposure scenario in which the animal ingested contaminated vegetation over a long time period. Diquat is fairly toxic to wild horses and burros, particularly under food ingestion scenarios (similar to 2,4-D and diuron); however, diquat is an aquatic herbicide, and frequent exposure to wild horses and burros would not be expected. Therefore, the No Action Alternative would prevent the use of a greater repertoire of herbicides that are not injurious to terrestrial animals, possibly increasing per area risks to wild horses and burros if more injurious herbicides are used instead (e.g., 2,4-D, bromacil, diuron, tebuthiuron, triclopyr), as well as decreasing the possibilities of more effective rangeland improvements. However, elimination of diquat from use, particularly in rangeland riparian areas could somewhat decrease per area risk to wild horses and burros.

2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine were approved for use in the earlier BLM EISs, but the BLM has not used any of these herbicides, except fosamine (< 50 acres annually) since 1997, and does not plan to utilize them in the near future. None of these herbicides would normally be used in rangeland treatments where wild horses and burros might come into contact with the chemical. Instead, the BLM would use other herbicides, including triclopyr, sulfometuron methyl, bromacil, diuron, and Overdrive®, which are effective in controlling weeds and invasive vegetation, but have less risk to wild horses and burros.

The BLM would not be able to use herbicides in Alaska, Nebraska, and Texas under the No Action Alternative, but would be able to conduct herbicide treatments in these states under the other herbicide-treatment alternatives. No wild horses or burros use lands in these states.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

The Preferred Alternative would result in the treatment of approximately 932,000 acres in 17 western states. In addition to the 14 previously approved herbicides, the BLM would be able to use the four new herbicides evaluated in this PEIS. This alternative would result in the most extensive effects to wild horses and burros (both negative and positive) because it proposes the most acres for treatment (3 times the acreage that would be treated under the No Action Alternative). The extent of positive and negative impacts to wild horses and burros would depend on the relative amount each of the herbicides was used, and whether they would be applied in rangeland environments, and the method of application. The chance for negative impacts would be highest if diuron, diquat, bromacil and/or 2,4-D were used extensively. However, diquat, an aquatic herbicide, and bromacil and diuron, non-selective herbicides, are not likely to be used extensively in rangelands. If these herbicides were used in restricted scenarios, as is proposed, and other herbicides are used effectively to increase the abundance of native forage relative to unpalatable weeds, positive impacts to wild horses and burros could outweigh negative impacts.

Because more acres would be treated under this alternative, benefits to wild horses and burros from improved rangeland and riparian conditions should be much greater than under the other alternatives. Over 375,000 acres are proposed for treatment using herbicides in Nevada, Utah, and Wyoming, states with the largest populations of wild horses and burros. The percentage of treatments occurring in plant communities would be similar to that of the No Action Alternative (43% of acres treated would occur in evergreen shrublands, 19% in annual and perennial grasslands, 18% in perennial forb communities, and 9% in evergreen woodlands, but 4 times as many acres would be treated in these states under this alternative.

Furthermore, the ability to use the four new herbicides (diquat, fluridone, imazapic, and Overdrive®) as well as future herbicides that become registered with the USEPA would allow BLM managers more options in choosing herbicides that best match treatment goals and application conditions and are less toxic. As a result, there could be an increase per capita benefits and a reduction in overall per capita risks to wild horses and burros (three of the four new herbicides present little to no risk to wild horses and burros) and an increase in habitat and ecosystem benefits from treatment. This alternative would also reduce risks and negative impacts associated with other vegetation management methods (e.g., risk of escaped prescribed fires; see the PER).

Alternative C – No Use of Herbicides

Under Alternative C, wild horses and burros would not be affected by herbicide use. Primary impacts would stem from other vegetation treatment methods (see the accompanying PER; USDI BLM 2005a). Positive benefits to rangelands as a result of vegetation management could be reduced under this alternative, as certain invasive species are only effectively controlled by herbicides, and in some situations other methods are impractical due to cost, time, or public concerns. For example, mechanical and manual methods are impractical over large land areas, which are more effectively treated by broadcast herbicide applications. In addition, it is often difficult to eradicate some species (e.g., rabbitbrush, honey mesquite, sand shinnery oak, cholla), such as shrubs that resprout from rhizomes, by means other than herbicide application. Similarly, pre-emergent herbicides that persist in the soil are the most effective means of controlling invasive plants with seeds that remain viable for long periods of time.

Under this alternative, without the use of herbicides, invasive plant populations would likely continue to spread, possibly at increasing rates, and cause further damage to susceptible native vegetation communities including rangeland forage for wild horses and burros, particularly in areas and for species where other treatment methods are not effective or possible (e.g., large tracts of rangeland or grassland dominated by invasive, resprouting shrubs or without enough fine fuels to carry prescribed fires). The spread of invasive weed populations would likely have deleterious effects on wild horses and burros. For example, rangeland within HMAs that contains excessive or unpalatable brush cover is not useful for grazing. However, it is uncertain how potential negative impacts from this alternative (mostly indirect) would compare with negative direct and indirect impacts from herbicide use.

Alternative D – No Aerial Applications

Alternative D would be the same as the Preferred Alternative as far as herbicides that could be used, and areas that could be treated. Therefore, both alternatives would be equally likely to have both positive and negative effects on wild horses and burros and rangeland. The BLM would be able to choose from a suite of currently-approved herbicides and herbicides that could be approved under this PEIS, or in the future.

However, this alternative would not allow the BLM to apply herbicides aerially. Fewer acres would be treated (540,040 acres) because some large areas, including rangelands, cannot be effectively treated by ground application methods. However, acres proposed for aerial treatments comprise only about 20% of all acres proposed for treatment in the primary wild horse and burro states—Nevada, Utah, and Wyoming. And of these acres, about 65% of aerial treatments in these states would occur in evergreen shrublands, and 13% in evergreen woodlands, habitats that provide less value to wild horses and burros than grassland and riparian habitats.

This alternative would substantially reduce the impacts of off-site drift to wild horses and burros, an exposure scenario that is not specifically modeled for most herbicides (consumption of contaminated vegetation off-site was modeled for most of the Forest Service herbicides, with no risk demonstrated to wild horses and burros for any of these herbicides, except triclopyr at the maximum application rate). Conversely, without the option to spray herbicides aerially, large areas of rangeland may remain untreated under Alternative D, and which could negatively impact wild horse and burro habitat and forage in these areas over the long term.

Under this alternative, long-term negative impacts to rangeland could be greater than any potential short-term negative effects to wild horses and burros that would result from aerial applications, particularly given that wild horses and burros would likely not be removed from rangeland application areas before aerial spraying. Furthermore, most of the herbicides that are potentially damaging to wild horse and burro (e.g., bromacil, diquat, diuron, glyphosate, hexazinone, tebuthiuron) are not likely to be applied aerially in rangelands, and aerial spraying of other damaging herbicides (e.g., 2,4-D, Overdrive®) could be avoided. In addition, direct and indirect impacts from other vegetation treatment options could increase if these methods were used more extensively to compensate for the reduced number of acres treated by herbicides (see PER).

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Approximately 466,000 acres would be treated under Alternative E, which is slightly less than the acreage that would be treated under Alternative D, and less than half of the acreage that would be treated under the Preferred Alternative, but is still be an increase from the average annual treatment acreage that has occurred over the past 8 years and would likely occur under the No Action Alternative. Herbicide-related impacts to wild horses and burros would be lower under this alternative than under the Preferred Alternative because fewer acres would be treated with herbicides, and additional protective standards would be required during herbicide treatment (e.g., preferential use of spot rather than broadcast applications, preferential treatment of small versus large infestations).

Sulfonylurea herbicides and other ALS-inhibiting herbicides (e.g., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, sulfometuron methyl) block the synthesis of amino acids that are required for protein production and cell growth, thereby resulting in plant death. ALS-inhibiting herbicides would not be used under this alternative because data suggest they have the potential to damage off-site native and crop plant species under the right conditions of environment and application. These herbicides are biologically active at low concentrations, and are applied at lower application rates than other herbicides to manage target plants. It is uncertain whether these lower application rates would result in fewer cases of unintended damage to wild horses and burros and rangeland or more cases due to the high potency of the herbicides and their persistence. In 1981, the Environmental Effects Division of the USEPA did recommend against registering sulfonylurea herbicides because they persist for long periods of time in the environment and they cannot be detected at low levels. However, in this assessment, none of the ALS-inhibiting herbicides resulted in risk to wild horses and burros at the typical application rate under any of the modeled scenarios, suggesting that the elimination of these herbicides would not benefit wild horses and burros and could indirectly harm wild horses and burros if more toxic herbicides were used in their place.

Alternative E incorporates other management practices that would be likely to have positive impacts on wild horses and burros and rangelands. Alternative E would limit the use of broadcast applications, which would reduce the possible risks to wild horses and burros associated with off-site drift and consumption of vegetation across large areas; however these applications would be available for use in appropriate situations (i.e., where no other method is practical and susceptible non-target plant species and aquatic areas are distant from the application area), which would allow some positive ecosystem benefits from larger-scale herbicide applications. While per-treatment ecosystem benefits may be greater under Alternative E than under the other herbicide-use alternatives as a result of this ecosystem-based management approach, overall positive vegetation and ecosystem benefits (that cannot be attained by other treatment methods) across the western states would be lower under this alternative because of the relatively low treatment acres and the inability to use certain practices in situations that might require their use (e.g., use of ALS-inhibitor herbicides on highly aggressive weeds). For example, imazapic, which has been shown to be effective in treating downy brome and leafy spurge, would be unavailable under this alternative. The BLM would also be unable to use chlorsulfuron and metsulfuron methyl to control yellow starthistles and several species of thistles that are harmful to wild horses and burros.

Mitigation for Herbicide Treatment Impacts

The following actions would greatly reduce the risk of herbicide applications to wild horses and burros:

- Apply diuron, glyphosate, hexazinone tebuthiuron, and triclopyr at the typical application rate to minimize risks to wild horses and burros.
- Do not apply 2,4-D, bromacil, diuron, Overdrive®, picloram, or triclopyr across large application areas to limit impacts to wild horses and burros, particularly through the contamination of food items, where feasible.
- Where practical, limit glyphosate and hexazinone to spot applications in rangeland to avoid contamination of food items.
- Do not aerially apply diquat directly to wetlands and riparian areas.
- Do not apply bromacil and diuron in grazing lands within HMAs and use appropriate buffer zones (see Vegetation section) to limit contamination of vegetation in off-site foraging areas.
- Do not apply 2,4-D, bromacil, or diuron at typical application rates, and these herbicides and Overdrive® and hexazinone at maximum application rates, in HMAs during the peak foaling season (March though June, and especially in May and June).

Paleontological and Cultural Resources

Invasive plants may have long-term negative impacts on paleontological and cultural resource sites by altering native vegetation and increasing the potential for soil erosion, potentially leading to the loss of paleontological and cultural resources. In addition to limiting these impacts, removal of invasive vegetation would contribute to the restoration and maintenance of historic and ethnographic cultural landscapes (USDI National Park Service 2003).

Herbicides could harm traditional use plants, or threaten the health of the people gathering, handling, or ingesting recently treated plants, fish, or wildlife that are contaminated with herbicides (BPA 2000). Since roots and other plant materials harvested by Native peoples are often found in close proximity to weed treatment areas, the potential exists for herbicides to drift from treatment areas onto areas used by Native peoples (ENSR 2001). In some cases, vegetation important to Native peoples, including juniper, may be treated in areas where these plants are invasive and crowding out more desirable vegetation.

Scoping Comments and Other Issues Evaluated in the Assessment

Some respondents felt that cultural preservation is an important issue, and encouraged addressing the impacts to cultural and archaeological sites. Other respondents suggested that traditional cultural properties should be properly safeguarded, and treatments should be completed in a way that is sensitive to cultural resources. There was concern about the effects of herbicides on basket plants and the people who collect them, in particular Native Americans. Respondents noted that fire generally helps these basket plants, while herbicides are detrimental.

Standard Operating Procedures for Addressing BLM Actions on Paleontological, Cultural, and Subsistence Resources

Before proceeding with vegetation treatments, the effects of BLM actions on cultural resources would be addressed through compliance with the NHPA, as implemented through a national Programmatic Agreement (*Programmatic Agreement among the*

Bureau of Land Management, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers Regarding the Manner in Which BLM Will Meet Its Responsibilities Under the National Historic Preservation Act) and state-specific protocol agreements with SHPOs. Effects on paleontological resources would be addressed as outlined in resource management plans developed under the authority of the FLPMA and site specific NEPA documents developed for vegetative treatments. The BLM's responsibilities under these authorities are addressed as early in the vegetation management project planning process as possible.

The processes for identifying and managing cultural resources are addressed in USDI BLM manuals 8100 *(The Foundations for Managing Cultural Resources)*, 8110 *(Identifying and Evaluating Cultural Resources)*, 8120 *(Tribal Consultation under Cultural Resource Authorities)*, 8130 *(Planning for Uses of Cultural Resources)*, 8140 *(Protecting Cultural Resources)*, and Handbook H-8120-1 *(Guidelines for Conducting Tribal Consultation)*. Processes for identifying and managing paleontological resources are outlined in Manual 8270 (*Paleontological Resource Management*). The BLM Cultural Resource Management program is responsible for the study, evaluation, protection, management, stabilization, and inventory of paleontological, historical, and archeological resources. The program also ensures the close consultation with Native American tribal and Alaska Native group governments, as required by law, for the maintenance, preservation, and promotion of native cultural heritage and resources, including plant and animal subsistence resources and the use of vegetation for religious and ceremonial purposes. The BLM initiated consultation with Native American tribes and Alaska Native groups to identify their cultural values, religious beliefs, traditional practices, and legal rights that could be affected by BLM actions. Consultation included sending out letters to all tribes and groups that could be directly affected by vegetation treatment activities, and requesting information on how the proposed activities could impact Native American and Alaska Native interests, including the use of vegetation and wildlife for subsistence, religious, and ceremonial purposes (see Appendix F).

Paleontological Resources

The processes for identifying paleontological resources will include consultation with BLM regional paleontologists, paleontology program contacts in BLM field offices, State geological survey agencies, local colleges, universities or museums, or SHPOs (if individual SHPO's deal with fossil resources) as part of the planning process. Procedures will be developed for protecting significant fossil resources as outlined in BLM Handbook 8270-1 (*General Procedural Guidance for Paleontological Resource Management)*. Resource Management Plans may be in place that have classified sensitivity levels for important fossil resources and management prescriptions associated with each sensitivity level. Specific protective measures for paleontological resources would be identified at the local level during project development. If RMPs lack this classification scheme, project specific analysis would be needed to assess the need to conduct paleontological resource inventories based on available information. If a project area contained documented known locations with paleontological resources within the proposed project area, or had geological or geomorphic characteristics likely to contain vertebrate fossils, a field inventory could be required to locate and report previously unrecorded paleontological resources. Site specific mitigation measures would be developed during the implementation stage of the vegetation treatments if needed.

Cultural Resources

Treatment methods will follow standard procedures in identifying cultural resources for compliance with Section 106 of the NHPA, as implemented through the Nationwide Programmatic Agreement and state protocols. The process includes necessary consultations with SHPOs and interested tribes and Tribal Historic Preservation Offices (THPOs), where they are in place, at the state or local level as projects are planned.

As part of the process of preparing for vegetation treatments, cultural resource specialists will identify historic properties eligible for the NRHP. Historic properties may include any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP. Impacts to National Register-eligible cultural resources can be avoided through project redesign or can be mitigated through recordation, data recovery, monitoring, or other appropriate measures. When National Register-eligible cultural resources are discovered during vegetation treatment, appropriate actions will be taken to protect these resources or recover data following consultation processes. An important concern regarding the presence of non-cultural resource personnel on the ground during any of the treatment processes is the unauthorized collection of artifactual material, especially from National Register-eligible properties. Procedures will be developed as part of an unanticipated discoveries plan that will include reporting previously unrecorded cultural resources to local BLM professionals.

Subsistence Resources

Discussions will be held with Native American tribes and Alaska Native groups to determine which plants that could be affected by proposed project treatments have traditional lifeway values and whether there are specific, traditional collecting areas. Target plants include oak, juniper, pinyon, lodgepole pine, cottonwood, mesquite, amaranth, cattail, and bracken fern. These trees, shrubs, and plants or their fruits and seeds are traditionally used for subsistence, clothing, basketry, shelter, utilitarian items, and possibly medicines by one or more tribes or groups in the western U.S. and Alaska. Since other target species have common names similar to those of some plants used traditionally, such as whorled milkweed or giant reeds, the difference should be explained to Native Americans and Alaska Natives in those areas where treatments are planned. Treatments of plants that are important to maintaining traditional lifeways may need to be modified or cancelled in certain areas. On the other hand, there may be long-term benefits such as reducing or eliminating non-native or invasive plant competitors that would allow proliferation of traditionally used native species.

Herbicide Impacts on Paleontological and Cultural Resources

Paleontological Resources

The effect of herbicide treatments on fossil material would vary with respect to: (1) fossil type; (2) minerals; (3) degree of fossilization; and (4) whether the fossil is exposed or buried. Although it may be possible for chemicals found in herbicides to impact unique fossil material, herbicide treatments are more likely to affect researchers, students, or other field personnel conducting paleontological research than the paleontological resources. More likely, damage to fossil materials, if present, would result from the use of wheeled equipment used to apply herbicides. The potential for impacts to fossils would depend on the attributes of the fossil material, whether the fossil is buried or exposed, and the method of herbicide application. Methods involving the use of vehicles driving cross-country would potentially crush fossil material exposed on the surface.

Cultural Resources

While herbicide treatments may affect buried organic cultural resources, they are more likely to have a negative effect on traditional cultural practices of gathering plant foods or materials important to local tribes or groups. The effect of herbicide treatments on cultural resources depends on the method of herbicide application and the herbicide type used. Some chemicals can cause soil acidity to increase, which would result in deterioration of artifacts—even some types of stone from which artifacts are made. Application of chemical treatments can also result in impacts such as altering or obscuring the surfaces of standing wall masonry structures, pictograph or petroglyph panels, and organic materials. While chemicals may affect the surface of exposed artifacts, they can generally be removed without damage if treated soon after exposure. Organic substances used as inactive ingredients in herbicide formulations, such as diesel fuel or kerosene, may contaminate the surface soil and seep into the subsurface portions of a site. These organic substances could interfere with the radiocarbon or Carbon 14 (C-14) dating of site (USDI BLM 1991a).

Depending on the selected application method for herbicide treatment plans, there may be limited control in avoiding plants identified by Native American tribes and Alaska Native groups as being important in traditional subsistence, religious, or other cultural practices. Consultation would be undertaken with tribes and groups to locate any areas of vegetation that are of importance to the tribe and that might be affected by chemical treatments. Certain chemical treatments could also pose a possible health risk, through residues left on plants used as traditional foods or for ceremonial purposes, or as a result of contaminating other food sources or drinking water, as discussed below. A study to assess the exposure of basketweavers to forestry herbicides showed that detectable residues of herbicides were found on 49% of plant materials used by Native Americans inside treatment areas, but only 3% outside of treatment areas, and that residues continued to be detected for several months (Segawa et al. 1997). However, a study of herbicide uptake by lomatium and bitterroot roots in rangeland treated with picloram and sulfometuron methyl showed that no herbicide residues were found in roots at 2, 6, and 45 weeks after treatment (ENSR 2001). Thus, risks would vary depending upon the time of plant use and herbicide treatment, and the portions of the plants that are used.

Herbicide Impacts on Native American Health

Exposure Characterization

The potential risks to Native Americans from exposure to herbicides used in BLM programs were evaluated separately from other public receptors (see Human Health and Safety section in this chapter). Native Americans could have higher levels of exposure to herbicides as a result of subsistence and cultural activities such as plant gathering and consumption of fish caught in local streams; therefore, risk levels determined for Native American receptors reflect unique exposure scenarios as well as typical scenarios for public receptors, but with higher levels of exposure than general public receptors.

The BLM risk assessments assume that the Native American receptors (154 pounds adult and 33 pounds child) are exposed to herbicides via dermal contact with spray, dermal contact with sprayed foliage, ingestion of drinking water from a sprayed pond, ingestion of berries containing spray, dermal contact with water in a sprayed pond, and ingestion of fish from a sprayed pond.

Dermal Contact

For potential herbicide contact, the risk assessments assume the 50th percentile surface area of the Native American's lower legs, lower arms, and hands are exposed (i.e., 698 in^2 for adult men and women and 249 in^2 for children [USEPA 1997]), and that Native American receptors contact foliage for 3 hours per day of subsistence activities (Harper et al. 2002). A dermal transfer coefficient value—to estimate the amount of herbicide transferred from foliage to skin—at the high end of the range was used for harvesting blueberries (i.e., 232 in^2/hour for the adult [USEPA 2000b] and 47 in^2/hour for the child based on the child to adult surface area ratio [CalEPA 1996]). The USEPA (2001c) recommends an exposed surface area of 2,790 in^2 for an adult swimmer and 1,023 in^2 for a child swimmer. Because no specific data were available regarding surface area, these estimates were used to evaluate the Native American child and adult in the HHRA. The exposure time for swimming is assumed to be 2.6 hours/day in accordance with Harris and Harper (1997) which results in a swimming exposure frequency of 2.6 hours/day for 70 days/year. Incidental ingestion during swimming was not evaluated for the Native American since it is assumed that the pond is also used as a source of drinking water; any incidental ingestion during swimming is therefore included in the drinking water scenario.

Ingestion

Risk assessments assume that adult Native Americans ingest 1 quart of water per day (Harper et al. 2002) from the sprayed pond, and Native American children consume half the adult rate, resulting in 0.5 quart/day from a sprayed pond. The berry ingestion rate was developed from information provided in Harper et al. (2002), which lists an ingestion rate of 0.7 lbs/day for an adult for aboveground gathered terrestrial vegetation for the Native American Spokane tribe. Berries are likely to be a small fraction of this 0.7 lbs/day. However, since this rate was not subdivided into additional categories, it was conservatively assumed that the ingestion rate for berries is 0.7 lbs/day for an adult Native American. For the Native American child, the ingestion rate was scaled by body weight (i.e., 0.7 lbs/day x 33 lbs / 154 lbs) to 0.15 lbs/day (per CalEPA 1996). The adult fish ingestion rate was assumed to be 2 lbs/day based on a high fish diet scenario discussed in Harper et al. (2002). The high fish diet consists primarily of fish, supplemented by big game, aquatic amphibian/crustacean/ mollusks, small mammals, and upland game birds. This value is much higher than the 95th percentile fish ingestion rate of 0.4 lbs/day recommended in USEPA (1997) for a Native American subsistence population. For the Native American child, the ingestion rate was scaled by body weight (i.e., 1.9 lbs/day x 33 lbs / 154 lbs) to 0.4 lbs/day (per CalEPA 1996).

The Forest Service risk assessments evaluated risk to Native Americans—in addition to typical risk for public receptors—for the scenarios of acute and chronic consumption of contaminated fish.

Risk Characterization

Native American adults face the same risks that public receptors face, as well as additional risks to some herbicides as a result of unique subsistence practices or increased time spent in treated areas. Native American adults face risk from exposure to diquat when accidentally spilled or applied at the maximum rate (low risk) and from the consumption of fish contaminated with 2,4-D (high risk), hexazinone (moderate to high risk), or picloram (low risk). Native American children face risk when diquat is applied at the typical rate and fluridone is accidentally spilled; and risk from berry picking in an area sprayed with diquat at the typical rate. Both Native American adults and children residing near the treatment area would face additional risks (i.e., low risk from diquat at the typical and maximum rates and moderate risk from diquat when accidentally spilled; low risk from fluridone at the maximum rate and when accidentally spilled). See the Vegetation, Fish and Aquatic Invertebrates, Wildlife, and Human Health and Safety sections in this chapter for more information on the risks of herbicides to Native Americans and the resources they use.

Impacts by Alternative

The following is a discussion of how risk from herbicides would vary under each herbicide treatment alternative.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Of the herbicide treatment alternatives, the lowest number of acres would be treated under the No Action Alternative; therefore, levels of risk to paleontological and cultural resources, and health risk to Native Americans, Alaska Natives, and other human receptors would be lower than under the other herbicide treatment alternatives. If greater numbers of acres were to be treated by other vegetation management methods (e.g., prescribed fire, manual, mechanical, or biological treatments) under the No Action Alternative, then the risks from these methods would also have to be considered (see the associated PER; USDI BLM 2005a). In addition, the new herbicides proposed in this PEIS (diflufenzopyr+dicamba [Overdrive®], diquat, fluridone, and imazapic) would not be used. Of these new herbicides, diquat poses a high risk to humans; however, diflufenzopyr, dicamba, and imazapic are all relatively safe to humans, with no potential adverse effects evident from the human health risk characterization, except in cases of unlikely accidental scenarios for dicamba. Of the 20 previously-approved herbicides, only four (clopyralid, imazapyr, metsulfuron methyl, and sulfometuron methyl) have negligible to low risks to humans. Therefore, failure to approve the four new herbicides would limit the options for treatment of vegetation without appreciable risk to humans. Thus, the risk to humans per each herbicide application may be greatest under the No Action Alternative.

This alternative may be less successful in controlling weeds and poisonous plants that adversely affect humans, especially weeds most effectively controlled by the four newly proposed herbicides. Weeds and other invasive vegetation can displace native species that may be desirable to Native Americans, and may provide poorer quality forage and cover for wildlife used by Native American tribes.

Under the No Action Alternative, the BLM would be able to continue to use six herbicides that were approved for use under earlier BLM vegetation treatment RODs—2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine. Except for fosamine, which has been used on < 50 acres annually, these chemicals have not been used by the BLM since 1997 and are not proposed for use under the other herbicide treatment alternatives. It is unlikely that these chemicals would be used under the No Action Alternative, as well.

In 1998, the BLM conducted a literature review to determine if the earlier vegetation treatment ROD conclusions for asulam, atrazine, mefluidide, and simazine were justifiable based on past and 1998 toxicology and risk assessment procedures; a literature review was not done for 2,4-DP and fosamine, but these herbicides were analyzed in the *California Vegetation Management Final EIS* (USDI BLM 1988a, McMullin and Thomas 2000). This assessment was based on a literature search and California EIS to identify potential human health risks. Based on this analysis, it was determined that systemic risks from using asulam may be greater than were projected in the earlier EIS, but that risks to humans from the other three herbicides were similar to, or less than, those identified in earlier EISs. Based on the earlier EISs, literature reviews done for the BLM, and other studies, the risks to humans would be low for asulam, fosamine, and mefluidide, low to moderate for 2,4-DP, and simazine, and moderate to high for atrazine (USEPA 1995d). The BLM uses sulfometuron methyl, bromacil, and diuron in treatment situations where it used atrazine in the past, and triclopyr instead of fosamine. These substitute herbicides have similar, or lower, risks to humans than the herbicides they would replace.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Because of the large number of acres treated, this alternative would likely result in the most overall risk to paleontological and cultural resources and human health. The number of acres treated using ground-based application methods would be higher under this alternative and Alternative D than under the other alternatives, increasing the risk of damage to paleontological and cultural resources from equipment.

However, human health could benefit from a reduction in the noxious weeds and poisonous plants that adversely affect humans, which would likely occur under this alternative. In addition, this alternative would include the use of the new herbicides evaluated in the BLM HHRA (ENSR 2005l). Of these four herbicides, three appear to be relatively harmless to humans; therefore, the use of these herbicides would increase the options for appropriately managing vegetation while minimizing the risk to human receptors. It is suggested that diquat be used only in very limited scenarios at the typical application rate and where risk to human receptors is not predicted, such as ground applications from trucks not near residences or berry gathering sites. 2,4-D, glyphosate, picloram, and tebuthiuron would be used for about 70% of herbicide treatments. There is low risk to human health at normal application rates from use of glyphosate, picloram, and tebuthiuron, but risks to human health are low to moderate for 2,4-D.

Although the BLM would be able to treat vegetation in Alaska, Nebraska, and Texas under the Preferred Alternative and alternatives D and E, it is unlikely that the BLM would use herbicides in Alaska, especially in areas with important Alaska Native resources.

Alternative C – No Use of Herbicides

Alternative C would eliminate risks to paleontological, cultural, and human health from herbicide applications. However, risks to these resources and human health associated with alternative vegetation management methods would likely increase (these risks are perhaps greatest for prescribed fire treatments [see PER]). In addition, human health might be adversely affected if the noxious weeds and poisonous plants that adversely affect humans were maintained at current levels or increased in occurrence as a result of ceasing herbicide treatments.

Alternative D – No Aerial Applications

Human health risks per application area would be lower for Alternative D than for the No Action and Preferred alternatives because herbicides would not be likely to drift as far, potentially affecting fewer humans. For many herbicides, the greatest risks to occupational receptors were associated with aerial applications; these risks would be eliminated under this alternative. Furthermore, this alternative would allow the use of the new herbicides, which pose on average less risk to humans than the currently used herbicides. Overall risks to human health would be lower than under the Preferred Alternative, which would treat about 400,000 more acres and would use aerial spraying (however, the Preferred Alternative may eliminate more noxious and poisonous weeds that adversely affect human health than Alternative D). Overall risks to cultural and paleontological resources from ground-based equipment would be similar to the Preferred Alternative, but risks associated with the herbicides themselves would be less since fewer acres would be treated with chemicals. Risks under Alternative D would likely be greater than under Alternative E, as Alternative E places emphasis on spot applications over broadcast applications, establishes herbicide-free zones to protect culturally significant plant and wildlife resources, and prioritizes treatments that would enhance and preserve culturally significant plants and animals. However, Alternative E would not allow the use of ALS-inhibiting herbicide active ingredients (i.e., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl), which exhibit the lowest risks to humans. In addition, these chemicals are effective in controlling weeds that can displace native plant species and associated wildlife that are of value to Native American tribes. Because 240,000 more acres would be treated under Alternative D than under the No Action Alternative, but higher risk aerial applications would not occur and chemicals of lower risk would be used, it is difficult to infer which alternative would result in lower overall risk.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

The five herbicides (chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl) that would not be used under this alternative are among those that pose the least risk to human health. Even in accidental scenarios, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl do not pose a risk to humans, and chlorsulfuron only poses a risk to workers for ground broadcast applications at the highest application rate and for the general public at the upper limits of exposure for the accidental spill of a large amount of chlorsulfuron into a very small pond—an unlikely scenario. From a practical perspective, eye and/or skin irritation are likely to be the only effects of mishandling the ALS-inhibiting herbicides; these effects can be minimized or avoided by prudent industrial hygiene practices during the handling of these compounds. Bromacil, diquat, and diuron, which pose the most severe human health risks, could be used under Alternative E; therefore, risk per area treated is not likely to decrease dramatically as a result of elimination of ALS-inhibiting herbicide active ingredients.

Alternative E does place increased emphasis on spot rather than broadcast applications, which would tend to decrease per area risk relative to the No Action and Preferred alternatives, except in the few possible cases where occupational receptors would be at a greater risk from spot applications. In addition, the proposed number of acres treated (466,000) is half that of the Preferred Alternative (932,000), which would result in lower overall risk. Conversely, more acres would be treated under Alternative E than under the No Action Alternative (305,000), so overall risk would be greater.

Under all alternatives, the BLM would collaborate with Native American tribes and Alaska Native groups to identify and protect culturally significant plants used for food, basketweaving and other fibers, medicine, and ceremonial purposes, and would use minimal impact treatments where culturally significant species are known to occur. In addition, under Alternative E the BLM would establish herbicide-free zones to protect culturally significant plant and wildlife resources, which would reduce the likelihood that Native Americans and Alaska Natives would consume vegetation with herbicide residues.

Mitigation for Herbicide Treatment Impacts

In addition to SOPs, there are certain herbicide-specific measures that could be taken to substantially reduce or eliminate human health risk from herbicide use. The following mitigation measures were developed based on the BLM HHRA, the Forest Service HHRAs and the 1991 13-Sate EIS:

- Use the typical application rate when applying 2,4-D, bromacil, diquat, diuron, fluridone, hexazinone, tebuthiuron, and triclopyr in known traditional use areas.
- Avoid applying bromacil or tebuthiuron aerially in known traditional use areas.
- Limit diquat applications to areas away from high residential and traditional use areas to reduce risks to Native Americans and Alaska Natives.

Visual Resources

Visual resources consist of land, water, vegetation, wildlife, and other natural or manmade features visible on public lands. Vast areas of grassland, shrubland, canyonland, and mountain ranges on public lands provide scenic views to recreation visitors, adjacent landowners, and travelers. In addition, roads, rivers, and trails pass through a variety of characteristic landscapes where natural attractions can be seen and where cultural modifications exist. Activities occurring on these lands have the potential to disturb the surface features of the landscape and impact scenic values.

Bureau policy requires that all acres of BLM land be inventoried for scenic values and be assigned a Visual Resource Management (VRM) Class (I-IV) during the land use planning process. These VRM classes are part of the land use plan decisions for a particular office and set the management standards for visual resources that activity level plans must subsequently meet. The amount of acres within BLM-managed public lands that are categorized as either Class I, II, III, or IV is not currently known. It is, however, an accurate estimated that each of these VRM classes is represented, to some degree, within the geographic areas pertinent to this PEIS.

The proposed vegetation treatments would affect visual resources by changing the scenic quality of the landscape. Herbicide treatments would kill vegetation in the applied area, resulting in visual contrast such as more open, "browned" landscape until new plants were to grow in the area. The degree of change to scenic quality could, in terms of visitor perception, vary relative to a particular area's inherent visual appeal, distances from human activity, and public sensitivity to changes in the landscape character of an area. However, according to the BLM's VRM policy, the extent of visual impact must be evaluated at a project level according to the visual contrast rating process (Handbook 8431-1). This process compares the amount of contrast to the form, line, color, and texture of the characteristic landscape of an area as a result of a surface disturbing activity.

In general, the effects of vegetation treatments on the visual quality of the landscape would be most notable to travelers, sightseers, and residents for the first year to several years following treatment, particularly in impacted areas found near major roads or residential areas. The greatest potential for scenic impacts from vegetative treatments are likely to be associated with projects which 1) reduced the visual rating of the treatment site over the long term, or 2) resulted in short- or long-term degradation of high-sensitivity visual resources.

Scoping Comments and Other Issues Evaluated in the Assessment

Scoping comments stressed that treatments should improve management of public lands for multiple use and maximum public benefit. The visual quality of the landscape is seen as one component of public benefit, particularly if lands are located in highly visible areas along roads.

Standard Operating Procedures

There are several SOPs that would help reduce the impact of herbicide treatments on visual resources. The BLM would minimize the use of broadcast foliar applications in sensitive watersheds to avoid creating large areas of browned vegetation. Similarly, the BLM would consider the surrounding land use before assigning aerial spraying as an application method and would avoid aerial spraying near agricultural or densely populated areas, where feasible. This would serve to reduce the visual impacts of large herbicide treatments and resulting landscape changes, since treatments would be unlikely to be near areas of high visibility. Furthermore, at areas such as visual overlooks, the BLM would leave sufficient vegetation in place, where possible, to screen views of vegetation treatments. In addition, SOPs relating to minimizing off-site drift and mobility of herbicides (e.g., do not treat when winds exceed 10 mph; minimize treating areas where herbicide runoff is likely; establish appropriate buffer widths between treatment areas and residences) would also serve to contain the visual changes to the intended treatment area. If the area was a Class I or II visual resource, the BLM would be required to ensure that the change to the characteristic landscape is low and does not attract attention (Class I), or if seen, does not attract the attention of the casual viewer (Class II).

Visual impacts could be lessened by 1) designing projects to blend in with topographic forms; 2) leaving some low-growing trees or planting some low-growing tree seedlings adjacent to the treatment area to screen short-term effects; and 3) revegetating the site following treatment. When restoring treated areas, the BLM would design activities to repeat the form, line, color, and texture of the natural landscape character to meet established VRM objectives. A more detailed list of SOPs is found in BLM Manual Handbook H-8431-1 (*Visual Resource Contrast Rating*).

BLM Assessment of Visual Resource Values

The BLM identifies and evaluates visual resource values through the VRM Inventory system (Handbook H-8410-1; USDI BLM 1986b). The VRM system is a policy used by the BLM to inventory and manage visual resources on public land based on the aforementioned VRM classes describing scenic quality, sensitivity level, and distance zone criteria. Visual resource management objectives are established in resource management plans in conformance with land-use allocations (USDI BLM 1984c). These area-specific objectives provide the standards for planning, designing, and evaluating future management projects.

A Contrast Rating System (BLM Manual Handbook H-8431-1; *Visual Resource Contrast Rating*; USDI BLM 1986c) provides a systematic means to evaluate the approved VRM objectives, and to identify mitigation measures to minimize adverse visual impacts. The Contrast Rating System is designed to compare the respective features of the existing characteristic landscape and a proposed project and to identify those parts that are not in harmony. These features include the basic design elements of form, line, color, and texture that characterize the landscape and the surrounding environment. Modifications to a landscape that repeat the natural landscape's basic elements are said to be in harmony with their surroundings, while those that differ markedly may be visually displeasing. The information generated is used to determine the amount of visual contrast created and whether the VRM objective for the area would be met, and to develop additional mitigation measures necessary to meet the VRM objective.

Summary of Herbicide Impacts

The removal of vegetation would affect the visual qualities of treatment sites by creating openings and other vegetation-free areas that provide a noticeable visual contrast to the surrounding areas. In addition, the use of herbicides could create visually distinct areas of discolored vegetation (i.e., areas where herbicides have killed vegetation), which could contrast markedly from surrounding areas of green vegetation. The degree of these effects would depend on the amount of area treated, the appearance of the background vegetation and the vegetation being removed, the type of treatment method used, and the season of treatment.

In general, herbicide treatments would have short-term negative effects and long-term positive effects on visual resources. The greater the area of vegetation treatment, the greater the visual impact is likely to be. Large treatments alter a larger portion of the landscape, and the effects are more likely to be observed by people. However, areas receiving large-scale treatments are most likely to be degraded lands of low to moderate scenic quality, resulting in a smaller visual impact from treatment and likely an improvement in the scenic quality of the land over the long term. Color contrasts caused by vegetation removal would be most apparent in areas dominated by green and/or flowery vegetation and by large plants, such as coniferous forests. The visual impacts would be heightened if the herbicides also prevented the manifestation of seasonal changes in vegetation, such as spring flowers and/or fall color. The contrast between a cleared area and the surrounding vegetation would be less for much of the arid west, where low-growing shrubs, and browns, grays, and earth tones dominate the landscape than areas with greater amounts of rainfall (e.g., Marine Ecoregion). Therefore, browned vegetation would not be as apparent. In addition, the brown colors associated with vegetation treatments would be the least noticeable during the late fall and the winter, when they would blend more naturally with surrounding colors than in the spring and summer, when the green colors of new growth are more likely to be present.

For all treatment methods, impacts to visual resources would begin to disappear within one to two growing seasons after treatment in most landscapes. The regrowth of vegetation on the site would eliminate much of the stark appearance of a cleared area. Impacts would last for the longest amount of time in forests and other areas where large trees and shrubs were removed.

Over the long term, vegetation treatments would likely improve visual resources on public lands. Treatments that aim to rehabilitate degraded ecosystems, if successful, would result in plant communities that are dominated by native species. Native-dominated communities also tend to be more visually appealing than plant communities that have been overtaken by weeds (e.g., plant communities supporting a downy brome monoculture) or other undesired species (e.g., grasslands experiencing encroachment by conifer seedlings).

Impacts by Alternative

Alternative A – Continue Present Herbicide Use (No Action Alternative)

The No Action Alternative would continue current vegetation and herbicide treatments; therefore, visual impacts would remain the same. These impacts would be less than those under The Preferred Alternative, because only one-third as many acres would be treated using herbicides. Greatest visual impacts would likely be associated with the largest treatment areas. Under the No Action Alternative, projects with the largest treatment acreage (those over 1,500 acres in size; 10% of all herbicide treatments) would be located in New Mexico (one-third of all large-scale treatments) and Idaho/Nevada (one-third of all large-scale treatments). However, assuming that treatments are effective in reducing or eliminating invasive species populations and promoting conditions that favor the development of native plant communities, the visual quality of degraded landscapes would not improve over the long term to the same extent as under the other treatment alternatives. As compared to the Preferred Alternative, many lands would be left untreated that would continue to be dominated by invasive plants or would be invaded in the future by invasive plants. Landscapes containing a high portion of invasive species often contrast with surrounding natural landscapes and have a negative visual impact. For example, downy brome often turns brown during summer, while native species usually remain green long into summer or fall.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

The Preferred Alternative would result in the greatest short-term negative impact on visual resources, as it involves the largest number of acres treated by herbicides. The most dramatic effects would be seen in states with large numbers of acres treated, such as Idaho, Nevada, and Wyoming, and in project areas where large acreages are treated. Under the Preferred Alternative, projects with the largest treatment acreage (those over 2,000 acres in size; 10% of all herbicide treatments) would be located in Idaho (one-third of large-scale treatments) and Wyoming (20% of all large-scale treatments). One third fewer large-scale treatments would occur in New Mexico under this alternative than under the No Action Alternative. However, herbicide treatments in drier states, such as New Mexico, Nevada, and Wyoming, could have reduced visual impact because visual color contrast between natural and "browned" treated areas would be less dramatic (versus wetter states with higher percentages of green vegetation, especially coniferous forests). Over the long term, this alternative could have the largest positive impact on visual resources, as invasive plants and unwanted vegetation would be removed and visually preferable native vegetation and ecosystems would become reestablished on a larger number of acres.

Alternative C – No Use of Herbicides

Because no herbicide treatments would take place under Alternative C, visual resources would not be adversely impacted by herbicide treatments. Conversely, visual resources would not improve over time, and the visual quality of landscapes could become further degraded as invasive plants continued to invade and spread. There are certain kinds of invasive plants that are most effectively removed by herbicide treatments (e.g., Russian knapweed, purple loosestrife, Canada and Scotch thistles, yellow starthistle); it may be difficult to eliminate these by non-chemical treatment methods (e.g., prescribed fire, manual, biological). In addition, if prescribed burning were to increase under this alternative in order to maintain control of invasive plants, visual impacts from blackened vegetation and landscapes and short-term smoke would likely be more dramatic than visual impacts from herbicide use.

Alternative D – No Aerial Applications

Impacts to visual resources under Alternative D would be less than under the Preferred Alternative, and similar to those under the No Action Alternative and Alternative E based on number of acres treated. In addition, because large scale treatments are less feasible without aerial spraying, fewer large areas of vegetation are likely to be killed by herbicides, further minimizing the short-term visual impact of herbicide treatments. Over the long term, however, this alternative would leave more large tracts of land untreated than the other treatment alternatives. Therefore, the No Action and Preferred alternatives, and Alternative E, could result in more large land areas of recovering native vegetation and ecosystems, and consequently improving in visual quality over time.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

Based on number of acres treated, the visual impacts from herbicide treatments under this alternative would be similar to those under Alternative D. Visual impacts under this alternative would be somewhat moderated as compared to the Preferred Alternative because aerial and boom/broadcast spraying of larger tracts of land would be avoided, thereby reducing visibility of treated lands and sensitivity to treatments. In addition, imazapic, which is proposed for use in treating large expanses of downy brome, would not be used. As fewer large tracts of land with degraded visual quality would be treated, however, fewer large improvements would be made in the visual quality of vegetation and landscapes.

Mitigation for Herbicide Treatment Impacts

No mitigation measures are proposed for visual resources.

Wilderness and Special Areas

Because of their special status, wilderness and special areas have strict guidelines for vegetative treatments. These guidelines prohibit activities that degrade the quality, character, and integrity of these protected lands. Vegetation treatments used in wilderness areas follow the guidance contained in 43 CFR 6300 (*Wilderness Management*; Federal Register 2000), and in the *Management of Designated Wilderness Areas* Handbook H-8560-1 (USDI BLM 1988f), *Management of Designated Wilderness Areas* Manual 8560 (USDI BLM 1993), *Interim Management Policy for Lands under Wilderness Review* Handbook H-8550-1 (USDI BLM 1995) and the *Wilderness Inventory and Study Procedures* Handbook H-6310-1 (USDI BLM 2001b). The guidance states:

- Noxious weeds may be controlled by grubbing or with chemicals when they threaten lands outside wilderness or are spreading within the wilderness, provided the control can be done without serious impacts on wilderness values and treatments are necessary to maintain the natural ecological balances.
- Plant control must be approved for native plants when needed to maintain livestock grazing operations where practiced prior to the designation of wilderness.
- Reseeding may be done by hand or aerial methods to restore natural vegetation.

There are no set restrictions on vegetative treatments in other types of special areas. However, the unique characteristics of these areas would be considered when preparing management plans for treatment activities.

Herbicide treatments can be used to remove noxious weeds, as long as they do not adversely affect wilderness values. The proposed vegetation treatments could affect wilderness and special areas by altering the existing plant species composition and structure, and altering the visual qualities of treated areas.

Scoping Comments and Other Issues Addressed in the Assessment

Respondents suggested that weeds should be stopped from spreading into wilderness areas by treating them outside of these areas, while others requested that treatments within wilderness areas be undertaken only after the spread of weeds outside of these areas has been effectively halted. Other respondents proposed that unique natural areas, including riparian zones, roadless areas, old growth areas, and areas of highest biological integrity, should be protected and that roadless areas should not be treated.

Standard Operating Procedures

Actions that reduce the risk of spreading noxious weeds, prevent the establishment of new invaders, and promote public awareness would be encouraged by the BLM in wilderness and special areas. In particular, the BLM would encourage backcountry pack and saddle stock users to feed their livestock only weed-free feed for several days before entering a wilderness area. In addition, stock users would be encouraged to tie and/or hold stock in such a way as to minimize soil disturbance and loss of native vegetation. Disturbed sites would be reseeded with native vegetation, where feasible. Educational materials would be provided at trailheads and other wilderness entry points to make the public aware of the need to prevent the spread of weeds.

The BLM would use the "minimum tool" to treat noxious and invasive vegetation, relying primarily on use of ground-based tools, including backpack pumps, hand sprayers, and pumps mounted on pack and saddle stock. The BLM would give preference to those herbicides that have the least impact on non-target species and on the wilderness environment, and would use herbicide treatments during periods of low human use, where feasible (USDI BLM 1988f). Other SOPs that would be used by the BLM include addressing wilderness and special areas in management plans, and maintaining adequate buffers for Wild and Scenic Rivers (¼ mi on either side of river, ½ mi in Alaska).

Summary of Herbicide Impacts

In general, vegetation treatments in wilderness and special areas would have short-term negative effects and long-term positive effects on wilderness and special status area values. In wilderness areas and WSAs, only treatments that improve the natural condition of these areas would be allowed. Therefore, long-term effects, if treatments were successful, would be beneficial by reducing noxious weed infestations and reducing the risk of future catastrophic wildfires in these areas.

The overall effect of herbicides on wilderness and special areas would depend on whether the end condition of the treatment site (considering both long-term benefits and short-term impacts) was an improvement in wilderness characteristics. In many cases (e.g., an eradication of a small population of an incipient pest, a prescribed fire that mimicked historical fire), communities in the treatment area would quickly recover, and the overall effect would be positive. In other cases (e.g., treatments that require the creation of access roads to treatment sites, treatments that require repeated access to a site in order to meet a desired objective), the impacts of the treatment to the wilderness character of the site would outweigh the potential long-term benefits.

The short-term effects of vegetation treatments in other special areas would typically be less than those in wilderness areas, as human activities and influences are not necessarily incompatible with their unique qualities. However, all treatments would have the potential to alter these unique qualities, as well as to provide long-term benefits by controlling weeds and reducing fire risks.

The reduction of hazardous fuels and noxious weeds on lands adjacent or near to wilderness and special areas would provide long-term benefits by reducing the likelihood that noxious weeds would spread onto these unique areas, or that a catastrophic wildfire would burn through them, thus degrading their unique qualities. Because there would be fewer restrictions on the intensity of treatments on lands adjacent to wilderness and special areas, preventative treatments in these areas would eliminate or reduce the need for intrusive treatments in wilderness and special areas in the future.

The need for emergency fire suppression activities, which can be very damaging, would also be reduced.

Use of herbicides to treat undesirable vegetation could potentially affect the "naturalness" of wilderness areas and wilderness study areas by killing non-target native vegetation through imprecise application and/or drift. The degree of effects would depend on the application method, with spot applications less likely to cause adverse effects than aerial applications. For the most part, vehicle-mounted sprayers would not be used to treat vegetation, given the existing restrictions on wilderness areas. However, vehicles could be used in extreme scenarios, if approved. The long-term effects of herbicide treatments on wilderness and special areas would depend on the success of the treatment in controlling noxious weeds. In most cases, the benefits of eradicating noxious weeds from wilderness and special areas would far outweigh the potential short-term negative effects of using chemical treatments.

The potential effects of chemical treatments on other special areas would depend on numerous site-specific factors, as discussed for the effects of other treatment methods above. Some special areas would support resources that are more sensitive to exposure to herbicides than the resources in other areas. There would also be human health risks involved with using certain types of herbicide application (e.g., aerial application) in special areas that are managed to support recreational activities.

Impacts by Alternative

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Impacts to wilderness and special areas under the No Action Alternative as a result of herbicide treatments would be similar to those that are currently experienced. Wilderness and special areas that are dominated by invasive species are usually less visually appealing and less attractive to recreationists. The No Action Alternative would treat only a third of the number of acres treated under the Preferred Alternative. Although BLM field offices did not specifically identify how many acres would be treated in wilderness and special areas when providing information for this PEIS, presumably fewer acres in wilderness and special areas would be treated under the No Action Alternative than under the other herbicide-treatment alternatives. Therefore, fewer positive benefits from herbicide treatments would be generated under this alternative, but there would also be fewer negative impacts on wilderness recreation, species of concern, and other resources associated with herbicide treatments in wilderness and special areas. In addition, per capita vegetation treatments would not likely be as effective in restoring wilderness and special lands because the No Action Alternative would not allow the use of the four new herbicides evaluated in this PEIS.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Because Alternative B involves the largest number of treatment acres, it could also have the largest short-term adverse impact on wilderness and special areas, primarily by resulting in the temporary closure of more lands. Along with these closures, there might be more lost opportunities for collection of edible goods than under other alternatives. Although only a small portion of the acres treated using herbicides would be in wilderness and special areas, more acres in wilderness and special areas would be treated under this alternative than the other alternatives. Thus, this alternative could have the largest positive impact on wilderness and special areas since it would reduce the risk of visitor contact with undesirable plant species and would increase visitor exposure to desirable plants and wildlife over the largest acreage possible. As a result, recreation hours spent at a given site could be greatest under this alternative. Given the larger number of acres that would be treated, it is more likely that the BLM would be able to contain and eradicate noxious weed populations in wilderness and special areas under this alternative.

Under this alternative, four new herbicides would be available for use by the BLM, and herbicide treatments could occur in Alaska, Nebraska, and Texas. Based on the HHRA and ERA, the risks to recreationists and sensitive species from these new herbicides, in many cases, are less than risks associated with currently-available herbicides, such as 2,4-D, hexazinone, and triclopyr. The Alaska BLM does not anticipate using herbicides on public lands, while public lands in Nebraska and Texas are not associated with wilderness or other special areas.

Alternative C – No Use of Herbicides

Alternative C would have the positive benefit of protecting wilderness and special area users, sensitive species, and other resources from accidental exposure to herbicides. However, there are certain plants that could be injurious to humans, which are most easily controlled or eradicated using herbicides (e.g., Russian knapweed, purple loosestrife, Canada and Scotch thistles, yellow starthistle). Therefore, Alternative C could negatively impact wilderness and special area activities, particularly camping, hiking, and other activities that would present opportunities for easy contact with these noxious weeds. Visitation to these lands could be lower than under the Preferred Alternative, and higher concentrations of visitors could occur in other wilderness and special areas, resulting in higher impact to these areas.

Furthermore, if other treatment methods were used in place of herbicides, these methods could have a greater impact on wilderness and special area values. For example, prescribed burning would be more likely to result in restricted access by recreationists, decreased air quality, more dramatic changes in the visual landscape for a longer period of time, and shorter visit times by recreationists and site-seers. In addition, it is likely that fewer acres would be treated in highly visible areas overall (as a result of the adverse visual and air quality impacts of prescribed burning), meaning that in the long term these areas would remain of a lower ecosystem quality, limiting their attraction to recreationists. Fire use would also displace sensitive wildlife and could lead to erosion that impacts fish habitat.

Alternative D – No Aerial Applications

Aerial spraying would be uncommon in wilderness and special areas under all treatment alternatives. Through eliminating aerial spraying, Alternative D would also likely limit the number of acres that could be covered by a single treatment. This limit to acreage could have the positive benefit of reducing the acreage of lands that are temporarily closed to recreation. Furthermore, recreation associated with wilderness and special areas could be disproportionately negatively affected by this alternative if prescribed burning were to increase as a result of fewer larger-scale areas being treated with herbicides. Hunting, camping, backpacking, horseback riding, and other pursuits would be limited in burned areas, and possibly shifted to other areas.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Several components of Alternative E pertain to wilderness and special areas (see Appendix G). As discussed in the other resource sections, fewer acres would be treated under this alternative than under the Preferred Alternative and Alternative D. While a fewer number of treated acres would tend to result in fewer negative and positive impacts, an increased emphasis on ecosystem-based management techniques under Alternative E would tend to decrease the short-term negative benefits and possibly increase the long-term positive benefits associated with this alternative. Limits on herbicide use in riparian areas under this alternative would minimize the potential for direct and indirect harm to riparian vegetation, aquatic animals, and water quality.

Under Alternative E, "Except for treatment of small infestations without motorized equipment, prescribe treatments within designated wilderness or wilderness study areas only after the spread of invasive species from outside these areas has been effectively halted." Under the other treatment alternatives, however, actions could be taken to control invasive species within wilderness and special areas before control over invasive species populations outside special areas. The BLM policy is to treat infestations where they are found and to prevent their further spread. By not treating an infestation in a wilderness or other special area until the "larger" invasive species problem outside of the area is addressed, invasive species populations within wilderness and special areas could grow beyond an effectively treatable level.

The five herbicides (chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl) that would not be used under this alternative are some of the least risky herbicides with respect to human health (see Human Health and Safety section). In addition, the ERAs predicted no risk to fish and terrestrial wildlife from most ALS-inhibiting herbicides (chlorsulfuron, imazapic, sulfometuron methyl), and a few cases of low risk (imazapyr, metsulfuron methyl), suggesting that the elimination of these herbicides would not likely benefit wildlife and could indirectly harm wildlife in wilderness and special areas if more toxic herbicides were used in their place (see Wildlife Resources section). The other herbicides proposed for use by the BLM pose risks to non-target that are similar to those associated with these five herbicides; therefore, it is uncertain whether this use restriction would actually reduce risk to non-target plants. Thus, avoidance of ALS-inhibiting herbicides might provide few, if any, benefits to wilderness and special areas and special area users.

Mitigation for Herbicide Treatment Impacts

Mitigation measures that may apply to wilderness and special area resources are associated with human and ecological health and recreation. Please refer to the Vegetation, Fish and Other Aquatic Resources, Wildlife Resources, Recreation, and Human Health and Safety sections of this chapter.

Recreation

Approximately 40% of public lands are within a day's drive of 16 major urban areas in the west (USDI BLM 2005c). Outdoor recreation, nature, adventure, and heritage tourism are the fastest growing segments of the travel and tourism industry. Recreational use of public lands consists predominately of camping and picnicking, which represented 43% of all visitor days in 2003 (USDI BLM 2005d). Other important recreational activities included non-motorized travel, such as hiking, horseback riding, and mountain biking; OHV travel; viewing public land resources and interpretation and education; and hunting. Snow- and ice-based activities, such as cross-country skiing, snowmobiling, and snowshoeing represented less than 1% of visitor days. The BLM administers many acres of public lands and facilities at least in part for these recreational pursuits. Many of these lands are managed for multiple-uses, such that activities designed for one program or purpose (e.g., vegetation control/enhancement) must be compatible with other programs and purposes.

Less than 1% of the acreage considered in this PEIS consists of intensively managed, developed recreation areas that tend to have high public visitation. Many of these areas are near major urban areas in California, Arizona, and Utah, and include National Monuments and other National Conservation Areas (see Map 3-12). In these areas, the goals of vegetation treatments include maintaining the appearance of the area and protecting visitors from the adverse effects of contact with noxious weeds and other invasive/unwanted species. Treatments would likely be done using mechanical and manual methods, or with spot treatments using herbicides, and treatment effects on the public would be minimal. However, herbicide treatments would be more likely with increasing distance away from high-use visitor areas. Thus, hikers, hunters, campers, horsemen, livestock owners, and users of plant resources for cultural, social, and economic purposes would be at the greatest risk of coming into contact with herbicide treatment areas.

Scoping Comments and Other Issues Evaluated in the Assessment

Several respondents remarked that treatments should not be used as an excuse to close OHV trails. Another commentor requested that areas not be treated solely to improve recreational use. If any travel or access routes would be closed, the impacts on recreation and nearby areas that would handle the shift in use should be addressed. The effects of herbicides on recreational users should also be addressed.

Standard Operating Procedures

There are several SOPs that could help reduce the negative impacts of herbicide treatments on recreation:

- Schedule treatments to avoid peak recreational use times, while taking into account the optimum management period for the targeted species.
- Notify the public of treatment methods, hazards, times, and nearby alternative recreation areas.
- Adhere to entry restrictions identified on the herbicide label for public and worker access.
- Minimize the area of disturbance for new access roads and other recreational facilities to minimize invasive species introduction.

In addition, SOPs identified in the Human Health and Safety, Fish and Aquatic Resources, and Wildlife Resources sections should be implemented to further reduce risks to recreationists and the resources they use.

Summary of Herbicide Impacts

Vegetation treatments would have short-term negative impacts and long-term positive impacts on recreation. During treatments, there would be some scenic degradation, as well as distractions to users (e.g., noise from machinery). In addition, there would be some human health risks to recreationists associated with exposure to herbicides. These risks are discussed in more detail in the Human Health and Safety section. Finally, some areas would be off-limits to recreation activities as a result of treatments, generally for a few hours or days, but could be for at least one full growing season or longer depending on the treatment. In most cases, recreationists would be able to find alternative sites offering the same amenities, but a lessened experience could result if concentrated use occurred in these alternative sites.

Site closures would generally last for a short time period following herbicide application, depending on the recommendations on the herbicide label. Usually the recommended exclosure periods would not exceed 24 hours; however, recreational access could be restricted for a season or more to allow vegetation to recover following treatment.

During site closures, signs would be posted stating the chemical used, the date of application, and a contact number for more information, and would remain in place for a period of at least 2 weeks following treatment. Dead brown vegetation could temporarily reduce recreational potential until vegetation recovered. Chemical treatments could also pose some health risks to recreational users, which would be highest with aerial herbicide applications or from activities such as ingesting berries or fish (see Human Health and Safety section). Chemical treatments would generally result in long-term benefits to recreationists by controlling noxious weeds and toxic plants and improving plant species diversity. Herbicide use would likely negatively impact sightseeing recreational opportunities, as further discussed in the Visual Resources section.

Developed recreation sites with public facilities would be treated in order to maintain the appearance of the area and to protect visitors from the adverse effects of unwanted vegetation (e.g. thistles, ragweed, and poison ivy). Long-term adverse effects on developed recreational facilities would be unlikely, as treatments are expected to improve the vegetative health and utility of these sites. In some cases, developed recreation sites could be temporarily closed during treatment implementation.

Dispersed recreation in non-developed areas would potentially be affected to a greater degree than developed recreation sites because most of the 6 million acres of vegetation treatments would occur in these undeveloped, dispersed areas. Recreational activities in these areas are spread out across the landscape, and different types of recreational activities would be affected differently. For example, hikers or backpackers would likely avoid using an area treated with herbicides, but would probably continue to use a trail passing through a mowed or mulched area. Impacts to recreation in areas with a greater abundance of recreational opportunities (e.g., Alaska) would not be as significant as impacts to areas with less extensive recreational opportunities. However, over the long-term, recreationists in these dispersed recreation areas would likely benefit from a reduction in invasive plants (especially thorny or poisonous noxious weeds) provided by herbicide treatments. In addition, herbicide treatments that reduce the risk of wildfire would reduce the likelihood of recreationists being displaced from favorite hunting, fishing, and camping sites by wildfires. During the recent wildfires that swept through the Great Basin, not only were traditional recreation activities affected, but some special events were altered or cancelled. Signs were destroyed, hiking and camping areas burned over, wildlife and game displaced, and the scenery in the Great Basin marred (USDI BLM 1999).

Recreational use of motorized vehicles on public lands is typically limited to designated routes and trails. Trails located in areas of vegetation treatments would be closed during treatments and for a period of time following treatments to allow vegetation to recover. Closures could last for several growing seasons following more intensive treatments where vegetation is completely removed, while less intensive treatments may not require site closures beyond what is recommended for safety on herbicide-use labels.

The effects of herbicide treatments on fish and wildlife could have indirect negative impacts on recreational activities such as fishing, hunting, and wildlife viewing. For example, aerial application of an herbicide over a large area could adversely affect these types of recreation activities by harming or displacing game and non-game fish and wildlife species.

Vegetation treatments could also impact scenic views, particularly where treatments are large and take place next to roads. The effects of vegetation management on the visual quality of the landscape are discussed further in the Visual Resources section.

The impacts of individual herbicides on recreation would differ primarily based on human health risks to recreationists and short-term recreation area closures. The Human Health and Safety section describes the potential risks the different herbicides would have on different types of recreationists (e.g., hikers, hunters, anglers, swimmers, and plant collectors). Herbicide-use labels present the minimum period of time that a sprayed site must be closed to humans. The longer a site is closed, the greater the adverse effect to recreationists in terms of lost use days, particularly at sites that experience a higher volume of visitors. Because most mandatory site closure periods are less than 24 hours, it is expected that the impacts would be minimal, particularly if closures were scheduled during a period of low visitation. On some sites, however, where more extensive treatments occur, closures may be longer to allow vegetation to recover.

Unintended impacts of herbicides on non-target plants and animals could also impact recreation activities (e.g., hiking, plant collecting, hunting, and fishing) in off-site areas. The risks to non-target species from use of the evaluated herbicides are discussed in the Vegetation, Fish and Aquatic Resources, Wildlife Resources sections. The longer an herbicide lingers in soil (depending also on its ability to bind to soil [Koskinen et al. 2003]), the more likely it is to contaminate groundwater or run off into waterbodies used by recreationists.

Over the long term, herbicide treatments would have a positive effect on recreation on treated lands. Removal of weedy vegetation would return public lands to a more "natural" or "desirable" condition, which hikers and nature enthusiasts would likely value over that of degraded lands. In addition, the increased aesthetic value of treated sites would benefit most recreational users. In some instances, treated sites could become more desirable as destinations for outdoor activities, making them more popular to recreational users. In addition, fuels reduction treatments would reduce the likelihood of future wildfires on public lands used for recreation. As a result, recreationists would be provided with safer conditions, and there would be less of a chance that a wildfire would destroy a large acreage of lands used for recreation. Where wildfires do occur, they are capable of causing greater damage to recreational resources in larger areas and require long periods of time for recovery. Treatment of sites to restore native vegetation would enhance fish and wildlife habitat, to the benefit of hunters, birdwatchers, and other users of these resources.

Impacts by Alternative

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Impacts to recreation areas under the No Action Alternative as a result of herbicide treatments would be similar to those that are currently experienced. With the steady increase in number of recreational users of public lands (although numbers of recreational visitors have held steady or trended slightly downward in recent years), there would be more impact to lands from human activities (e.g., spreading weeds, starting fires) but the same level of treatment. Developed, as well as undeveloped, recreation lands that are dominated by invasive species are usually less visually appealing and less attractive to recreationists.

Most treatments would occur in New Mexico (32%), Idaho (19%), Wyoming (12%) and Nevada (8%). Although these states would account for 71% of treatment acres, they accounted for only 20% of visitor days during 2004 (USDI BLM 2005d). Thus, the likelihood of visitors to public lands coming into contact with herbicide treatment areas would be minor as treatments would occur in states with fewer visitors.

The No Action Alternative would treat only a third of the number of acres treated under the Preferred Alternative, and therefore would fall short of the Preferred Alternative in its ability to treat vegetation and generate positive benefits for recreation lands and users, but would also have fewer negative impacts on recreation associated with herbicide treatments. In addition, per capita vegetation treatments would not likely be as effective in restoring recreation lands because the No Action Alternative would not allow the use of the four new herbicides evaluated in this PEIS. Because fewer total acres would be treated under this alternative than under the other herbicide treatment alternatives, this alternative might have fewer long-term recreation benefits than the other treatment alternatives, if a greater amount of treatment acres were to translate to a greater improvement of ecosystem health and scenic quality.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

Because Alternative B involves the largest number of treatment acres, it could also have the largest short-term adverse impact on recreation, primarily by resulting in the temporary closure of more lands. Along with these closures, there might be more lost opportunities for collection of edible goods than under other alternatives. Because of the large number of treatment acres, however, this alternative could have the largest positive impact on recreation, since it would reduce the risk of visitor contact with undesirable plant species and would increase visitor exposure to desirable plants and wildlife over the largest acreage possible. As a result, recreation hours spent at a given site could be greatest under this alternative.

Under the Preferred Alternative, most treatments would occur in Idaho (28%), Nevada (22%), Wyoming (16%), and New Mexico (10%). Although these states account for 76% of treatment acres, they accounted for only 20% of visitor days during 2004 (USDI BLM 2005d). Thus, the likelihood of visitors to public lands coming into contact with herbicide treatment areas would be minor as treatments would occur in states with fewer visitors.

Under this alternative, four new herbicides would be available for use by the BLM, and herbicide treatments could occur in Alaska, Nebraska, and Texas. Based on the HHRA, the risks to recreationists from these new herbicides, in many cases, are less than risks associated with currently-available herbicides, such as 2,4-D, hexazinone, and triclopyr. Although the Alaska BLM does not anticipate using herbicides on public lands, treatments in Nebraska and Texas could potentially affect recreational users in those states.

Alternative C – No Use of Herbicides

Alternative C would have the positive benefit of protecting recreationists from accidental exposure to herbicides. However, there are certain plants that could be injurious to humans, which are most easily controlled or eradicated using herbicides (e.g., Russian knapweed, purple loosestrife, Canada and Scotch thistles, yellow starthistle). Therefore, Alternative C could negatively impact recreation activities, particularly camping, hiking, and other activities that would present opportunities for easy contact with these noxious weeds. Over 900,000 acres that would be treated under the Preferred Alternative would not be subject to herbicide treatment under this alternative. As a result, these areas could have fewer recreationists because of dominance by undesirable plant species. Visitation to these lands could be lower than under the Preferred Alternative, and higher concentrations of visitors could occur in other areas, resulting in higher impact to these areas.

Furthermore, if other treatment methods were used in place of herbicides, these methods could have a greater impact on recreation. For example, prescribed burning would be more likely to result in restricted access by recreationists, decreased air quality, more dramatic changes in the visual landscape for a longer period of time, and shorter visit times by recreationists and sightseers. In addition, it is likely that fewer acres would be treated in highly visible areas overall (as a result of the adverse visual and air quality impacts of prescribed burning), meaning that in the long term these areas would remain of a lower ecosystem quality, limiting their attraction to recreationists.

Alternative D – No Aerial Applications

It is unlikely that aerial spraying would occur in high public use recreational areas under all alternatives, but aerial spraying would occur in dispersed use areas under the other alternatives. Through eliminating aerial spraying, Alternative D would also likely limit the number of acres that could be covered by a single treatment. This limit to acreage could have the positive benefit of reducing the acreage of lands that are temporarily closed to recreation. Furthermore, dispersed recreation (i.e., recreation in non-developed areas) could be disproportionately negatively affected by this alternative if prescribed burning were to increase as a result of fewer larger-scale areas being treated with herbicides. Hunting, camping, backpacking, horseback riding and other pursuits would be limited in burned areas, and possibly shifted to other areas. In the long term, however, prescribed burning would likely have a positive impact on recreation in these areas improving ecosystem health, including visual aspects and habitat for desirable plants and animals.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Alternative E would result in impacts similar to those under Alternative D, with slightly fewer acres being treated and a reduced, but not eliminated, emphasis on aerial spraying. While a fewer number of treated acres (over Alternative D) would tend to result in fewer impacts, an increased emphasis on ecosystem-based and passive management techniques under Alternative E would tend to decrease the short-term negative effects and possibly increase the long-term positive benefits associated with this alternative. For example, because spot treatments would be favored over broadcast treatments, Alternative E would limit the negative short-term impacts to recreationists from drift of herbicides into off-site areas that have not been temporarily closed to visitors. In addition, limits on herbicide use in riparian areas would minimize the potential for direct and indirect harm to riparian vegetation, aquatic animals, and water quality. As compared to the Preferred Alternative, however, this alternative would treat substantially fewer acres, resulting in fewer long-term improvements to the environmental quality of recreation sites.

The five herbicides (chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl) that would not be used under this alternative are some of the least risky herbicides with respect to human health (see Human Health and Safety section). In addition, the

ALS-inhibiting herbicides mostly resulted in no risk to terrestrial wildlife (chlorsulfuron, imazapic, sulfometuron methyl), except for a few cases of low risk (imazapyr, metsulfuron methyl), suggesting that the elimination of the use of these herbicides would not likely benefit fish and wildlife and may indirectly harm fish and wildlife if more toxic herbicides are used in their place (see Fish and Other Aquatic Resources and Wildlife Resources sections). Thus, avoidance of use of ALS-inhibiting herbicides might provide few, if any, benefits to anglers and hunters.

Mitigation for Herbicide Treatment Impacts

Mitigation measures that may apply to recreational resources are associated with human and ecological health. Please refer to the Vegetation, Fish and Other Aquatic Resources, Wildlife Resources, and Human Health and Safety sections of this chapter.

Social and Economic Values

Introduction

Herbicide treatments have the potential to affect people, communities, and economies in each of the 17 western states that could receive treatments. The susceptibility of these entities to social and economic effects stems from the importance of public lands to the lives of the people and communities in the West, especially in the states with the largest amounts of public land. Public lands commonly provide a major portion of economic sustenance, especially in rural areas by supporting ranching (grazing leases), mining, active and passive recreation opportunities, and a myriad of other activities that westerners rely on. The dollar value of the social sustenance may not be readily quantifiable, but it, too, is important to the way of life of westerners. "Wide open spaces" are not just a cliché in western songs and novels, they are a tangible part of the experience that attracts and/or retains people who live in Western states. The large expanses of federal lands are a significant contributor to the open spaces that define the "sense of place" in many parts of the West. Through support of economies and the social context of the West, federal lands are highly important to the Western states. Actions that affect federal lands, such as the application of herbicides, have the potential to affect the economic and social environment of the region.

The extent of potential effects would vary from state to state because of the differing prevalence of federal lands and also because the treatment area in each state would vary, both in acreage and in percentage of land area treated, depending on local issues and needs. The most pervasive effects would likely occur in states with large amounts of public land. During 2002, information was gathered from BLM field offices on the general location of herbicide treatment projects for the No Action and Preferred alternatives. Based on this information, nearly two-thirds of herbicide treatments proposed under the Preferred Alternative would occur in Idaho, Nevada, and Wyoming, with the largest increases in use from current levels likely to occur in Nevada.

This EIS is programmatic in nature and very broad in scale. A programmatic analysis at this scale does not permit the completion of a detailed, quantitative social and economic analysis. Therefore, only general effects and expected trends will be addressed here. Concerned individuals should be assured that more detailed, site-specific analyses would be conducted during the development of actual projects for use of herbicides. Public participation in the development of the details of such proposals would be encouraged at appropriate times in those processes.

Scoping Comments and Other Issues Evaluated in the Assessment

Among the major concerns identified during scoping, were suggestions that economic and ecological costs and benefits to local communities and residents should be examined. Some individuals proposed that the BLM's needs for people and fiscal resources should be addressed, as should costs to state and local governments and private individuals, including secondary costs from such things as loss of recreational use activities. Environmental justice issues—disproportionate effects on minorities, low-income, and child populations —and Indian Trust issues were raised. Several comments addressed potential economic effects on ranchers from grazing restrictions or changes to forage productivity, while others questioned whether grazing permittees would pay for a portion of the treatment costs. A few respondents questioned whether the BLM would perform the treatment work or contract it out; others proposed contracting to local vendors; and some were concerned about potential economic effects on local fire fighters. Evaluation of the effects of the herbicide use alternatives, both beneficial and detrimental, will address these issues to the greatest degree possible, given the scale of the potentially affected geographic area and the necessarily inexact nature of the alternatives in advance of specific treatment project proposals.

There are numerous stakeholders throughout the western U.S. with differing needs and perspectives, and all of their interests must be taken into consideration when planning the treatment program. On a local level, stakeholders include people in communities located in the vicinity of public lands, such as adjacent landowners, local businesses, users of public lands (e.g. ranchers and recreationists), as well as the counties and states that benefit from BLM revenues. On a national level, the stakeholders include all taxpayers, whose tax dollars support BLM programs and who have partial "ownership" of federal public lands. Given the wide range in stakeholders whose needs and interests must be considered, many different and often conflicting opinions must be considered. The alternative selected for implementation will be one that balances both national and local interests.

Standard Operating Procedures

Herbicide use would affect local social and economic resources; some effects would be adverse. Following selected standard operating procedures would reduce some of the adverse effects. The following general procedures are designed to reduce potential adverse impacts to social and economic conditions from the application of herbicides in the BLM vegetation management program:

- Consider surrounding land use before selecting aerial spraying as a method, and avoid aerial spraying near agricultural or densely-populated areas.
- Post treated areas and specify reentry or rest times, if appropriate.
- Minimize application areas where possible.
- Notify adjacent landowners prior to treatment.
- Notify grazing permittees of livestock feeding restrictions in treated areas if necessary as per label instructions.
- Notify the public of the project to improve coordination and avoid potential conflicts and safety concerns during implementation of the treatment.
- Control public access until potential treatment hazards no longer exist, per label instructions.
- Observe restricted entry intervals specified by the herbicide label.
- Notify local emergency personnel of proposed treatments.
- Use the minimum amount of chemical needed to achieve results and follow the product label.
- Avoid accidental direct spray and spill conditions to reduce potential impacts to people and human activities.
- Avoid aerial spraying during periods of adverse weather conditions (imminent snow or rain, fog, or air turbulence).
- Helicopter applications should be made at an airspeed of 40 to 50 miles per hour (mph), and at about 30 to 45 feet above ground.
- Comply with herbicide-free buffer zones to ensure that drift will not affect crops or nearby residents/landowners.
- Use spot applications or low-boom broadcast applications where possible to limit the probability of contaminating non-target food and water sources, especially vegetation over areas larger than the treatment area.
- Consult with Native American tribes and Alaska Native groups to locate any areas of vegetation that are of significance to the tribe and that might be affected by herbicide treatments.
- Work with Native American tribes and Alaska Native groups to minimize impacts to these resources.
- To the degree possible within the law, hire local contractors and workers to assist with herbicide application projects.
- To the degree possible within the law, purchase materials and supplies, including chemicals, for herbicide treatment projects through local suppliers.
- Provide public educational programs on the herbicides proposed for local use to minimize fears based on lack of information.

These procedures would help minimize impacts to people, communities, and human activities in the vicinity of herbicide treatment projects on public lands in the 17-state study region.

Impact Assessment Assumptions

The social and economic analyses for the application of herbicides are guided by a number of key assumptions. First and foremost, this is a 17-state PEIS with no site-specific information on which types of herbicides would be used in any particular area. Consequently, there will be little or no discussion of specific application parameters; any such discussion will be strictly to provide examples. It is expected communities that are particularly dependent on a single industry would be more susceptible to the effects of herbicide use than other communities. In particular, ranching communities and recreation-dependent communities may be more affected than more diversified communities. However, it is not possible to identify particular communities at this scale of analysis. More specific analysis of the effects to communities would be conducted when individual projects are proposed and the analysis would consider elements cited in this section.

The proposed use of herbicides will only apply to public lands; this PEIS would not attempt to predict possible decisions or actions by other agencies or private individuals. Also, it is not expected that any of the alternatives would significantly affect ongoing, long-term trends such as the increasing demand for outdoor recreation or the growth in urban, suburban and rural population, particularly in states from the Rocky Mountains to the Pacific.

It is assumed that herbicide treatments alternatives would meet to different degrees the need for the proposed action (i.e., reduce the risk of wildland fire and improve ecosystem health). Herbicide treatments would reduce the risk of wildland fire by reducing hazardous fuels that would reduce the number of wildland fires, reduce size of wildland fires, and reduce the severity of wildland fires. This would reduce the cost of wildland fire suppression and reduce the loss of life and property. Treatments that improve ecosystem health may increase or improve the amount and quality of commercial and casual uses, improve or maintain market and non-market values of existing uses, and reduce the cost of operations on public lands. However, it was not possible to quantify these benefits at this programmatic level of analysis since there is uncertainty as to when, where, and how treatments would occur.

Summary of Herbicide Impacts

Social effects of the individual herbicides are, for the most part, impossible to differentiate at the scale addressed by this PEIS. The potential for differing social effects among the chemicals would derive from people's perceptions of different health and safety risks for different chemicals. Data on such perceptions are not available, and, in fact, could differ from one community to another, depending on the level of knowledge about herbicides in the community and possible past experiences with use of herbicides (or "misuse," such as accidental spills or damage to non-target plants). The Human Health and Safety section in this chapter discusses health and safety issues related to the proposed herbicides in more detail. There is also some potential for beneficial or adverse effects on the social fabric of communities depending on the success or failure of vegetative treatment programs using various chemicals. Successful improvement in the productivity of rangeland, for example, would help sustain a ranching-dependent community, whereas lack of success could put additional pressure on often tight economic margins in ranching, which would tend to encourage out-migration. Successfully reducing the hazardous fuels in the WUI could encourage people to remain in, or move to, a community, whereas major fire losses, particularly in smaller communities, could encourage some people to move away. These potential effects are somewhat speculative, but should be examined more closely at the project-specific level.

Economic effects of individual herbicides on communities could be similar to social effects. Changes in range productivity, wildfire risk, and access or attractiveness for recreation activities could potentially affect employment opportunities and income levels in a community, in either a positive or negative fashion. As with social effects, however, the broad scale of this PEIS and the lack of data preclude the ability to accurately predict whether and where such effects would occur, and whether they would be beneficial or adverse.

There would be direct and indirect economic effects from application of herbicides. These effects would vary, depending on the quantities of each herbicide selected for use and the methods of application for each. Table 3-23 illustrates the dramatic differences in costs associated for the various chemicals used in 2003, which ranged from approximately $1 per acre for tebuthiuron to almost $177 per acre for bromacil.

In addition to the chemical costs, there would also be costs for applying the herbicides. The Forest Service estimated the average cost per acre for application at $100 for ground application and $25 for aerial application (USDA Forest Service 2005). The BLM's range of estimated application costs is even broader. For ground applications, BLM's estimates range from $50 to $300 per acre for backpack or ATV applications and $25 to $75 per acre for boom sprayer applications. Aerial applications are estimated at $6 to $40 per acre for fixed-wing aircraft and $25 to $200 per acre for helicopter applications. The differences are largely due to the variation in labor and time required to cover an acre by each application mode. It takes many more man-hours to treat an acre on foot or from a small ATV, for example, than to treat an acre with an aircraft. At best, all of these estimates are crude averages; actual costs would vary widely, dictated by terrain, scale of a treatment project, accessibility of the treatment area, size of the problem vegetation stand being treated, and other factors. None of the specifics of these factors are available for evaluation at the programmatic level, but they would be analyzed in greater detail for specific projects as they are developed.

The source of labor for the applications, included in the application cost, would vary with the project. Aerial application projects would be contracted out in most cases. Ground applications would be done by a combination of contractors and BLM personnel, either full-time or part-time employees. The determination of in-house or contract application would be determined for each project individually, depending on the specific needs of the project and the capabilities of the state or local BLM office.

Purchase of chemicals and contracting of applications would generate dollars to benefit the economy; the location of the benefit would depend on where the chemicals and contractors were obtained. Locally purchased chemicals would generate more local benefit, for example, whereas mass purchase of chemicals from a state or national distributor would likely have little local benefit. Herbicide application would tend to sustain local employment, and, in some cases, provide temporary employment for others.

Impacts by Alternative

Impacts Common to All Alternatives

Population and Demography

None of the five alternatives being analyzed is likely to cause substantive changes to existing patterns and trends in population or demographic conditions in the western states. While there would be some increased employment generated by the increase in BLM acreage treated with herbicides under each of the alternatives, the jobs would generally be short-term, temporary positions or contracted work, which would not be sufficient to encourage measurable in-migration of workers and their families. With few exceptions, perhaps including pilots and certified herbicide applicators, jobs generated by the increased herbicide treatments program would tend to pay moderate wages. Depending on the size and duration of any particular treatment project, there could be small, localized population increases, but it is not possible to ascertain if, or where, such changes would take place at this time. It is unlikely that any such growth would excessively burden the community where it would occur because the growth would be small, even in the context of the rural West.

Environmental Justice

Executive Order No. 12898, "*Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations*" (59 FR 7629), is "intended to promote nondiscrimination in federal programs substantially affecting human health and the environment, and to provide minority communities and low-income communities access to public information on, and an opportunity for participation in, matters relating to human health and the environment." It requires each federal agency to achieve environmental justice as part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects, including social and economic effects, of its programs, policies, and activities on minority and low-income populations.

Environmental justice concerns are usually directly associated with impacts on the natural and physical environment, but these impacts are likely to be interrelated with social and economic impacts as well. Native American and Alaska Native access to cultural and religious sites may fall under the umbrella of environmental justice concerns if the sites are on tribal lands or a treaty right has granted access to a specific location.

USEPA guidelines for evaluating potential adverse environmental effects of projects require specific identification of minority populations when either: (1) a minority population exceeds 50% of the population of the affected area, or (2) a minority population represents a meaningfully greater increment of the affected population than of the population of some other appropriate geographic unit.

Public lands occur predominantly in rural areas. There are large minority populations in rural areas of the West and Alaska, particularly Hispanics and Native Americans. Approximately 63% of the nation's Hispanic population, 68% of the nation's American Indian population, and 50% of the nation's Asian/Pacific Islander population reside in the western U.S., which contains less than 32% of the nation's total population (Table 3-15). In addition, Hispanics represent a high percentage of the total population of some states, including New Mexico, California, Texas, and Arizona, in particular. Similarly, Alaska, New Mexico, and several other western states have disproportionately high percentages of Native Americans and Alaska Natives. Issues of concern might include the propensity of Native Americans and Alaska Natives to use native plants for cultural and traditional purposes, and the potential for herbicides to damage some of these native plants if projects are not carefully planned and implemented. This combination of factors suggests the possibility that any significant effects associated with herbicide use for vegetation treatments could disproportionately affect these minority populations. It is not possible to determine whether minorities or low income populations would actually be disproportionately affected at this broad scale of analysis, however, because it is not known if treatment areas would coincide with concentrations of minority or low-income populations, or with Native American and Alaska Native use areas. Specific evaluations of environmental justice impacts would be conducted in concert with environmental analyses for site-specific treatment project proposals.

Issues specific to Native Americans (such as subsistence gathering of rangeland products) have been addressed in more detail in the Cultural and Paleontological Resources section, but they, too, must be addressed in detail with project-specific analyses.

Protection of Children

Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks,* instructs federal agencies to identify and assess environmental health risks and safety risks that may disproportionately affect children, and to ensure that their policies, programs, activities, and standards address disproportionate risks to children that result from environmental health or safety risks. Children could have a greater chance of being exposed to health and safety risks associated with vegetation treatments than adults because they typically spend more time outdoors, and because children, especially young children, tend to be more vulnerable to adverse effects from exposure to environmental contaminants. Although children may spend more time outdoors, they are not often on public land without adult supervision because of the remoteness of most public lands. Thus, the increased opportunity for exposure would generally be negligible to minor. If there are potential risks of adverse effects to people who happen to be outside in the vicinity of herbicide treatments, the project could have a disproportionate effect on children.

Employment and Income

All of the vegetation treatment alternatives would produce economic benefits to western states and local communities by providing employment and labor income opportunities. The BLM would require the services of local pesticide applicators, pilots, and others creating jobs and generating income. The benefits are not quantifiable at the scale of this analysis; they would be small in the context of the 17-state region, but could be more significant for some communities, depending on the expertise and availability of personnel in the relevant BLM offices. Local effects cannot be determined at the scale of this PEIS, but details of local economic effects would be determined at the time specific projects were analyzed under NEPA regulations. Regardless of the local economic situation, the nature of treatments indicates employment and related income effects would be short-term in nature and geographically dispersed, benefiting certain communities throughout the 17-state study area. In general, it is expected that communities located in areas with large amounts of public lands, and therefore the most potential treatment acreage, would receive the greatest employment and economic benefits. Idaho, Nevada, Wyoming, and New Mexico are the four states with the largest anticipated treatment acreage under each of the five alternatives, which suggests communities in these states would also be among the largest beneficiaries of employment and income effects from the proposed herbicide program. Employment and income effects would have the greatest impact on smaller communities, where the increase in jobs and dollars would have a greater influence on the area economy than it would near larger towns and cities.

Perceptions and Values

A range of stakeholder perceptions and values would be influenced by the herbicide treatment alternatives. For example, individuals who have an aversion to chemical use in the environment could find all of the alternatives offensive. Alternatively, individuals with a much greater concern about wildfires or the effects of invasive species would likely favor the most efficient means of attacking vegetation problems. Some westerners have philosophical issues with government ownership and management of large land areas, but they might be somewhat encouraged by plans to employ private contractors for some of the treatment work and would presumably favor the most efficient means possible to reduce fire risk and improve range productivity. Some individuals place high values on the health and pristine nature of the land and would therefore prefer to see that the least intrusive methods be implemented. All of the alternatives have similar negative and positive responses to these perceptions and values. The few differences are addressed below.

Wildland Fire Cost Savings

All of the herbicide treatment alternatives would commit approximately half of the treatment acreage to hazardous fuels and invasive weed reduction in the WUI. Neither the suppression cost savings nor the reduction in property losses can be quantified at the 17-state regional scale. The potential savings should be addressed further in environmental reviews for specific projects, although they may not be quantifiable even at that scale because of the number of variables contributing to when and where a fire may start and how much damage it may cause. These factors include weather conditions, terrain, human acts of omission and commission, and structure type and density, among others. Further, it may take several years to build a sufficient experience base of data to quantitatively estimate the benefits of vegetative treatment on wildfire suppression costs and damage reduction. The Forest Service and BLM came to similar conclusions when trying to ascertain the effects of vegetation treatment activities on future fire suppression costs in the Interior Columbia Basin (USDA Forest Service and USDI BLM 2000).

Despite the lack of quantifiable data, it is expected that herbicide treatments in non-WUI areas would also reduce hazardous fuels, including invasive weeds, which contribute disproportionately to fire risk. Downy brome provides one example of the potential cost savings from attacking invasive weeds, and the costs of fighting downy brome-fueled fires have been estimated at around $20 million per year, and up to $15 million annually in southern Idaho alone, including rehabilitation costs (Duncan and Clark 2005). Consequently, it is expected that all of the alternatives would reduce the cost of fire suppression in the backcountry as well as in the WUI.

Economic Activity and Public Revenues Generated from BLM Lands

Commercial activities that occur on public lands could be affected by vegetation treatments. Vegetation treatments would not directly affect mineral resources but could temporarily reduce access to such resources. Vegetation treatments would be unlikely to cause significant reductions in BLM revenues generated from mineral leases. Most of the BLM's mineral lease revenues come from Alaska, Colorado, and Montana (see Table 3-18), yet only about 8% of the herbicide treatments would occur in these three states under the Preferred Alternative; herbicide treatments would not be allowed in Alaska under the No Action Alternative. Further, restrictions on access for these activities are likely to be minimal in most places because durable road access is generally required for commercial mineral extraction ventures. Consequently, adverse effects on employment and revenue from mineral production due to herbicide treatments, if any, would likely be very minor.

Historically, nearly all of the BLM's revenues from timber sales came from Oregon. In 2004, timber sales amounted to $23.4 million and nearly all timber revenues were from Oregon ($23.3 million, Table 3-18), where at most about 8% of all herbicide treatments are proposed to occur. Treatments would result in long-term improvements in the condition of forest resources and would lead to increases in potential products and revenues generated from public lands over the long term. Forest products managed in this way would provide economic benefits generated through forest management instead of those that would be generated by forest products being consumed by fire. The potential effects are not quantifiable at the scale of this PEIS.

Effects on harvesting other vegetation (non-timber) products would depend on the product and the design of specific herbicide treatment projects. Indiscriminate application of herbicides could damage resources or reduce their value. Alternatively, herbicidal control of undesirable, invasive plants could enhance the habitat for desirable species. Public involvement in project planning and environmental review should be encouraged to minimize adverse effects and maximize benefits.

Herbicide treatments would necessitate some site closures to grazing activities during treatments and for a suitable recovery period afterward, both for effectiveness of the treatment and for safety of the livestock. Treatments that require temporary rest from grazing would result in a reduction in forage for livestock. Although alternative grazing site may be available, the costs associated with grazing in a different area would likely be higher. The economic effects of temporarily reducing forage production and/or access would vary depending on the size and flexibility of the affected ranching operations. It is not possible to quantify the effects at the 17-state regional scale. Although forage production could decrease initially following treatment, production would likely increase over the long-term as woody vegetation and weed species were controlled, increasing the suitability of rangeland areas for grazing. Treatments would result in an increased quantity and quality of forage, increased animal production, reduced fire hazard, and a reduced risk of sickness in livestock as a result of ingesting poisonous plants (see the Livestock section in this chapter for more information). As for other vegetation products, public involvement in project planning and site-specific environmental review should be encouraged to minimize adverse effects and maximize benefits.

Recreation-based businesses such as outfitters, bait shops, OHV sales and repair shops, fish and hunting shops, and outdoor gear and equipment rental shops are direct beneficiaries of this activity. Other services such as gas stations, restaurants, and hotels that are frequented by recreationists also benefit. Temporary closure of a popular recreation site, either to protect public safety during herbicide treatments or to decrease user-related impacts during a site's post-treatment recovery, would result in temporary losses of revenues to surrounding businesses. In most cases, these effects would be short term in nature, lasting only as long as the site closure. In general, most recreational activities would continue, but would shift to other locations (see the Recreation section in this chapter). Depending on the location of the alternate use area, the economic benefits would shift from one community to another. If there were a suitable nearby alternative to the closed site, the effects on surrounding businesses would be minimal; if not, the businesses would be adversely affected for a period of time. It is not possible to quantify the potential effects at the 17-state regional scale, or to identify businesses that would benefit or be harmed from potential shifts in recreational activities. Over the long term, an improvement in the quality of a site from vegetation treatment could lead to increased recreational usage and a net increase in revenues to surrounding businesses. Reductions in hazardous fuels and the risk of wildfires would benefit the economies of rural communities, which are often dependent on recreational and wilderness values. In some cases, severe wildfires, particularly when they occur during the tourist season, could cause long-term disruption to recreation values, which would adversely affect recreational businesses. To the degree that treatments would reduce the risk of wildland fires, the herbicide treatment alternatives would benefit recreation-related economic activity.

Recreation provides revenues to the BLM through fees and permits. Closure of a popular fee-based recreation site would result in a loss of revenues to the BLM. The severity of any such losses cannot be determined at this scale because no specific fee-based recreation sites have been identified for treatment. Detailed effects would be examined at the site-specific project level.

Expenditures by BLM (Financial Efficiency)

Herbicide treatments would require a large financial investment by the BLM, which would vary by alternative. These costs represent a substantial input of financial resources into the communities surrounding BLM lands, particularly in areas where BLM land-holdings are extensive.

The most cost-effective alternative is the one that produces the greatest benefits for the least amount of financial investment. The cheapest alternative, if it would not substantially improve the health of the land, could require indefinite repeat treatments, thus costing more money over the long term. Unfortunately, it is not possible to determine on a 17-state region scale which broad alternative would be most cost-effective. Benefits to the health of the public lands depend on the specific problem to be addressed in each specific area. These benefits would be evaluated on a site-specific basis as project proposals were developed. Irrespective of the particular alternative selected, the costs associated with restoring or maintaining an ecosystem through vegetation treatments is generally much less than the cost of suppressing wildfires and implementing fire rehabilitation programs (USDI 2001).

An additional consideration regarding BLM expenditures is the distribution of payments to state and local governments (see Table 3-24). None of the herbicide treatments would affect these payments, as they are established by Congress, and none of the alternatives would alter the formula-based payments.

If goods and services were purchased locally, or additional workers were hired locally in support of the herbicide treatment alternatives, state and local governments would benefit through increased tax revenues. The relative public benefits would depend on the taxing structure of the individual states.

Effects on Private Property

Herbicide treatments could affect private property in the vicinity of public lands, particularly parcels adjacent to treatment areas. Over the short term, there would be minor risks for property damage associated with herbicide treatments because it is possible that some herbicide could drift onto private property, especially during aerial treatments. Under such a scenario, crops could be lost, or, alternatively, rangeland weeds could be killed, resulting in benefits to private property. Losses and gains would likely be minor and short term in nature.

Over the long term, a reduction in hazardous fuels on public lands would reduce the likelihood of wildfires migrating from public lands to nearby private property and impacting the WUI. Herbicide treatments would also reduce the risks of noxious weeds spreading onto neighboring parcels, including poisonous weeds, which could harm livestock. A reduction in such risks could lead to increased property values over the long term. Any such effects are not quantifiable at this scale of analysis.

Impacts of Individual Alternatives

The following sections discuss the expected effects of each of the five alternatives on social and economic resources. These effects vary in degree, for the most part, rather than in kind. The differences depend on the percentage of acres treated using different application methods and on the total acreages to be treated. Because very little quantification of effects is possible at the 17-state regional scale, the differences are often stated roughly in proportion to the acreages to be treated.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Under the No Action Alternative, the BLM would continue its ongoing vegetation treatment programs in 14 western states, and would be able to use 20 herbicides previously approved under earlier RODs. Approximately 305,000 acres would be treated with herbicides annually.

As future treatment levels would be similar to current levels, there would likely be little change to existing patterns and trends in population or demographic conditions in the western U.S. While there would be localized increases in employment generated by the increase in BLM acreage treated with herbicides under this alternative, the jobs would generally be short-term, temporary positions or contracted work, which would not be sufficient to encourage measurable in-migration of workers and their families.

Most treatments would occur in New Mexico (32%), Idaho (19%), Wyoming (12%) and Nevada (8%). Except for New Mexico, these states have substantially lower per capita minority and Native American populations than for the entire western U.S. (see Table 3-15). In addition, the percentage of the population under 18 in these states is less than or similar to the percentage for the remainder of the western U.S. (see Table 3-15). Thus, disproportionate impacts to minority populations and children from vegetation treatments should not occur under this alternative. Public lands provide lifeway values for Indian tribes, and there is concern among Indian tribes and the public that the BLM vegetation treatments could adversely impact native plants used for cultural and traditional purposes if projects are not carefully planned and implemented. The BLM would consult with Indian tribes before implementing treatments that could impact vegetation of importance to Indian tribes to reduce these potential impacts.

Based on the assumption that the average costs to treat vegetation using ground-based and aerial methods are $35 per acre and $125 per acre, respectively, and using information on the cost of herbicides in Table 3-23 and assumptions from the BLM on the percentage of acres to be treated using ground- and aerial-based methods for each herbicide, approximately $30.1 million would be spent on herbicide applications; $24 million would be spent on ground-based applications, and $6.1 million would be spent on aerial applications under the No Action Alternative. The cost per acre treated would be approximately $98.70 per acre.

These expenditures would provide employment and income benefits. Regardless of the local economic situation, the nature of treatments indicates employment and related income effects would be short-term in nature and geographically dispersed, benefiting certain communities throughout the 17-state study area. In general, it is expected that communities located in areas where the most acres were treated would receive the greatest employment and economic benefits.

Neither the suppression cost savings nor the reduction in property losses can be quantified at the 17-state regional scale under this alternative. However, benefits would be most likely to occur in those ecoregions/states with the greatest number of acres treated (Idaho, Wyoming, Nevada, and New Mexico; Temperate Desert Ecoregion), or where the risk of fire starting by lightning or human causes is greatest (Alaska and California in 2004; USDA Forest Service 2000, USDI BLM 2005d).

Commercial activities that occur on public lands could be affected by vegetation treatments. As noted earlier, most treatments would occur in New Mexico, Idaho, Wyoming, and Nevada. Only about 1% of timber sales occur in these states. Effects on timber sales from vegetation treatments would be greatest in Oregon, where over 95% of timber sales occur. Based on grazing leases, licenses, and permit fees, over 55% of these expenditures occur in these states, while 44% of active animal unit months occur in these states (see Table 3-6; USDI BLM 2005d). Oregon and Utah also have large populations of livestock on public lands. Thus, vegetation treatment activities could affect grazing activities and income in these states. Effects on recreation expenditures would likely be modest, as only 27% of recreation expenditures would occur in these four states. Treatments in California, Oregon, and Utah would be more likely to affect recreation expenditures, as nearly 56% of annual recreation expenditures occur in these states.

Herbicide treatment effects on private property from drift and accidental applications would be less under this alternative than under the other treatment alternatives. Over the long term, a reduction in hazardous fuels on public lands would reduce the likelihood of wildfires migrating from public lands to nearby private property and impacting the WUI. Herbicide treatments would also reduce the risks of noxious weeds spreading onto neighboring parcels, including poisonous weeds. These benefits would be less under this alternative than under the other treatment alternatives.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

The Preferred Alternative would result in herbicide treatments on approximately 932,000 acres annually in 17 western states. In addition to the 14 previously-approved herbicides, the BLM would be able to use the four new herbicides evaluated in this EIS.

As future treatment levels would be 3 times that of current levels, there would likely be minor change to existing patterns and trends in population or demographic conditions in the western states. While there would be localized increases in employment generated by the increase in BLM acreage treated with herbicides under the Preferred Alternative, the jobs would generally be short-term, temporary positions or contracted work, which would not be sufficient to encourage measurable in-migration of workers and their families.

Under the Preferred Alternative, most treatments would occur in Idaho (28%), Nevada (22%), Wyoming (16%), and New Mexico (10%). Except for New Mexico, these states have substantially lower per capita minority and Native American populations than for the entire western U.S. (see Table 3-15). In addition, the percentage of the population under 18 in these states is less than or similar to the percentage for the remainder of the western U.S. Thus, disproportionate impacts to minority populations and children from vegetation treatments should not occur under this alternative. The potential for impacts to plants that provide traditional lifeway values would be greatest under this alternative. Some treatments could occur in Alaska, Nebraska, and Texas under this alternative.

Anticipated adjustments to herbicide usage would not substantively change the expenditure per acre for chemicals, as nearly 90% of the herbicide usage would simply be a proportional increase in the pattern of active ingredients used in recent years. Of the four new herbicides, imazapic would be the most heavily used; it falls in the lower price range for chemicals. Detailed information is not available on types of herbicides to be used for each of the proposed treatment projects. However, based on information obtained from field offices in 2002, it is assumed that approximately 45% of the acreage would be treated from the air and 55% from the ground. Under this scenario, it is expected that existing social and economic trends would continue, with a substantial increase in economic activity generated.

Based on the assumptions given under the No Action Alternative for costs to treat vegetation using herbicides, approximately $69.6 million would be spent on ground-based applications, and $19.5 million on aerial applications, or $89.1 million for all applications under the Preferred Alternative. This figure is about 3 times the amount that would be spent under the No Action Alternative. However, the average cost per acre treated would be $95.60 per acre, or 3% less per acre than under the No Action Alternative.

Considering the scale of the increase in the herbicide treatment program under the Preferred Alternative, it is expected that the economic benefits would likely spread to more local communities than under the other treatment alternatives, and that some individual communities would experience substantial gains. Which communities would be affected, and to what degree, cannot be determined at this time.

Neither the suppression cost savings nor the reduction in property losses can be quantified at the 17-state regional scale under this alternative. However, benefits would be greatest under this alternative because of the acreage treated. As with the other treatment alternatives, benefits would be most likely to occur in those ecoregions/states with the greatest number of acres treated (Idaho, Wyoming, Nevada, and New Mexico; Temperate Desert Ecoregion), or where the risk of fire starting by lightning or human causes is greatest (Alaska and California in 2004; USDA Forest Service 2000, USDI BLM 2005d).

Commercial activities that occur on public lands could be affected by vegetation treatments. As with the other treatment alternatives, effects on commercial activities should be greatest in those states with the most acres treated (Idaho, Wyoming, Nevada, and New Mexico), where most timber sales occur (Oregon), where most grazing occurs (Wyoming, Montana, Idaho, Utah, and Oregon), and with the greatest recreation expenditures (California, Oregon, and Utah).

Herbicide treatment effects on private property from drift and accidental applications would be greatest under this alternative. Some herbicide could drift onto private property, especially during aerial treatments. Under such a scenario, crops could be lost. Alternatively, rangeland weeds could be killed, resulting in benefits to private property. Losses and gains would likely be minor and short term in nature.

Over the long term, a reduction in hazardous fuels on public lands would reduce the likelihood of wildfires migrating from public lands to nearby private property and impacting the WUI. Herbicide treatments would also reduce the risks of noxious weeds spreading onto neighboring parcels, including poisonous weeds. These benefits would be greatest under this alternative.

Alternative C – No Use of Herbicides

Under Alternative C, the BLM would not be able to use herbicides to treat vegetation. Positive social benefits could be less than under the other alternatives because wildfire risk reduction in WUI areas would not be as effective and the economic benefits to ranching communities would not be as great as under the other alternatives. It is unlikely that fire suppression costs and fire damage losses would be less under Alternative C than under the other alternatives. Benefits to rangelands also could be less under this alternative, as certain invasive species are effectively controlled only by herbicides, and in some situations other methods are impractical due to cost, time, or public concerns.

Under this alternative, invasive plant populations would likely continue to spread, possibly at increasing rates, without use of herbicides. Related declines in rangeland capacity, combined with the potential for the spreading of invasive plants from public lands to private ranch lands under this alternative in areas where other treatment methods were not effective or practical, would adversely affect ranching profits and would thus be detrimental to local economies in rural areas of the West.

Generally, non-herbicide vegetation treatment methods tend to be more labor intensive and thus more expensive on a per acre basis in situations where herbicides would be preferred, which would translate into less effective control of undesirable vegetation. It could mean more workers would be hired in some places, although many of the additional jobs would likely be low paying, unskilled labor positions.

Alternative D – No Aerial Applications

Alternative D would be the same as the Preferred Alternative as far as which herbicides could be used, but the limitation on aerial application would preclude treatments in some areas that would not be suitable for ground application due to access difficulties or the scale of vegetation problems. Because of this limitation, and perhaps also because of the often higher cost of ground application, fewer acres—530,000—would be treated under Alternative D than under the Preferred Alternative. Nearly 2 times more acres would be treated under Alternative D than under the No Action Alternative. Consequently, the types of social and economic effects of Alternative D would be similar to the effects described for the No Action and Preferred alternatives, but would fall between them in magnitude.

As with the other herbicide treatment alternatives, most treatments would occur in Idaho, Wyoming, Montana, and Nevada. These states have lower per capita minority and Native American populations, and percentage of the population under 18 in these states is less than or similar to the percentage for the remainder of the western U.S. (see Table 3-15). Thus, disproportionate impacts to minority populations and children from vegetation treatments should not occur under this alternative.

Based on the assumptions given under the No Action Alternative for costs to treat vegetation using herbicides, approximately $76.7 million would be spent on ground-based applications under Alternative D, or about 14% less than would be spent under the Preferred Alternative, although 43% fewer acres would be treated under Alternative D. The average cost per acre treated would be $144.72, or nearly 51 and 47% more than for treatments under the Preferred and No Action alternatives, respectively.

It is expected that the economic benefits to local communities would be less than under the Preferred Alternative, but greater than under the No Action Alternative. Which communities would be affected, and to what degree, cannot be determined at this time.

Herbicide treatment effects on private property from drift and accidental applications would be intermediate between the No Action and Preferred alternatives. Over the long term, a reduction in hazardous fuels on public lands would reduce the likelihood of wildfires migrating from public lands to nearby private property and impacting the WUI. Herbicide treatments would also reduce the risks of noxious weeds spreading onto neighboring parcels, including poisonous weeds. These benefits would be intermediate to those of the Preferred and No Action alternatives, and similar to Alternative E.

Alternative E – No Use of Acetolactate Synthase-inhibiting Active Ingredients

Approximately 466,000 acres would be treated under Alternative E, which would be approximately 11% less than the acreage that would be treated under Alternative D, and about half of the acreage that would be treated under the Preferred Alternative. The acreage treated would be one and one-half times the acreage that would be treated under the No Action Alternative.

Alternative E would have somewhat more positive social effects than other alternatives in that it would clearly establish protection for Native American and Alaska Native resources. Economically, it could result in prohibitions or restrictions on certain commercial and recreational activities that support and sustain some rural communities. Without more specific information on such restrictions, however, it is not possible to accurately predict how significant the effects would be. In most other respects, the social and economic effects of Alternative E would be similar to those associated with other alternatives and proportional to the acreage treated.

The profile of selected active ingredients under Alternative E would be very similar to the profile for the No Action Alternative, and would only notably differ from the Preferred Alternative in that there would be more use of glyphosate and no use of imazapic (Table 2-4). Because these are both lower priced active ingredients, the adjustment would not significantly affect economic activity.

Based on the assumptions given under the No Action Alternative for costs to treat vegetation using herbicides, approximately $57.7 million would be spent on ground-based applications, and $2.3 million would be spent on aerial applications (assuming that percentage of acres treated using aerial methods for each herbicide would only be one-third the percentage of acres treated using aerial methods for each herbicide under the Preferred Alternative). Thus, although half as many acres would be treated under this alternative compared to the Preferred Alternative, costs would be reduced by only one-third. The cost per acre treated would be about $128.75 under this alternative, or 11% less than under Alternative D, but 35 and 30% greater than the cost per acre treated under the Preferred and No Action alternatives, respectively.

Mitigation for Herbicide Treatment Impacts

No mitigation measures are proposed for social and economic resources.

Human Health and Safety

The use of herbicides under a variety of application methods, as proposed in this PEIS, involves potential risk or the perception of risk to workers and members of the public living or engaging in activities in or near herbicide treatment areas. Therefore, as part of the PEIS, a HHRA has been conducted to evaluate potential human health risks that may result from herbicide exposure both during and after treatment of public lands. The HHRA has been conducted to be scientifically defensible, to be consistent with currently available guidance where appropriate, and to meet the needs of the BLM vegetation treatment program.

Risk to two types of human "receptors" was evaluated: occupational receptors and public receptors. Receptors are representative population groups that could have specific exposures to the herbicides. Occupational receptors included those workers that mix, load, and apply herbicides and operate transport vehicles, recognizing that in some cases an occupational receptor may perform multiple tasks, increasing his or her exposure. Public receptors included those members of the public most likely to come into contact with applied herbicides. The public receptors included adult hiker/hunters and anglers, and adult and child berry pickers, swimmers, Native Americans, and residents. Receptors were evaluated assuming both accidental (e.g., direct spray or spill onto skin) and routine exposure scenarios (e.g., ingestion of berries that have been recently sprayed).

Scoping Comments and Other Issues Evaluated in the Assessment

A large number of respondents during public scoping were concerned about the risks to human health from herbicide treatments. Respondents suggested that at-risk groups like infants, elderly, sick people, and people with sensitivities to chemicals be specifically addressed. Numerous respondents urged the BLM to describe all potential toxicological hazards of herbicide chemicals, including their ability to disrupt hormone systems and immune systems. Establishing a goal of using the minimum effective dosage and developing protocols for achieving this was encouraged. There was also concern for the effects of herbicides on basket plants and the people who collect them, in particular Native Americans. Some respondents also felt that the uncertainties regarding the environmental effects of herbicides and inert ingredients should be disclosed. According to some respondents, Oust® (herbicide formulated with sulfometuron methyl) should be considered for evaluation even though it was evaluated previously in the 1991 13-State Vegetation EIS (USDI BLM 1991a). One respondent noted that if there are insufficient toxicological data to be found for a specific herbicide, then that herbicide should not be used.

Standard Operating Procedures

Standard operating procedures designed to reduce potential unintended impacts to human health from the application of herbicides in the BLM vegetation management program and considered when evaluating impacts are listed in Table 2-6. These include following the "Environmental Hazards" section on the herbicide label; using protective equipment; avoiding accidental direct spray and spill conditions; minimizing application areas where possible; establishing appropriate (herbicide specific) buffer zones; selecting herbicide products carefully to minimize additional impacts from adjuvants and inert ingredients; and notifying the public when the potential exists for exposure. The results from the HHRA will help inform BLM field offices on the proper application of herbicides to ensure that impacts to humans are minimized to the extent practical.

Human Health Risk Assessment Methodology

The BLM conducted a HHRA to evaluate potential risks to humans from exposure to the following six active ingredients, four of which are proposed for us on public lands. These are dicamba, diflufenzopyr, diquat, fluridone, imazapic, and sulfometuron methyl. The four active ingredients not currently used on public lands are diflufenzopyr, diquat, fluridone, and imazapic. Sulfometuron methyl and dicamba were evaluated for risks to humans in earlier EISs and are currently used by the BLM, but were reevaluated for this PEIS. Oust® has been found to impact non-target vegetation when carried on soil to untreated areas, and these effects were not evaluated in the earlier vegetation treatment EISs. Dicamba is used in formulation with diflufenzopyr (as Overdrive®), and was reassessed as part of the evaluation of the formulation. These active ingredients may be formulated into herbicides under a variety of trade names and manufacturers. Therefore, specific trade names and manufacturers are not discussed in this report.

The remaining 18 active ingredients that are available for use by the BLM were evaluated in other HHRAs. The BLM relied on HHRAs prepared in recent years for the Forest Service to evaluate the risks to human health for nine active ingredients (2,4-D, chlorsulfuron, clopyralid, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, and triclopyr). For the remaining nine active ingredients (2,4-DP, asulam, atrazine, bromacil, diuron, fosamine, mefluidide, simazine, and tebuthiuron), the BLM relied on information discussed in earlier BLM vegetation treatment EISs (USDI BLM 1988a, 1989a, 1991a).

As this PEIS relies upon the HHRA results developed by both BLM and Forest Service, the following sections discuss the risk assessment methods used by the BLM in the current assessment, the risk assessment methods used by Forest Service, and the methods used by BLM in the earlier EIS HHRAs. This is followed by a discussion of the uncertainties in the risk assessment process.

BLM Human Health Risk Assessment Methodology

The BLM HHRA follows the four-step risk assessment model as identified by the National Academy of Sciences (NAS; 1983). These steps are: 1) hazard identification, 2) dose response assessment, 3) exposure assessment, and 4) risk characterization. The outcome of each of these steps is discussed below. More detailed information on the methodology used to evaluate risks is in Appendix B and in the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l).

Hazard Identification

The hazard identification section provides information on the herbicide active ingredient characteristics and usage, and toxicity profiles. Much of the toxicity information discussed in this section is from USEPA reports, such as the Pesticide Fact Sheets or HHRAs conducted by the USEPA OPP Health Effects Division to evaluate use of the pesticides on specific crops. In addition, a literature search was conducted to ensure that relevant available information was used in these toxicity profiles. The databases searched include the National Library of Medicine's Hazardous Substances Data Bank and Toxline. The USEPA receives many unpublished toxicity data sets that are referenced in USEPA reports using Master Record Identification (MRID) numbers. The HHRA references USEPA reports for the MRID information.

Both acute (short-term) and chronic (longer-term) toxicity information is discussed for the active ingredient. The USEPA has developed toxicity categories for pesticides based on acute toxicity animal tests conducted in support of registration of the pesticides (USEPA 2003g). Acute toxicity studies are used to determine a number of toxicity endpoints based on short-term exposure to a substance. The toxicity endpoints considered are oral, inhalation, and dermal acute toxicity, eye irritation, skin irritation, and dermal sensitization. An important endpoint in acute testing is the toxicity reference level known as the median lethal dose (LD_{50}), which is the dose, usually administered orally, that kills 50% of the test animals. The lower the LD_{50} is, the greater the toxicity of the chemical. For the different toxicity endpoints, the USEPA defines four toxicity categories (Lists; I through IV), with higher toxicity categories representing lower herbicide acute toxicity. In longer-term toxicity studies (chronic or subchronic), the endpoints for evaluation are the dose at which no adverse effects were seen NOAEL, and the LOAEL.

In addition to the active ingredients, most herbicides also contain inert ingredients (i.e., those substances included in the formulation that are not the active ingredients) that have various functions such as diluents, binders, dispersants, carriers, stabilizers, neutralizers, antifoamers, and buffers.

The USEPA categorizes inert ingredients into four lists (54 FR 48314):

- List 1 – Inert ingredients of toxicological concern. Any product containing a List 1 ingredient must include the label statement, "this product contains the toxic inert ingredient (name of inert)."
- List 2 – Inerts of unknown toxicity/high priority for testing inerts.
- List 3 – Inerts of unknown toxicity. Inert ingredients on this list have not yet been determined to be of known potential toxicological concern nor have they been determined to be of minimal concern. These substances will continue to be evaluated to determine if they merit reclassification to List 1, 2, or 4.
- List 4 – Inerts of minimal concern. List 4 is subdivided into List 4A (minimal risk inert ingredients) and List 4B (inerts that have sufficient data to substantiate they can be used safely in pesticide products).

BLM scientists received clearance from USEPA to review Confidential Business Information (CBI) on inert compounds identified in products containing the six active ingredients evaluated in this risk assessment. The information received listed the inert ingredients, their chemical abstract number, supplier, USEPA registration number, percentage of the formulation and purpose in the formulation. Because this information is confidential, this information, including the name of the ingredients may not be disclosed.

The USEPA has a listing of regulated inert ingredients at http://www.epa.gov/opprd001/inerts/index.html. This listing categorizes inert ingredients into the four categories listed above. The number of inert ingredients present in the formulations containing the six active ingredients evaluated in this risk assessment are shown below:

- List 1 – no inerts found
- List 2 – no inerts found
- List 3 – 6 inerts found
- List 4 – 29 inerts found

Therefore, the majority of the inerts are of minimal risk. A few are in the category of unknown toxicity.

Dose-response Assessment

The purpose of the dose-response assessment is to identify the types of adverse health effects an herbicide may potentially cause and to define the relationship between the dose of an herbicide and the likelihood or magnitude of an adverse effect (response). The dose-response assessment identifies quantitative dose-response values that are used in risk calculations to derive risk estimates. The dose-response values used in the HHRA were developed by the USEPA. None of the six herbicides evaluated in the BLM HHRA are designated as potential carcinogens by USEPA; therefore, this toxicity assessment focuses on non-carcinogenic effects (i.e., potential toxic effects other than cancer). Non-carcinogenic effects are evaluated differently depending on whether the exposure is dietary or non-dietary.

For dietary exposures to non-carcinogenic chemicals, toxicity is represented by a population adjusted dose (PAD) and may be calculated for acute effects or chronic effects. A PAD is an acute or chronic RfD divided by the Food Quality Protection Act (FQPA) Safety Factor, which accounts for cases where infants and children may have extra sensitivity to the pesticide (USEPA 2000c). Reference doses are derived by identifying a NOAEL, which is obtained from the acute or chronic toxicity studies, and dividing the NOAEL by the appropriate uncertainty factors (UFs). Typically, a 10-fold UF is applied to account for variation within the human population (i.e., to account for individuals that may be more sensitive to the effects; intraspecies), and an additional 10-fold factor is applied to account for the differences between humans and animals (interspecies; USEPA 2000c). The FQPA Safety Factor is applied to the PAD in addition to the uncertainty factors used to derive the RfD.

A margin of exposure (MOE) approach is used to evaluate potential non-dietary exposures to herbicides. For evaluating non-cancer effects for non-dietary exposures, toxicity is represented by the NOAEL. The NOAELs are identified for a variety of exposure durations and exposure routes (short-, intermediate-, and long-term exposure durations via oral, dermal, and inhalation exposure routes). The NOAELs representing non-dietary exposures were used to evaluate the occupational receptors and the public receptors for the following scenarios: dermal contact with spray, dermal contact with foliage, dermal contact with water while swimming, and incidental ingestion of water while swimming. The NOAEL divided by the intake (see the Exposure Assessment section below for a description of how intakes are derived) results in the MOE (USEPA 2000c). Unless specified otherwise, the target MOE is 100, which accounts for uncertainties in the NOAEL. MOEs greater than the target MOE indicate no significant risk.

Exposure Assessment

The purpose of the exposure assessment is to predict the magnitude and frequency of potential human exposure to the herbicides under consideration. The BLM takes care to prevent exposures to applied pesticides both through worker training programs and by posting areas that have just been sprayed with information on when reentry into these areas is appropriate. However, to be conservative, the HHRA has evaluated both routine use and accidental exposure scenarios. In addition, exposures were evaluated for two application scenarios: applications using the maximum application rate as designated by the herbicide label, and applications using a typical application rate that was defined by BLM for this program.

To estimate the potential risk to human health that may be posed by the planned herbicide use, it was first necessary to estimate the potential exposure dose of each herbicide for each receptor via each applicable exposure route. Exposure dose equations combine the estimates of herbicide concentration in the environmental medium of interest with assumptions (exposure parameters) regarding the type and magnitude of each receptor's potential exposure to provide a numerical estimate of the exposure dose. The exposure dose is defined as the amount of herbicide taken into the receptor and is expressed in units of milligrams of herbicide per kilogram of body weight per day (mg/kg-day). The exposure doses were combined with the dose-response values (PADs or NOAELs) to estimate potential risks and hazards for each receptor.

Various guidelines and databases, such as the USEPA's *Exposure Factors Handbook* (USEPA 1997) and the *Framework for Assessing Non-Occupational, Non-Dietary (Residential) Exposure to Pesticides* (USEPA 1998c), were used to develop the exposure parameters. For each exposure scenario, the exposure parameters were used to calculate an exposure factor (EF), which was then used in the risk calculations. The use of the EF combines all the exposure parameters into one value in order to simplify the risk calculations.

Occupational Exposure Scenarios. Both routine-use and accidental exposure scenarios were included in the occupational evaluation. For the routine-use exposure scenario, the exposure assumptions were derived using information from the BLM concerning proposed use of the herbicides, and unit exposure (UE) information from the Pesticide Handlers Exposure Database (PHED), which is a generic database containing empirical dermal and inhalation exposure data for workers mixing, loading, or applying pesticides (USEPA 1998d). To add consistency to the risk assessment process, the USEPA, in conjunction with the PHED task force, has evaluated all data within the system and developed a series of surrogate standard UE values for various exposure scenarios. The majority of the UE values have been taken from these surrogate values. In addition to these values, the USEPA recommended UEs separately for aquatic applications of diquat and fluridone. Generally, UEs are expressed in units of milligrams per pound of active ingredient and equate the milligrams of active ingredient absorbed by an occupational receptor to the pounds of active ingredient handled in a given day or exposure scenario.

For aerial applications, occupational receptors that may come into routine contact with herbicides include pilots and mixer/loaders. For ground applications by backpack, the occupational receptor is assumed to be an applicator/mixer/loader. For the remaining application methods (horseback; and spot and boom/broadcast methods for ATV, truck mount, and boat applications), applicators, mixer/loaders, and applicator/mixer/loaders were evaluated. In addition, for each occupational receptor, dermal and inhalation exposure pathways were evaluated. For the routine exposures, the exposure dose was calculated using the herbicide application rate and the acres treated per day. Details on how this was done are presented in the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l).

Accidental exposures for occupational receptors could occur via spills or direct spray onto a worker. To calculate exposures from direct spills, it is necessary to know the concentration of active ingredient in the formulation that is spilled onto the worker. These concentrations were calculated from the information provided on the herbicide labels. As a worst case scenario for an accidental exposure, a direct spill event on an occupational receptor was evaluated. This HHRA used the same spill scenario evaluated by the BLM in the *Final EIS Vegetation Treatment on BLM Lands in Thirteen Western States* (USDI BLM 1991a). The spill scenario assumed that 0.5 L (½ quart) of the formulation is spilled on a worker receptor. It is assumed that 80% of the spill lands on clothing and 20% lands on bare skin. The penetration rate through clothing is assumed to be 30%. While some of the herbicide labels require the use of gloves while handling the herbicide, others do not. Therefore, it was assumed for this scenario that gloves are not worn.

Public Use Exposure Scenarios. This HHRA evaluates the potential risk to public receptors using public lands treated with herbicides. This was done by developing exposure scenarios that combine potential receptors and exposure pathways to identify potential exposures to the herbicide active ingredient addressed in this PEIS. Two types of public use exposure scenarios are addressed:

- Potential exposure by public receptors during routine use of public lands to herbicide active ingredient(s) that may have drifted outside of the area of application
- Accidental scenarios where public receptors may prematurely enter a sprayed area (a reentry scenario), be sprayed directly, or may contact water bodies that have accidentally been sprayed directly or into which an herbicide active ingredient has accidentally been spilled

Although all of these public scenarios are expected to occur rarely, they are nonetheless used as the basis for evaluating potential public health risks associated with herbicide use in the BLM vegetation treatment program.

Based on consideration of potential public uses of BLM lands and consistent with the 1991 13-State EIS (USDI BLM 1991a), receptors evaluated in this HHRA include 1) hiker/hunter; 2) berry picker - child and adult; 3) angler; 4) swimmer - child and adult; 5) nearby resident

- child and adult; and 6) Native American - child and adult.

Although there are many different exposure scenarios and receptors that could be evaluated, these scenarios cover a range of potential exposures that could occur under worst case conditions on public lands. It is assumed that public receptors could be exposed through one or more of the following exposure pathways 1) dermal contact with spray, 2) dermal contact with foliage, 3) dermal contact with water while swimming, 4) ingestion of drinking water or incidental ingestion of water while swimming, 5) ingestion of berries, and 6) ingestion of fish.

Although all public receptor exposures to herbicides used on pubic lands are considered to be accidental, public receptor exposures were evaluated under two scenarios. Routine-use exposures are assumed to occur when public receptors come into contact with environmental media that have been impacted by spray drift. Accidental exposures are assumed to occur when public receptors come into contact with environmental media that have been subject to direct spray or spills. Each of these scenarios is discussed below.

Public receptors could be exposed to herbicides via off-site drift following routine aerial application. AgDRIFT, a computer model that is a product of the Cooperative Research and Development Agreement between the USEPA's Office of Research and Development and the SDTF (a coalition of pesticide registrants), was utilized in the HHRA to evaluate the off-site deposition of herbicides (SDTF 2002). See Appendix C of the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l) for a complete description of AgDRIFT modeling methods.

In addition, public receptors could be exposed to herbicides via surface runoff. The GLEAMS model, a modified version of the Chemical Runoff Erosion Assessment Management System (CREAMS) model that was originally developed to evaluate non-point source pollution from agricultural field-size areas, was used to simulate surface runoff of the three terrestrial herbicides considered in the HHRA. See Appendix D of the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l) for a complete description of GLEAMS modeling methods.

In addition to exposures due to inadvertent spray drift, this HHRA also evaluates potential acute accidental exposures by public receptors to the herbicide active ingredient. Accidental exposure could occur through direct spray and spills. The same types of receptors introduced above are also evaluated for the accidental scenarios. However, because direct spray or spills are localized, exposures to multiple media are not assumed in these scenarios. It is assumed that each of the herbicide active ingredients could be directly sprayed onto humans, foliage, and/or berries, and each of the herbicide active ingredients could be directly sprayed or spilled into a water body. However, for the aquatic herbicide active ingredients (fluridone and diquat), the direct spray into a water body pathway is a reentry scenario.

Risk Characterization

The purpose of the risk characterization is to provide estimates of the potential risk to human health from exposure to herbicides. The results of the exposure assessment are combined with the results of the dose-response assessment to derive quantitative estimates of risk. For the noncarcinogenic active ingredients evaluated in this HHRA, risk is described simply by the comparison of the exposure doses to the appropriate dose-response values.

The USEPA risk assessment guidance for pesticides provides different non-cancer methods for evaluating food and non-food exposures (USEPA 2000c). For food exposure, a percent (%) PAD method is used, and for non-food exposure, a MOE method is used, as described in the Dose-Response Assessment section above.

Aggregate Risk Indices. In assessing risks to humans, it is important to evaluate the cumulative or aggregate risk from all potential exposure pathways for each receptor. For the public receptors, both dietary and non-dietary pathways have been evaluated. To address this, USEPA's OPP has developed the aggregate risk index (ARI) approach, which combines potential risks from various pathways expressed as MOEs (for non-dietary exposures) and %PADs (for dietary exposures; USEPA 1999d, 2001d). It is important that only exposure pathways encompassing similar exposure durations be combined (i.e., acute exposures cannot be combined with chronic exposures). The ARI is an extension of the MOE concept. As with the MOE, potential risk increases as the ARI decreases. The ARI is compared against a target value of 1, which is the LOC set by the USEPA. Values > 1 do not exceed the USEPA's LOC. The ARI method allows for direct comparisons between routes and between chemicals. It considers each route's potency when route-specific NOAELs that may have different UFs are used. ARIs were developed for each of the identified exposure scenarios. Cumulative accidental ARIs were not calculated, as it is assumed that each receptor would be accidentally exposed via only one potential exposure pathway. Details on the ARI method are provided in the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l).

Forest Service Human Health Risk Assessment Methodology

The Forest Service risk assessment methodology was similar to that used by the BLM (see SERA [2001a] for a complete description of the methodology). The steps involved in the Forest Service risk assessments include hazard identification, exposure assessment, dose response assessment, and risk characterization.

Hazard identification involved the review of toxicological data with a focus on the dose-response relationships to determine the effect levels (e.g., NOAEL, LOAEL) and assessment endpoints (e.g., acute toxicity, subchronic or chronic systemic toxic effects, reproductive and teratogenic effects) that are most relevant for the herbicide risk assessments. Carcinogenic endpoints were evaluated for the Forest Service herbicides as some contain potential carcinogens in their formulations (i.e., hexachlorobenzene in clopyralid and picloram) and 2,4-D was still being evaluated by the USEPA for carcinogenicity.

In the exposure assessment phase, the Forest Service developed general and accidental exposure scenarios for workers expected to be handling the herbicides and for the general public who could be inadvertently exposed to herbicides. General exposure for workers included exposure via directed foliar, broadcast ground, and broadcast aerial applications. Accidental exposure scenarios for workers included immersion or contaminated clothing and spills. Exposure scenarios for the public included 1) direct spray, 2) dermal exposure from contaminated vegetation, 3) exposure to contaminated water, 4) acute exposure via spills, 5) consumption of contaminated fish, and 6) consumption of contaminated vegetation.

Dose response assessment described the degree or severity of risk as a function of dose. The Forest Service assessments used RfDs, derived by other government agencies. The RfD is designed to be protective of chronic or lifetime exposure, and it is a very conservative component of the Forest Service risk characterization process because the duration of any plausible and substantial exposures is far less than lifetime.

The risk characterization process then compared the exposure assessment to the dose response assessment to determine a HQ for a specific exposure scenario. Hazard quotients are calculated by dividing the exposure level determined in the HHRA by the RfD. A higher HQ indicated that the exposure level exceeded the RfD by a large amount. A quantitative risk assessment for carcinogenicity was conducted for hexachlorobenzene (found in the herbicide formulations of clopyralid and picloram), but not for any of the active ingredients. 2,4-D was still being reviewed as a potential carcinogen at the time of assessment, and therefore no carcinogenicity risk assessment was conducted.

Previous BLM EISs Methodology and Toxicology Literature Review

Asulam, atrazine, bromacil, diuron, fosamine, mefluidide, simazine, tebuthiuron, and 2,4-DP are herbicides currently available to the BLM for which new HHRAs were not conducted either by the BLM or the Forest Service. Human health risk assessments were conducted for these herbicides by the BLM for earlier vegetation treatment EISs (USDI BLM 1988a, 1989a, 1991a). The BLM has not used asulam, atrazine, mefluidide, simazine, and 2,4-DP, and fosamine has only been used sparingly (< 50 acres annually), since 1997. It is unlikely that the BLM would use these herbicides in the future, and they would not be available for use under the action alternatives (alternatives B though E).

Literature reviews and evaluations were conducted for the period 1991 to 1998 to assess whether toxicity data for many of these herbicides (asulam, atrazine, bromacil, diuron, mefluidide, simazine, tebuthiuron) that were reported since the 1991 13-State EIS would indicate that a new HHRA should be conducted (i.e., if the new toxicity data suggested greater risks to humans; McMullin and Thomas 2000). Neither 2,4-DP, atrazine, bromacil, diuron, simazine, nor tebuthiuron had more recent toxicity data suggesting additional risks to humans; therefore, the human health risks of these herbicides are reported in this chapter using results from the earlier EIS (also see Appendix B for more information on the risks associated with these herbicides). The literature review suggested that revisions may be warranted for asulam (based on a lower RfD) and for mefluidide (based on development of a RfD).

The 1991 13-State EIS HHRA also evaluated occupational and public receptors similar to the current PEIS. Doses to receptors were estimated using assumptions about the characteristics of typical herbicide applications based on realistic as well as worst case values for these estimates. Doses to receptors resulting from accidental exposures were evaluated. The risk assessment developed MOEs based on a ratio of the estimated herbicide intake to the acceptable concentration represented by the RfD. In addition, cancer slope factors were available for specific herbicides, such as bromacil. For these herbicides, potential cancer risks were also estimated. The cancer slope factor for bromacil was available from USEPA at the time of the 1991 EIS. However, in the current review, USEPA did not provide a cancer slope factor (USEPA 1994b), therefore bromacil is likely not considered potentially carcinogenic.

Exposure scenarios for the public included 1) dermal exposure through spray drift, 2) dermal contact with vegetation, and 3) consumption of berries, water, fish, and game. It was assumed that occupational receptors could be exposed through inhalation and dermal contact. Occupational receptors included 1) aerial pilots; 2) mixer-loaders; 3) backpack applicators; 4) ground mechanical applicators; and 5) hand applicators.

Routine and worst-case exposures were calculated using variable parameters such as application rate, size of treatment area, and drift conditions. The following accidental scenarios were also analyzed: 1) spills of herbicide concentrate and mix on a person's skin; 2) direct spraying of a worker from a broken hose; 3) direct spraying of a person from aerial application; 4) immediate reentry to a sprayed area; 5) consumption of water from a pond that has been aerially sprayed, or that has received a spill from an airplane or tank mix truck; and 6) consumption of berries that have been directly sprayed.

Uncertainty in the Risk Assessment Process

The risk assessments conducted by the BLM and Forest Service incorporate various conservative assumptions to compensate for uncertainties in the risk assessment process. Within any of the steps of the human health risk evaluation process, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk evaluation process. Regulatory risk evaluation methodology requires that conservative assumptions be made throughout the risk assessment process to ensure that public health is protected. This conservatism, both in estimating exposures and in setting toxicity levels likely led to an exaggeration of the real risks of the vegetation management program to err on the side of protecting human health.

Assessment of Human Health Risks for Each Herbicide

Each of the HHRAs developed risk estimates for occupational and public receptors for a variety of routine and accidental scenarios. The risk estimates for each herbicide, and for herbicides in general, are presented below.

Impacts Common to All Herbicides

Risk to two types of human "receptors" was evaluated: occupational receptors and public receptors. Occupational receptors included those workers that mix, load, and apply herbicides and operate transport vehicles, recognizing that in some cases an occupational receptor may perform multiple tasks, increasing his or her exposure. Public receptors included those members of the public most likely to come into contact with applied herbicides, assuming that certain activities would result in more or less exposure to an herbicide. The public receptors included adult hiker/hunters and anglers, and adult and child berry pickers, swimmers, Native Americans, and residents. Receptors were evaluated assuming both accidental (e.g., direct spray or spill onto skin) and routine exposure scenarios (e.g., ingestion of drinking water).

Occupational Receptors

Herbicide application methods may require the use of heavy machinery, which could involve potential health and safety impacts to people working in the herbicide application programs (occupational receptors); however, the main potential impact associated with the use of herbicides is exposure to the chemicals (including the herbicide active ingredient(s) and other compounds added to the herbicide formula). These chemicals can all be toxic to human workers and exposed members of the public to varying degrees (any chemical poses a health risk at a high enough dose). Most clinical reports of herbicide effects are of skin and eye irritation.

Short-term effects of excessive exposure to herbicides include nausea, dizziness, or reversible abnormalities of the nervous system. In extreme cases of prolonged, repeated, and excessive exposure (resulting from careless and/or negligent work habits), longer-term health problems can result, including: organ damage, immune system damage, permanent nervous system damage, production of inheritable mutations, damage to developing offspring, and reduction of reproductive success. It is important to note that the USEPA evaluates and registers herbicides according to a uniform, health-based standard to ensure a "reasonable certainty of no harm" to consumers. The USEPA is responsible for restricting a product's use according to its potential impacts on human health and the environment. Much of that restriction is done through the product label, which states the precautions that must be taken as well as how and where to apply a certain herbicide.

Occupational exposure to herbicides varies with the method of application. The greatest risk occurs when the worker must directly handle and/or mix chemicals. Spot and localized herbicide applications, including the use of backpack sprayers and aerial mixers/loaders, require the most hands-on use of herbicides and, therefore, carry the greatest risk of exposure. Under all application methods, workers can be exposed to herbicides from accidental spills, splashing, leaking equipment, contact with spray, or by entering treated areas. Exposure can occur either through skin or through inhalation. Adherence to operational safety guidelines, use of protective clothing, equipment checks, and personal hygiene can prevent incidents from occurring. The herbicide label and corresponding Material Safety Data Sheet (MSDS) detail these application requirements in addition to safety guidelines.

Public Receptors

Public receptors can be exposed from being accidentally sprayed, from entering areas soon after treatment (e.g., eating berries or other foods, touching vegetation), drinking contaminated water, or accidental exposure to herbicides that have drifted downwind. Members of the general public, both visitors and residents, are less likely to receive repeated exposures than vegetation management workers.

Members of the public, both visitors and nearby residents, could potentially be exposed to herbicides from drift or accidental spraying if they were in the area at the time of application. Since aerial and broadcast applications have a higher potential for drift, these application techniques might create a higher potential for public exposure, particularly under certain weather conditions (e.g., high winds).

Laboratory tests on animals have shown that most herbicides are not carcinogenic, even at doses and repeated exposures well above that which could occur accidentally as part of vegetation management activities. Furthermore, herbicides are designed to work on plants, not animals, so that the toxic effects generally do not affect the central nervous system or other vital functions.

Calculated dose response values and exposure doses were combined to estimate potential risks (in terms of ARIs for BLM HHRA herbicides and in terms of HQs for previously evaluated Forest Service herbicides) from each individual herbicide for each receptor. In addition, the strength of these risks was evaluated by herbicide as well as by receptor, herbicide treatment method (e.g., aerial vs. terrestrial), and herbicide treatment alternative.

Human Health Risks Associated with Herbicides Evaluated in the BLM Human Health Risk Assessment

The HHRA listed the acute toxicity categories for each herbicide developed by USEPA, and conducted risk calculations to determine potential risks from routine and accidental exposures for specific receptors. The USEPA has developed toxicity categories for pesticides based on acute toxicity animal tests conducted in support of registration of the pesticides (USEPA 2003h). All of the six herbicides evaluated in the BLM HHRA show slight to very slight acute toxicity to humans as designated by the USEPA in most categories. Based on the USEPA categories, dicamba may result in reversible eye irritation and severe skin irritation. Diquat shows moderate acute dermal effects and reversible eye irritation, and fluridone shows reversible eye irritation. The USEPA has not developed acute toxicity categories for sulfometuron methyl.

None of the six herbicides are designated as potential carcinogens by the USEPA. Therefore, the risk calculations discussed below consider noncancer risk.

Tables 4-27 and 4-28 present summaries of the level of risk each receptor (occupational and public) would face with the application of a given herbicide for both maximum and typical application rate scenarios. ARIs are partitioned into no, low, moderate, and high levels of risk for ease of comparison (no risk is identified as an

ARI > 1, low risk is between 1 and 0.1, moderate risk is between 0.1 and 0.01, and high risk is < 0.01). These designations are strictly for comparison purposes, and do not imply actual risks to people. The *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l) presents more detailed tables of ARIs for each herbicide and receptor.

Dicamba

For the routine application scenarios at the typical and maximum application rates, dicamba does not result in unacceptable risk to occupational or public receptors. However, dicamba applications do present low risk to occupational receptors during accidental scenarios.

Diflufenzopyr

For occupational receptors, routine use ARIs were calculated for inhalation exposures under both typical and maximum application rate scenarios. No dermal toxicity values are available for diflufenzopyr, which, based on laboratory data, is not expected to be toxic through the dermal route. Routine use ARIs are > 1 under both the typical and maximum application rate scenarios, indicating no exceedance of the USEPA's LOC. Because the accidental occupational scenarios all assume dermal exposure and diflufenzopyr does not have a short-term dermal NOAEL because it is not expected to be toxic through the dermal route, an accidental scenario ARI was not calculated.

For public receptors, routine use scenario ARIs are greater than 1 under both the typical and maximum application rate scenarios for all public receptors, indicating no LOC. Under the accidental scenario, it is assumed that public receptors are exposed directly to maximum herbicide application rates via dermal contact, incidental ingestion of water while swimming, or dietary exposure pathways at the maximum application rate. All accidental scenario ARIs are > 1, indicating no LOC.

These results indicate that diflufenzopyr risks are not expected to exceed the USEPA's LOC for occupational or public receptors under the scenarios evaluated.

Diquat

At the typical application rate, diquat results in low to moderate risk to some occupational receptors (all aerial, backpack, and horseback applicators), and low risk to child residents. When diquat is applied at the maximum application rate, there is low risk to all occupational receptors (except boat applicators) and public receptors (except swimmers). Diquat results in high risk to occupational receptors and low to moderate risk to public receptors under all accidental scenarios.

Fluridone

Fluridone does not result in risk to occupational or public receptors when applied at the typical application rate. When fluridone is applied at the maximum application rate, there is low risk to aerial mixer/loaders. For accidental scenarios, fluridone poses low to high risk to all occupational receptors, and low risk to child and resident public receptors.

Imazapic

Imazapic applications do not present risk to any receptors when applied in routine use situations at either the typical or maximum application rate. Accidental scenarios involving dermal contact with direct spray or vegetation or dietary exposure were not calculated because imazapic has not been shown to have acute dietary or dermal effects in hazard analyses conducted by USEPA (ENSR 2005l). Accidental scenarios involving dermal contact with a sprayed waterbody or a waterbody into which herbicide was spilled did not result in risk to swimmers.

Sulfometuron Methyl

Sulfometuron methyl applications do not present risk to any receptors when applied in routine use situations at either the typical or maximum application rate. Accidental scenarios involving dermal contact with direct spray or vegetation or dietary exposure were not calculated because sulfometuron methyl has not been shown to have acute dietary or dermal effects in hazard analyses conducted by USEPA (ENSR 2005l). Accidental scenarios involving dermal contact with a sprayed waterbody or a waterbody into which herbicide was spilled did not result in risk to swimmers.

Human Health Risks Associated with Herbicides Evaluated in the Forest Service Human Health Risk Assessment

The BLM used the results of HHRAs prepared by the Forest Serve for nine active ingredients (2,4-D, chlorsulfuron, clopyralid, glyphosate, hexazinone, imazapyr, metsulfuron methyl, picloram, and triclopyr [SERA 2005b]). The Forest Service HHRAs presented the risk results as HQs. In the summary tables presented

TABLE 4-27
BLM-evaluated Herbicide Risk Categories by Aggregate Risk Index for Occupational Receptors

Receptor	Dicamba			Diflufenzopyr			Diquat			Fluridone			Imazapic			Sulfometuron Methyl		
	Typ[1]	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid[2]	Typ	Max	Accid	Typ	Max	Accid
Plane - pilot	NE[3]	NE	NE	NE	NE	NE	L	M	H	0	0	L-H	0	0	NE	0	0	NE
Plane - mixer/loader	NE	NE	NE	NE	NE	NE	M	H	H	0	L	L-H	0	0	NE	0	0	NE
Helicopter - pilot	NE	NE	NE	NE	NE	NE	L	M	H	0	0	L-H	0	0	NE	0	0	NE
Helicopter - mixer/loader	NE	NE	NE	NE	NE	NE	M	H	H	0	L	L-H	0	0	NE	0	0	NE
Human/backpack - applicator/mixer/loader	0	0	L	0	0	NE	L	M	H	0	0	L-H	0	0	NE	0	0	NE
Human/horseback - applicator	0	0	L	0	0	NE	L	L	H	0	0	L-H	0	0	NE	0	0	NE
Human/horseback - mixer/loader	0	0	L	0	0	NE	0	L	H	0	0	L-H	0	0	NE	0	0	NE
Human/horseback - applicator/mixer/loader	0	0	L	0	0	NE	L	M	H	0	0	L-H	0	0	NE	0	0	NE
ATV - applicator[4]	0	0	L	0	0	NE	0	L	H	0	0	L-H	0	0	NE	0	0	NE
ATV - mixer/loader	0	0	L	0	0	NE	0	L	H	0	0	L-H	0	0	NE	0	0	NE
ATV - applicator/mixer/loader	0	0	L	0	0	NE	0	L	H	0	0	L-H	0	0	NE	0	0	NE
Truck - applicator[4]	0	0	L	0	0	NE	0	M	H	0	0	L-H	0	0	NE	0	0	NE
Truck - mixer/loader	0	0	L	0	0	NE	0	L	H	0	0	L-H	0	0	NE	0	0	NE
Truck - applicator/mixer/loader	0	0	L	0	0	NE	0	M	H	0	0	L-H	0	0	NE	0	0	NE
Boat - applicator	NE	NE	NE	NE	NE	NE	0	0	H	0	0	L-H	NE	NE	NE	NE	NE	NE
Boat - mixer/loader	NE	NE	NE	NE	NE	NE	0	0	H	0	0	L-H	NE	NE	NE	NE	NE	NE
Boat - applicator/mixer/loader	NE	NE	NE	NE	NE	NE	0	0	H	0	0	L-H	NE	NE	NE	NE	NE	NE

[1] Typ = Typical application rate; Max = Maximum application rate; and Accid = Accidental rate. Typical and maximum application rate categories include short-, intermediate-, and long-term exposures. Accidental scenario category includes accidents with herbicide mixed at both the typical and maximum application rates and with a concentrated herbicide.

[2] For all occupational receptors accidentally exposed to fluridone, there is low risk from exposure to solutions mixed with water to the typical application rate, moderate risk from exposure to solutions mixed with water to the maximum application rate, and high risk from exposure to concentrated solutions (prior to mixing with water).

[3] Risk categories: 0 = No risk (majority of ARIs > 1); L = Low risk (majority of ARIs >1 but < 0.1); M = Moderate risk (majority of ARIs > 0.1 but < 0.01); H = High risk (majority of ARIs < 0.01); and NE = Not evaluated. The reported risk category represents the typical/most common risk level for estimated risks from various time periods. See the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l) for the range of risk levels for each scenario.

[4] ATV and Truck categories include spot and boom/broadcast application scenarios.

TABLE 4-28
BLM-evaluated Herbicide Risk Categories by Aggregate Risk Index for Public Receptors

Receptor	Dicamba			Diflufenzopyr			Diquat			Fluridone			Imazapic			Sulfometuron Methyl		
	Typ[1]	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid
Hiker/hunter (adult)	0[2]	0	0	0	0	0	0	L	L	0	0	0	NE	NE	NE	NE	NE	NE
Berry picker (child)	0	0	0	0	0	0	0	L	L	0	0	L	NE	NE	NE	NE	NE	NE
Berry picker (adult)	0	0	0	0	0	0	0	L	L	0	0	0	NE	NE	NE	NE	NE	NE
Angler (adult)	0	0	0	0	0	0	0	L	L	0	0	0	NE	NE	NE	NE	NE	NE
Residential (child)	0	0	0	0	0	0	L	L	M	0	0	L	NE	NE	NE	NE	NE	NE
Residential (adult)	0	0	0	0	0	0	0	L	M	0	0	L	NE	NE	NE	NE	NE	NE
Native American (child)	0	0	0	0	0	0	0	L	L	0	0	0	0	0	0	0	0	0
Native American (adult)	0	0	0	0	0	0	0	L	L	0	0	0	0	0	0	0	0	0
Swimmer (child)	0	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0	0
Swimmer (adult)	0	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0	0

[1] Typ = Typical application rate; Max = Maximum application rate; and Accid = Accidental rate. Typical and maximum application rate categories include short-, intermediate-, and long-term exposures. Accidental scenario category includes accidents with herbicide mixed at both the typical and maximum application rates and with a concentrated herbicide.

[2] Risk categories: 0 = No risk (majority of ARIs > 1); L = Low risk (majority of ARIs >1 but < 0.1); M = Moderate risk (majority of ARIs > 0.1 but < 0.01); H = High risk (majority of ARIs < 0.01); and NE = Not evaluated. The reported risk category represents the typical/most common risk level for estimated risks from various time periods. See the *Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report* (ENSR 2005l) for the range of risk levels for each scenario.

TABLE 4-29
Forest Service-evaluated Herbicide Risk Categories by Hazard Quotient for Occupational Exposures

Treatment Method	Risk Categories																	
	2,4-D[1]		Chlorsulfuron		Clopyralid		Glyphosate		Hexazinone		Imazapyr		Metsulfuron Methyl		Picloram		Triclopyr[1]	
	Typ[2]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
General Exposures																		
Directed foliar and spot treatments (backpack)	L[3]	L	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	L
Broadcast ground spray (boom spray)	L	M	0	L	0	0	0	0	0	L	0	0	0	0	0	0	0	L
Aerial applications (pilots and mixer/loaders)	L	L	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	L
Aquatic applications	L	L	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Accidental/Incidental Exposures																		
Immersion of hands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wearing contaminated gloves	M	·M	0	0	0	0	0	0	L	L	0	0	0	0	0	0	0	L
Spill on hands	L	L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spill on lower legs	L	M	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0

[1] Where different formulations exist, risks reported are the most conservative.
[2] Typ = Typical application rate; and Max = Maximum application rate.
[3] Risk categories: 0 = No risk (majority of HQs < 1); L = Low risk (majority of HQs >1 but < 10); M = Moderate risk (majority of HQs > 10 but < 100); H = High risk (majority of HQs > 100); and NE = Not evaluated. Risk categories are based on typical and upper HQ estimates. To determine risk for lower or central HQ estimates, see the individual herbicide risk assessments (SERA 2005b). Risk categories are based on comparison to the HQ of 1 for typical and maximum application rates.

TABLE 4-30
Forest Service-evaluated Herbicide Risk Categories by Hazard Quotient for Public Exposures

Treatment Method	Hazard Quotient																	
	2,4-D[1]		Chlorsulfuron		Clopyralid		Glyphosate		Hexazinone		Imazapyr		Metsulfuron		Picloram		Triclopyr[1]	
	Typ[2]	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max
Acute/Accidental Exposures																		
Direct spray-child, entire body	0[3]	M	0	0	0	0	0	0	L	M	0	0	0	0	0	0	0	L
Direct spray-woman, lower legs	0	L	0	0	0	0	0	0	0	L	0	0	0	0	0	0	L	M
Dermal-contaminated vegetation, woman	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	L	L
Consumption of contaminated fruit	L	M	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	L
Consumption of contaminated water-pond, spill	M	H	0	0	0	L	0	L	M	M	0	0	0	0	0	L	0	L
Consumption of contaminated water-stream, ambient	L	L	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0
Consumption of contaminated fish-general public	M	M	0	0	0	0	0	0	L	L	0	0	0	0	0	0	0	0
Consumption of contaminated fish-subsistence populations	H	H	0	0	0	0	0	0	M	M	0	0	0	0	0	0	0	0
Chronic/Longer-term Exposures																		
Consumption of contaminated fruit	0	L	0	0	0	0	0	0	0	L	0	0	0	0	0	0	0	0
Consumption of contaminated water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated fish-general public	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumption of contaminated fish-subsistence populations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Where different formulations exist, risks reported are the most conservative.
[2] Typ = Typical application rate; and Max = Maximum application rate.
[3] Risk categories: 0 = No risk (majority of HQs < 1); L = Low risk (majority of HQs >1 but < 10); M = Moderate risk (majority of HQs > 10 but < 100); H = High risk (majority of HQs > 100); and NE = Not evaluated. Risk categories are based on typical and upper HQ estimates. To determine risk for lower or central HQ estimates, see the individual herbicide risk assessments (SERA 2005b). Risk categories are based on comparison to the HQ of 1 for typical and maximum application rates.

here, (Tables 4-29 and 4-30), HQs were designated as no, low, moderate and high risk levels for ease of comparison (no risk is identified as an HQ greater than 1, low risk is an HQ between 1 and 10, moderate risk is an HQ between 10 and 100, and high risk is an HQ greater than 100). Tables 4-29 and 4-30 present summaries of the risks to occupational and public receptors, respectively, associated with the Forest Service-evaluated herbicides.

2,4-D

Workers involved in ground or aerial application of 2,4-D may face low risks based on central estimates of exposure, or moderate to high risks based on upper limits of exposure (SERA 1998). At the typical and maximum application rates, workers involved in directed ground spray, broadcast ground spray, aerial application and aquatic application face low to moderate risk from 2,4-D exposure. Workers also face low to moderate risk from wearing contaminated gloves for 1 hour, exposure to a spill on the hands for 1 hour (maximum rate only), and exposure to spill on the lower legs for 1 hour. The general public faces low to moderate risk from most modeled scenarios at the typical and maximum application rates. The consumption of contaminated fish by the general public results in moderate risk and by subsistence populations results in high risk. However, the Forest Service HHRA asserts that (at the typical application rate) the general public should not have unacceptable risks from exposure to 2,4-D, but that accidental exposures may result in higher risk. The major concern for members of the general public involves the consumption of contaminated vegetation (fruit) over a period of several months, a scenario that is not likely to occur.

Chlorsulfuron

For both workers and the general public, most exposures to chlorsulfuron do not lead to risk at either the typical or maximum application rates (SERA 2004a). For workers, the ground broadcast applications at the maximum application rate results in low risk.

From a practical perspective, eye and/or skin irritation are likely to be the only overt effects of mishandling chlorsulfuron. These effects can be minimized or avoided by prudent industrial hygiene practices during the handling of the compound.

Clopyralid

Most of the anticipated typical and accidental exposure scenarios evaluated in the Forest Service risk assessment show no risks for clopyralid. Irritation and damage to the skin and eyes can result from direct exposure to relatively high levels of clopyralid; this is likely to be the only overt effect as a consequence of mishandling clopyralid (SERA 2004b). Children face low risk from consumption of water contaminated by an accidental spill.

The human health risks of hexachlorobenzene and pentachlorobenzene were also analyzed in the Forest Service HHRA, as technical grade clopyralid may be contaminated with these chemicals. Hexachlorobenzene was evaluated for potential carcinogenicity. Based on the levels of contamination of technical grade clopyralid with hexachlorobenzene and pentachlorobenzene, and the relative potencies of these compounds compared to clopyralid, this contamination is not significant in terms of potential systemic toxic effects. In addition, the contamination of clopyralid with hexachlorobenzene does not appear to present any substantial cancer risk above the Forest Service cancer risk LOC of one in one-million.

Glyphosate

For both workers and members of the general public, there were no risks at the typical or maximum application rate (SERA 2003b). All but one of the tested scenarios resulted in no risk, usually at least by a factor of 5. There is low risk to the general public for the accidental exposure scenario of consumption of contaminated water by a child after a spill into a small pond.

Hexazinone

Over the range of plausible application rates, all worker groups exposed to hexazinone may face risks, with the highest risks observed with workers using an over-the-shoulder broadcast applicator (belly grinder; SERA 1997). Workers exposed to hexazinone via directed and broadcast ground spray and aerial applications are at low risk at the maximum application rate. Accidental exposure with hexazinone mixed for the maximum application rate results in low risk with exposure via contaminated gloves (also low risk at the typical application rate) and low risk with exposure via spills on lower legs. The most likely effects include irritation to the eyes, respiratory tract, and skin. Even under the most extreme exposure scenarios, outward toxic effects are not likely to be observed; however, the upper estimates of exposure levels could be associated with subclinical (non-symptomatic) effects and possible reproductive effects. In some accidental exposure scenarios, members of the general public may face risks from exposure to hexazinone. At the typical application rate, low to moderate risk to public receptors results from the following scenarios: direct spray of the entire body, acute consumption of water contaminated by a spill, and acute consumption of contaminated fish by the general public and subsistence populations. At the maximum application rate the above scenarios result in low to moderate risk to public receptors and the following additional scenarios result in low risk: direct spray of the lower legs, acute and chronic consumption of fruit, and consumption of stream water contaminated by runoff or percolation.

Imazapyr

Most exposures to imazapyr do not lead to risks for either workers or members of the general public at either the typical or the maximum application rate, suggesting that workers and the general public would generally not be at any substantial risk from longer-term exposure to imazapyr even at the upper range of the application rate considered in the risk assessment (SERA 2004e). From a practical perspective, eye irritation is likely to be the only overt effect as a consequence of mishandling imazapyr. This effect can be minimized or avoided by prudent industrial hygiene practices during the handling of the compound.

Metsulfuron Methyl

Typical exposures to metsulfuron methyl at the typical or maximum application rates do not lead to risks for workers or the general public (SERA 2004f). For workers, no acute or chronic exposure scenarios result in risks even at the upper ranges of estimated dose. For members of the general public, no risks were observed for any of the exposure scenarios. From a practical perspective, eye and skin irritation are likely to be the only overt effects of mishandling metsulfuron methyl. These effects can be minimized or avoided by prudent industrial hygiene practices during the handling of this compound.

Picloram

Typical exposures to picloram do not lead to risks at either the typical or maximum application rates (SERA 2003c). For workers, there were no estimated risks even at the upper ranges of exposure. For members of the general public, there were no risks except for the consumption of water by a child following an accidental spill of a large amount of picloram into a very small pond, which resulted in a low risk. From a practical perspective, eye irritation and skin sensitization are likely to be the only overt effects as a consequence of mishandling picloram. Based on the standard assumptions used in this and other Forest Service risk assessments, the contamination of picloram with hexachlorobenzene does not appear to present any substantial cancer risk even at the upper ranges of plausible exposure.

Triclopyr

At the upper ranges of exposures for both evaluated formulations of triclopyr (triclopyr acid and triclopyr BEE), workers face low risk at the maximum application rate from directed and broadcast ground spray and aerial applications (SERA 2003d). At the maximum application rate, workers face low risk from accidental exposure to contaminated gloves (1 hour duration). Thus, for workers who may apply triclopyr repeatedly over a period of several weeks or longer, it is important to ensure that work practices involve reasonably protective procedures to avoid the upper extremes of potential exposure. At higher application rates, measures that limit exposure should be developed on a case-by-case basis depending on the application rate and method. The general public experiences low to moderate risk from triclopyr applications under several acute or accidental scenarios: 1) direct spray to entire body; 2) direct spray to lower legs; 3) dermal contact with contaminated vegetation; 4) acute consumption of contaminated fruit (maximum application rate only); and 5) acute consumption of pond water contaminated by a spill.

Human Health Risks Associated with Herbicides Evaluated in Previous BLM EISs and Literature Review

As discussed earlier, the human health risks of asulam, atrazine, bromacil, diuron, fosamine, mefluidide, simazine, tebuthiuron, and 2,4-DP were evaluated in earlier BLM vegetation treatment EISs. These herbicides were not reevaluated in the BLM HHRA for the current PEIS because a literature review and evaluation showed that most toxicity values for these herbicides reported in more recent studies were not substantially lower (i.e., present more risk) than the values used to assess risks to human health in the 1991 13-State EIS (McMullin and Thomas 2000). Tables 4-31 and 4-32 present summaries of the risks to occupational and public receptors associated with the nine herbicides that were evaluated in the earlier EISs and subsequent literature reviews. The earlier EISs calculate a margin of safety (MOS), which is the NOAEL divided by the exposure dose (and the same as the MOE used in the current HHRA), and cancer risk estimates for potential carcinogens. The EISs included summary tables that identified herbicides and scenarios resulting in high risk, where high risk is identified as a MOS < 100, or a cancer risk estimate greater than one in a million. Therefore, Tables 4-31 and 4-32 also report the herbicides and exposure scenarios resulting in high risk as presented in the earlier EISs.

Another difference between this PEIS HHRA and earlier EIS HHRAs is in the toxicity assessment. For the current HHRA, the USEPA either provided toxicity values for the various exposure durations (acute, short-term, long-term) and exposure routes (oral, dermal), or convened a panel to develop these values for this project. This ensured that the toxicity values used in the current HHRA are consistently derived and have had the benefit of peer review. In the development of these values, the USEPA selects the most sensitive endpoint from the most sensitive species, therefore, the values are protective of all other potential toxic effects (i.e., those that may occur at higher exposure levels). This methodology is standard practice for current HHRA guidance. However, during development of the earlier EISs, there was not much agency derived information on the herbicides evaluated, nor was the methodology for evaluation as standardized. Thus, the authors evaluated separate toxic endpoints for systemic and reproductive effects for each herbicide, not just the most sensitive endpoint. Thus, the results discussed by toxic endpoint below, rather than in the context of the most sensitive endpoint.

2,4-DP

According to the 1988 *California Vegetation Management Final EIS* (1988 California EIS), 2,4-DP applications result in risk to backpack and hand applicators from typical application practices (USDI BLM 1988a). Backpack and hand applicators and ground applicators, mixer-loaders, and applicator/mixer-loaders are also at risk of systemic and reproductive effects from maximum exposures. Risk of systemic, reproductive, and cancer effects to workers and public receptors results from the accidental scenarios of spill to skin and direct spray. Public receptors are at risk from systemic, reproductive, and cancer risk from vegetation contact by pickers, and from systemic and reproductive risks from drinking directly sprayed water and eating berries. Nearby residents are also face systemic and reproductive risks from treatments on public lands.

Asulam

According to the 1988 California EIS, asulam applications would result in few risks to workers or the public. Hand applicators would be at risk of systemic and reproductive effects from maximum exposures, while the public would be at risk of systemic, reproductive, and cancer effects from vegetation contact by pickers.

Atrazine

According to the 1991 13-State EIS, workers and the public would face numerous risks from exposure to atrazine. Workers would be at risk of systemic and/or reproductive effects under nearly all scenarios analyzed at the typical application rate, and would be at risk of systemic, reproductive, and cancer effects under all scenarios analyzed under the maximum application and accidental scenarios. The public would be at risk of systemic and/or reproductive effects under several scenarios at the maximum application rate. The public would be at risk of systemic, reproductive, and cancer effects under all scenarios from accidental exposures, except for contact with vegetation by a hiker or from fishing (systemic and reproductive effects only), or by living near a treated area (reproductive effect only).

Bromacil

According to the 1991 13-State EIS, bromacil applications result in risk to workers from several exposure scenarios resulting from typical application practices. Pilots and aerial mixer-loaders face risk of systemic, reproductive, and cancer effects from typical and maximum exposures to bromacil. Backpack and hand applicators and ground applicators, mixer-loaders, and applicator/mixer-loaders are also at risk of systemic and reproductive effects from maximum exposures. Risk of systemic, reproductive, and cancer effects to workers and public receptors results from the accidental scenarios of spill to skin (concentrate and mixture), direct spray (no cancer risk), consumption of fish from directly sprayed waterbody (no cancer risk), consumption of directly sprayed berries (no cancer risk), and drinking from water contaminated by a truck spill or a jettison of mixture (no cancer risk). The cancer slope factor for bromacil used in the HHRA was the one available from USEPA at the time of the 1991 13-State EIS. However, in its most recent review of bromacil, USEPA did not provide a cancer slope factor (USEPA 1994b), therefore bromacil is likely not considered potentially carcinogenic.

Diuron

According to the 1991 13-State EIS, diuron applications pose risk to both workers and the general public for both routine and accidental exposures. Aerial application results in risk of systemic effects to most evaluated public receptors and scenarios from worst-case exposures (e.g., direct exposure of hikers, berry pickers, anglers, and nearby residents; spray drift to skin; vegetation contact by berry pickers; consumption of contaminated drinking water and fish). Berry pickers also experience systemic risk from worst-case direct exposure and contact with vegetation scenarios. In aerial application scenarios, pilots and mixer-loaders are at risk of systemic and reproductive effects under both typical and worst-case exposures, and fuel-truck operators are at risk of systemic and reproductive effects for worst-case exposures. In addition, backpack and hand applicators and ground applicators, mixer-loaders, and applicator-mixer-loaders face risk of systemic and reproductive effects for typical (systemic only) and worst-case exposures. Risk of systemic and reproductive effects to workers and the public also results from the accidental scenarios of spill to skin (herbicide concentrate and mixture), direct spray, drinking or eating fish from directly sprayed waterbody, immediate reentry into a sprayed area by a berry.

Mefluidide

According to the 1991 13-State EIS, workers would experience few risks from applications of mefluidide. Pilots, backpack applicators, and hand applicators could experience systemic effects when mefluidide is applied at the maximum rate, and hand applicators could experience systemic effects at the typical application rate, as well. Hikers reentering a treated area, or drinking water contaminated by a truck, at the accidental rate could experience systemic risks.

Simazine

According to the 1991 13-State EIS, risks to workers would be limited to systemic and reproductive effects to pilots and aircraft mixer-loaders under the typical and maximum application rates. In addition, a spill to a worker's skin of either a concentrate or mixture of simazine could result in systemic, reproductive, and cancer effects. The public could experience systemic, reproductive, and cancer effects under most scenarios analyzed in the HHRA under accidental exposures. However, hikers entering recently treated areas and contacting vegetation, anglers, and nearby residents would not be at risk under the accidental exposure scenarios.

Tebuthiuron

According to the 1991 13-State EIS, tebuthiuron does pose health risks to workers in various application scenarios. Typical and worst-case aerial application exposure to tebuthiuron may result in risks of systemic and reproductive effects to pilots and to mixer-loaders (no systemic risk at typical exposures). Fuel-truck operators experience systemic risk from worst-case exposure to tebuthiuron during aerial application. Backpack applicators face systemic and reproductive risks from worst-case exposures to tebuthiuron. For workers using ground mechanical equipment, there are systemic and reproductive risks to applicators, mixer-loaders, and applicator/mixer-loaders from worst-case exposures to tebuthiuron. Hand applicators are at risk from typical (reproductive effects) and worst-case (systemic and reproductive effects) exposures. Several accidental scenarios also result in risk of systemic and reproductive effects to workers and the public: 1) spill of herbicide mixture to skin; 2) direct spray to person; 3) drinking directly sprayed water (reproductive only); 4) immediate reentry of a berry picker into a sprayed area; 5) consumption of directly sprayed berries; and 6) consumption of water contaminated by a jettison of mixture or by a truck spill.

Human Health Risks by Application Method

Air

Aerial applications of herbicides generally result in greater risk due to off-site drift, as herbicides applied at greater distances from the ground are able to drift farther from the target application area. Therefore, public receptors recreating or living at farther distances from an application area would be at greater risk if the herbicide is applied aerially than if the herbicide is applied by a ground application method. The BLM does not apply dicamba and diflufenzopyr by air.

Ground

Ground applications typically result in lower risk to off-site receptors than aerial applications because receptors are less likely to be exposed to spray drift. Similarly, spot rather than boom/broadcast applications are less likely to result in risk to downwind receptors. However,

TABLE 4-31
Scenarios Resulting in High Risk to Occupational Receptors from Herbicides Evaluated in the 1988-1991 BLM EISs

Treatment Method	2,4-DP			Asulam			Atrazine			Bromacil			Diuron		
	Typ[1]	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid
Aerial pilot	0[2]	0	NA	0	0	NA	S,R	S,R,C	NA	R,C	S,R,C	NA	S,R	S,R	NA
Aerial mixer-loader	0	0	NA	0	0	NA	S,R	S,R,C	NA	S,R,C	S,R,C	NA	S,R	S,R	NA
Aerial fuel truck operator	0	0	NA	0	0	NA	0	S,R,C	NA	0	0	NA	0	S,R	NA
Backpack applicator	S,R	S,R	NA	0	0	NA	R	S,R,C	NA	0	S,R	NA	S	S,R	NA
Ground mechanical applicator	0	S,R	NA	0	0	NA	R	S,R,C	NA	0	S,R	NA	S	S,R	NA
Ground mechanical mixer-loader	0	S,R	NA	0	0	NA	S,R	S,R,C	NA	0	S,R	NA	S	S,R	NA
Ground mechanical applicator/mixer-loader	0	S,R	NA	0	0	NA	S,R	S,R,C	NA	0	S,R	NA	S	S,R	NA
Hand applicator	S,R	S,R	NA	0	0	NA	R	S,R,C	NA	0	S,R	NA	S	S,R	NA
Skin spill, concentrate	NA	NA	S,R,C	NA	NA	S,R,C	NA	NA	S,R,C	NA	NA	S,R,C	NA	NA	S,R
Skin spill, mixture	NA	NA	S,R,C	NA	NA	S,R,C	NA	NA	S,R,C	NA	NA	S,R,C	NA	NA	S,R
Direct spray, person	NA	NA	NA	NA	NA	NA	NA	NA	S,R,C	NA	NA	S,R	NA	NA	S,R

Treatment Method	Fosamine			Mefluidide			Simazine			Tebuthiuron		
	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid	Typ	Max	Accid
Aerial pilot	0	0	NA	0	S	NA	S,R	S,R	NA	R	S,R	NA
Aerial mixer-loader	0	0	NA	0	0	NA	S,R	S,R	NA	R	S,R	NA
Aerial fuel truck operator	0	0	NA	0	0	NA	0	0	NA	0	S	NA
Backpack applicator	S	S,R	NA	0	S	NA	0	0	NA	0	S,R	NA
Ground mechanical applicator	0	S	NA	0	S	NA	0	0	NA	0	S,R	NA
Ground mechanical mixer-loader	0	S	NA	0	0	NA	0	0	NA	0	S,R	NA
Ground mechanical applicator/mixer-loader	0	S	NA	0	0	NA	0	0	NA	0	S,R	NA
Hand applicator	0	S	NA	S	S	NA	0	0	NA	R	S,R	NA
Skin spill, concentrate	NA	NA	S,R	NA	NA	S,R	NA	NA	S,R,C	NA	NA	0
Skin spill, mixture	NA	NA	S,R	NA	NA	S,R	NA	NA	S,R,C	NA	NA	S,R
Direct spray, person	NA	NA	NA	NA	NA	NA	NA	NA	S,R	NA	NA	S,R

[1] Typ = Typical application rate; Max = Maximum application rate; and Accid = Accidental application.

[2] Risk categories: 0 = No risk; S = Systemic risk; R = Reproductive risk; C = Cancer risk; and NA = Not applicable. Marked scenarios are those that result in high risk under the given herbicide. High risks are defined as those exposures that may result in a margin of safety (MOS) < 100 or a cancer risk greater than one-in-one million. The MOS is the NOEL divided by the dose; therefore, the larger the MOS, the smaller the estimated human dose compared to the animal NOEL, and the lower the presumed risk to human health.

In the earlier BLM EISs, risk estimates were presented separately for different land uses (rangeland, public domain forestland, oil and gas sites, ROW, and recreation and cultural sites). In this table, the scenario is marked if any of these land uses showed a high risk for the specific herbicide.

TABLE 4-32
Scenarios Resulting in High Risk to Public Receptors from Herbicides Evaluated in the 1988-1991 BLM EISs

Treatment Method	2,4DP[1]	ASU	Atrazine		BRO	DIUR	FOS	MEF	Simazine		TEB
	Accid[2]	Accid	Max	Accid	Accid	Accid	Accid	Accid	Max	Accid	Accid
Direct spray, person	S,R,C[3]	0	R	S,R,C	S,R	S,R	0	0	0	S,R,C	S,R
Drinking directly sprayed water	S,R	0	R	S,R,C	0	S,R	0	0	0	S,R,C	R
Eating fish from directly sprayed water	0	0	R	S,R,C	S,R	S,R	0	0	0	S,R,C	0
Immediate reentry, hiker	0	0	R	S,R	0	S	S	S	0	0	0
Immediate reentry, picker	S,R,C	S,R,C	S,R	S,R,C	S,R	S,R	0	0	0	S,R,C	S,R
Eating directly sprayed berries	S,R	0	S,R	S,R,C	S,R	S,R	0	0	0	S,R,C	S,R
Angler	0	0	0	S,R	0	0	0	0	R	0	0
Nearby resident	S,R	0	0	R	0	0	S	0	0	0	0
Drinking water contaminated by a jettison of mixture	NA	NA	0	S,R,C	S,R	S,R	NA	0	0	S,R,C	S,R
Drinking water contaminated by a truck spill	NA	NA	0	S,R,C	S,R	S,R	NA	S	0	S,R,C	S,R

[1] 2,4DP = 2,4-DP; ASU = Asulam; BRO = Bromacil; DIUR = Diuron; FOS = Fosamine; MEF = Mefluidide; and TEB = Tebuthiuron.
[2] Accid = Accidental application; and Max = Maximum application rate.
[3] Risk categories: 0 = No risk; S = Systemic; R = Reproductive; C = Cancer; and NA = Not applicable. Marked scenarios are those that result in high risk under the given herbicide. High risks are defined as those exposures that may result in a margin of safety (MOS) < 100 or a cancer risk greater than one-in-one million. The MOS is the NOEL divided by the dose; therefore, the larger the MOS, the smaller the estimated human dose compared to the animal NOEL, and the lower the presumed risk to human health.
In the earlier BLM EISs, risk estimates were presented separately for different land uses (rangeland, public domain forestland, oil and gas sites, ROW, and recreation and cultural sites). In this table, the scenario is marked if any of these land uses showed a high risk for the specific herbicide.

these spot applications may result in greater risk to the occupational receptors charged with applying the herbicide because they are more likely to come into contact with the herbicide—their exposure doses may be higher. In particular, occupational receptors applying diquat by backpack and horseback experience low to moderate risk from exposure to the herbicide, whereas those applying diquat at the typical application rate by ATV or truck are not at risk. However, in contrast, chlorsulfuron does not result in risk to workers involved with aerial applications, but does result in risk at high exposure doses to workers conducting ground broadcast applications (at the highest application rate), and exposure to hexazinone is highest for workers using an over-the-shoulder broadcast applicator.

Typical Application Rate

Most of the herbicides do not result in risk to human receptors when applied at the typical application rate. Diquat applications at the typical application rate result in low to moderate risk to plane and helicopter pilots and mixer/loaders, backpack applicator/mixer/loaders, horseback applicators and applicator/mixer/loaders, and child residents. 2,4-D, 2,4-DP, atrazine, bromacil, diuron, hexazinone, simazine, and tebuthiuron also result in risk to various public and occupational receptors when applied at the typical application rate.

Maximum Application Rate

At the maximum application rate, more herbicides, in a greater number of exposure scenarios, have the potential to adversely affect human health. Fluridone, chlorsulfuron, clopyralid, glyphosate, picloram and triclopyr did not result in risk at the typical application rate, but did result in risk in one or more exposure scenarios at the maximum application rate. Clopyralid, glyphosate and picloram only resulted in low risk at the maximum application rate for the accidental scenario involving consumption of water from a small pond that has experienced a recent spill, which is a very unlikely scenario. In addition, a greater number of exposure scenarios and receptors are at risk from herbicide application at the maximum application rate. Dicamba, diflufenzopyr, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl do not result in risk to any receptor when applied at the maximum (or typical) application rate.

Accidental Direct Spray and Spill Scenarios

Accidental direct spray and spill scenarios resulted in risk for many herbicides and receptors (accidental scenarios for diflufenzopyr, imazapic, and sulfometuron methyl were not evaluated because these chemicals are not considered toxic through short-term dermal exposure). These scenarios are unlikely, and hopefully can be avoided by following SOPs.

Human Health Risks by Receptor

Occupational

2,4-D, 2,4-DP, asulam, atrazine, bromacil, diquat, diuron, fosamine, mefluidide, simazine, and tebuthiuron result in potential risks to occupational receptors at both typical and maximum application rates. Atrazine and diuron results in risk to most receptors at the typical application rate. For 2,4-D, atrazine, diquat, bromacil, simazine, and tebuthiuron, receptors working with aerial applications experience low to moderate risk even at typical application rates, and all or most occupational receptors are at risk when applying these herbicides at maximum application rates. 2,4-D, 2,4-DP, atrazine, and fosamine also result in risks to ground applicators, particularly at the maximum application rate. In addition, atrazine and bromacil show potential cancer risk for workers applying the herbicide aerially (it should be noted that USEPA's latest toxicology assessment does list bromacil as potentially carcinogenic). Mixer/loaders working with aerial applications of fluridone are at low risk, and with atrazine, bromacil, diuron, simazine, and tebuthiuron are at high risk when applying at the typical and maximum application rates. Ground broadcast applicators are at risk from applying atrazine and diuron at the typical application rate, and 2,4-DP, bromacil, chlorsulfuron, fosamine, and tebuthiuron at the maximum application rate. All occupational receptors are at risk from applying atrazine, hexazinone, tebuthiuron, and triclopyr at the maximum application rate. The rest of the scenarios of potential occupational receptor exposure to herbicides do not result in risk to the receptor. Workers involved in the aerial application of herbicides appear to be at greater risk than other occupational receptors; however, the application method that creates the most risk to workers appears to depend on the herbicide, so application methods for each herbicide should be carefully evaluated with respect to potential human health effects.

Public

In general, public receptors experience less risk than occupational receptors. However, within this category, children can experience higher risk than adults. Public receptors do not appear to be at risk following chlorsulfuron, dicamba, diflufenzopyr, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl applications (accidental scenarios were not evaluated for imazapic and sulfometuron methyl because these chemicals are not toxic through short-term exposure for specific exposure routes). Diquat application at the typical application rate results in low risk to child residents. At the maximum application rate, diquat results in low to moderate risk to all public receptors, except swimmers. Diuron results in risk to most public receptors with worst-case exposures. In addition, 2,4-D, 2,4-DP, asulam, atrazine (also at maximum exposure), bromacil, clopyralid, diuron, fluridone, fosamine, glyphosate, hexazinone, mefluidide, picloram, simazine, tebuthiuron, and triclopyr may create risk to public receptors from one or more accidental exposure scenarios (e.g., exposure resulting from the spill of an herbicide into a small pond). For most herbicides (except diquat), risk to public receptors can be minimized or avoided by using the typical application rate and following SOPs that greatly reduce the likelihood of accidents.

Impacts by Alternative

The following is a qualitative discussion of how risk from herbicide exposure would vary under each herbicide treatment alternative.

Alternative A – Continue Present Herbicide Use (No Action Alternative)

Of the herbicide treatment alternatives (A, B, D, and E), the No Action Alternative has the lowest number of acres treated, and therefore, would result in lower levels of health risk to occupational and public receptors. If the No Action Alternative results in higher numbers of acres treated by other vegetation management methods (e.g., prescribed fire, manual, biological treatments), then health risks from these methods would also have to be considered (see the associated PER; USDI BLM 2005a). In addition, the new herbicides proposed in this EIS (diflufenzopyr+dicamba [Overdrive®], diquat, fluridone, and imazapic) would not be used. Of these new herbicides, diquat shows potential risks to humans through various exposure pathways; however, diflufenzopyr, dicamba, fluridone, and imazapic are all relatively safe to humans, with no potential adverse effects evident from the human health risk characterization, except in cases of unlikely accidental exposures for fluridone. Of the 20 previously-approved herbicides, only nine (asulam, clopyralid, fosamine, glyphosate, imazapyr, mefluidide, metsulfuron methyl, picloram and sulfometuron methyl) result in similarly negligible to low risks to humans. Therefore, failure to approve the four new herbicides would limit the options for treatment of vegetation without appreciable risk to humans, and because of this, the No Action Alternative may present more risk to humans per each herbicide application. In addition, this alternative may be less successful in controlling weeds and poisonous plants that adversely affect humans, especially weeds most effectively controlled by the four proposed herbicides.

Under the No Action Alternative, the BLM would be able to continue to use six herbicides that were approved for use under earlier BLM vegetation treatment RODs—2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine (USDI BLM 1988b, 1991b, 1992a). Except for fosamine, which has been used on < 50 acres annually, these chemicals have not been used by the BLM since 1997 and are not proposed for use under the other herbicide treatment alternatives.

In 1998, the BLM conducted a literature review to determine if the earlier vegetation treatment ROD conclusions for asulam, atrazine, mefluidide, and simazine were justifiable based on past and 1998 toxicology and risk assessment procedures; a literature review was not performed for 2,4-DP and fosamine, but these herbicides were analyzed in the 1988 California EIS (USDI BLM 1988a, McMullin and Thomas 2000). Based on this analysis, it was determined that systemic risks from using asulam may be greater than were projected in the earlier EIS, but that risks to humans from the other three herbicides were similar to, or less than, those identified in earlier EISs.

Based on the earlier EISs, literature reviews done by the BLM, and other studies (USEPA 1995d, 2002b), the risks to humans would be low for asulam, fosamine, and mefluidide, low to moderate for 2,4-DP and simazine, and moderate to high for atrazine. The BLM uses sulfometuron methyl, bromacil, and diuron in treatment situations where it used atrazine in the past, and triclopyr instead of fosamine. These substitute herbicides have similar, or lower, risks to humans than the herbicides they would replace.

Alternative B – Expand Herbicide Use and Allow for Use of New Herbicides in 17 Western States (Preferred Alternative)

This alternative would likely result in the most overall risk to human health of the five alternatives considered here because of the large number of acres treated. However, human health could benefit from the reduced occurrence of the noxious weeds and poisonous plants that adversely affect humans, which would likely be brought about by this alternative. In addition, this alternative would include the use of the new herbicides evaluated in the BLM HHRA (ENSR 2005l). Of these four herbicides, three (except diquat) appear to be relatively harmless to humans; therefore, the use of these herbicides would increase the options for appropriately managing vegetation while minimizing the risk to human receptors. Therefore, the Preferred Alternative could result in more positive impact to humans per application than the No Action Alternative. However, the new herbicide diquat potentially presents greater risk to humans in many application scenarios, and it is suggested that diquat not be used or be used only in very limited scenarios at the typical application rate, where risk to human receptors is below the LOC (e.g., possibly ground applications from trucks not near residences or berry gathering sites).

Alternative C – No Use of Herbicides

Alternative C would eliminate human health risk from herbicide applications. However, risks to humans associated with alternative vegetation management methods would likely increase (these risks are perhaps greatest for prescribed fire treatments [see PER]). In addition, human health might be adversely affected if the noxious weeds and poisonous plants that can harm humans increase in occurrence as a result of a cessation of herbicide treatments.

Alternative D – No Aerial Applications

Human health risks per application area would be lower for Alternative D than for the other herbicide treatment alternatives because herbicides would not be likely to drift as far, potentially affecting more humans. This alternative would allow the use of the new herbicides, which on average present less risk to humans than the currently-used herbicides. Overall risks would be lower than under the Preferred Alternative, which would treat about 400,000 more acres and would use aerial spraying (however, the Preferred Alternative may eliminate more noxious and poisonous weeds that adversely affect human health than Alternative D). Overall risks would likely be similar to Alternative E, as a similar number of acres would be treated and Alternative E places emphasis on spot applications over broadcast applications. However, Alternative E would not allow the use of ALS-inhibiting herbicide active ingredients (i.e., chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl), which exhibit low risks to humans. Because Alternative D would treat 240,000 more acres than the No Action Alternative, but would not use higher risk aerial applications and would use less risky chemicals, it is difficult to infer which alternative would result in lower overall risk.

Alternative E – No Use of Acetolactate Synthase-inhibiting Herbicides

The five ALS-inhibiting herbicides (chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl) that would not be used under this alternative present some of the lowest risks with respect to human health. Even in accidental scenarios, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl do not result in risk to humans, and chlorsulfuron only results in risk to workers for ground broadcast applications at the highest application rate. From a practical perspective, eye and/or skin irritation are likely to be the only overt effects of mishandling the ALS-inhibiting herbicides, and these effects can be minimized or avoided by prudent industrial hygiene practices during the handling of these compounds. Bromacil, diquat, diuron, and tebuthiuron pose higher human health risks, and these herbicides would not be excluded by Alternative E; therefore, risk per area treated could increase as a result of elimination of ALS-inhibiting herbicide active ingredients. Alternative E does place increased emphasis on spot rather than broadcast applications, which would tend to decrease per area risk over the No Action and Preferred alternatives, except in the few possible cases where occupational receptors are at greater risk from spot applications. In addition, the proposed number of acres treated (466,000) is half that of the Preferred Alternative (932,000), which would result in lower overall risk. Conversely, more acres would be treated under Alternative E than under the No Action Alternative (305,000), which would increase overall risk. Alternative D would treat more acres (540,000) than Alternative E, but would not use aerial spraying, although Alternative E would have a minimal amount of aerial spraying (spot applications are preferred over broadcast applications); however, Alternative D would allow the use of the ALS-inhibiting herbicides, which could decrease the use of herbicides that may present higher human health risks and increase the relative risk of Alternative E with respect to Alternative D.

Mitigation

In addition to following SOPs, there are certain herbicide-specific measures that can be taken to substantially reduce or eliminate human health risk from herbicide use. The following mitigation measures were developed based on the BLM HHRA, the Forest Service HHRAs, and the earlier BLM EIS HHRAs:

- Use the typical application rate, where feasible, when applying 2,4-D, 2,4-DP, atrazine, bromacil, diquat, diuron, fluridone, fosamine, hexazinone, tebuthiuron, and triclopyr to reduce risk to occupational and public receptors.
- Avoid applying atrazine, bromacil, diuron, or simazine aerially.
- Limit application of chlorsulfuron via ground broadcast applications at the maximum application rate.
- Limit diquat application to ATV, truck spraying and boat applications to reduce risks to occupational receptors; limit diquat applications to areas away from high residential and subsistence use to reduce risks to public receptors.
- Evaluate diuron applications on a site-by-site basis to avoid risks to humans. There appear to be few scenarios where diuron can be applied without risk to occupational receptors.
- Do not apply hexazinone with an over-the-shoulder broadcast applicator.

Cumulative Effects Analysis

The National Environmental Policy Act and its implementing guidelines require an assessment of the proposed project and other projects that have occurred in the past, are occurring in the present, or are likely to occur in the future, which together may have cumulative impacts that go beyond the impacts of the proposed project itself. According to the Act (40 CFR §1508.7 and 1508.25[a][2]):

"Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. In addition, to determine the scope of environmental impact statements, agencies shall consider cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

The purpose of this cumulative effects analysis is to determine if the effects of BLM vegetation treatments have the potential to interact or accumulate over time and space, either through repetition or combined with other effects, and under what circumstances and to what degree they might accumulate (NRC 2003).

Structure of the Cumulative Effects Analysis

For this Programmatic EIS, the analysis of cumulative impacts is a four-step process that follows guidance provided in *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ 1997):

- Specify the class of actions of which effects are to be analyzed.
- Designate the appropriate time and space domain in which the relevant actions occur.
- Identify and characterize the set of receptors to be assessed.
- Determine the magnitude of effects on the receptors and whether those effects are accumulating.

Class of Actions to be Analyzed

All vegetation treatment methods used by the BLM are considered in the analysis. These include herbicide use, manual, mechanical, and biological control methods, and use of fire as identified in Chapter 2 (Alternatives).

For this PEIS, potential cumulative effects include those that were assessed for all land ownerships including lands administered by other federal agencies and non-federal lands, especially regarding air quality and terrestrial and aquatic species.

The analysis and disclosure of cumulative effects alerts decision-makers and the public to the context within which effects are occurring, and to the environmental implications of the interactions of known and likely management activities. During subsequent analyses for site-specific activities, local cumulative effects should be important considerations in the design of site-specific alternatives and mitigation measures.

Appropriate Temporal and Spatial Domain

Temporal Domain

The analysis period covered by the cumulative effects analysis primarily begins in the 1930s with the passage of the Taylor Grazing Act, and continues through 2055. The ending date is based on the difficulty of predicting advances in technology and the types and amounts of vegetation treatments needed very far into the future. Thus, a reasonable analysis period, and one on which most of the cumulative effects analysis is focused, is 50 years into the future.

Spatial Domain

For individual resources and uses, the area of which an effect could be felt could be the "footprint," but for others the effect may extend well beyond that space. For example, noise effects to wildlife can extend miles beyond the footprint of the development. For purposes of this analysis, the spatial domain for past, present, and reasonably foreseeable activities is primarily the 17 western states evaluated in this PEIS. However, this PEIS also considers effects to resources that could occur outside of these states.

The alternatives analyzed in this PEIS identify alternative approaches to herbicide use, including abandonment of their use, as well as limitations on which herbicides may be used or how herbicides are applied. The effects of vegetation treatments disclosed in the PEIS and PER, combined with subsequent site-specific NEPA analysis, would provide a comprehensive assessment of cumulative effects of future vegetation treatment activities on public lands. In light of the broad geographic scope and spatial resolution of this PEIS, the cumulative effects analysis could not, and does not, address all possible cumulative effects that may result at specific sites on public lands.

For the purposes of this analysis, non-federal lands include lands owned and/or managed by individuals, corporations, American Indian tribes, Alaska Native corporations, states, counties, or other agencies. The BLM does not have the authority to regulate any activities or their timing on lands other than those the BLM administers. However, when an action takes place on public land, it may cause direct, indirect, or cumulative effects on non-federal lands. For example, a wildfire that begins on public land may bum to adjacent private land, or noxious weed infestations that began on private land may infest adjacent public land; for these examples, treatment activities outlined in the PEIS and PER could benefit adjacent landowners indirectly from better controls on noxious weeds and less severe forest fires.

This PEIS also considers the likely effects on public lands from reasonably foreseeable actions occurring on non-federal land. For example, development of non-federal land may have potentially direct impacts on terrestrial wildlife species that move between federal and non-federal habitats during the year or during their life cycle. The role of management of non-federal lands was considered in the analysis on those species and ecosystems. Localized actions on non-federal lands often affect local environmental conditions on nearby federal land and may also affect federal management decisions.

Set of Receptors to be Assessed

The set of receptors assessed in the cumulative effects analysis are the physical, biological, and human systems discussed in Chapter 3 (Affected Environment).

Magnitude of Effects and Whether Those Effects are Accumulating

The potential extent of the total cumulative effects (e.g., number of animals and habitat affected), and how long the effects might last (e.g., population recovery time) are estimated to determine the magnitude of effects that could accumulate for each resource. Where possible, the assessment of effects on a resource is based on quantitative analysis (e.g., level of risk to humans from use of an herbicide). However, many effects are difficult to quantify (e.g., animal behaviors; human perceptions) and a qualitative assessment of effects is made.

As suggested by the CEQ (1997) handbook, *Considering Cumulative Effects Under the National Environmental Policy Act*, this PEIS considers the following basic types of effects that might occur:

- "Additive" - total loss of sensitive resources from more than one incident
- "Countervailing" - negative effects are compensated for by beneficial effects
- "Synergistic" - total effect is greater than the sum of the effects taken independently

The purpose of the analysis of cumulative effects in this PEIS is to determine whether the effects are additive or synergistic or have some other relationship. Additive (or combined) effects on specific resources often are difficult to detect and do not necessarily add up in the strict sense of one plus one equals two. It is much more likely that an additive or combined effect would be greater than one but less than two. A synergistic effect, in theory, is a total effect that is greater than the sum of the additive effects on a resource. To arrive at a synergistic effect in this example (continuing with the numeric analogy), the total cumulative effect would need to end up greater than two. In the highly variable western U.S. environment, where natural variations in population levels can exceed the impacts of human activity, such an effect would need to be much greater than the hypothetical two to be either measurable or noteworthy. A countervailing effect occurs when an impact has both negative and beneficial effects. For example, herbicide treatments would harm or destroy vegetation used by some species of wildlife (negative effect), but would improve overall ecosystem health that would lead to improved watershed conditions and habitat for other wildlife (positive effect).

In the analyses that follows, effects should be considered to be additive in nature, unless otherwise noted. While synergistic impacts have been demonstrated in the laboratory (for certain types of chemical reactions, for example), there is almost no evidence of such impacts occurring when dealing with biological resources. Where synergistic impacts are not specifically accounted for in the analysis section, it is because there are neither studies nor information supporting the identification of such impacts. Resource analysts have tried to keep the cumulative analysis useful, manageable, and concentrated on meaningful potential effects. The cumulative analysis considers in greatest detail activities that are more certain to happen and that are geographically in or near public lands, and activities identified during scoping as being of greatest concern. Where possible, guiding principles from existing standards, criteria, and policies that control management of the natural resources of concern have been used to help focus the analysis. Where existing standards, criteria, and policies are not available, the resource experts used their best judgment on where and how to focus the analysis.

Resource Protection Measures Considered in the Cumulative Effects Analysis

The cumulative impacts assessment assumes that SOPs and mitigation developed for the alternatives (see Chapter 2 of the PEIS and PER) would be adopted to protect environmental and socioeconomic resources on public lands.

In addition, a number of federal, state, local, and tribal resource management and monitoring programs have been established to protect environmental resources and, in cases where there is existing environmental impairment, to effect restoration. The assessment of cumulative impacts recognizes the existence of these programs and assumes that the mandate under which each program was established will continue. The cumulative effects analysis assumes these programs effectively avoid or mitigate the environmental impacts that they are designed to address. The programs include:

Air Quality

Air quality is regulated under the PSD permitting process. For sources located in state waters and onshore, the PSD program is administered by the state air quality agencies. Although minor sources of air pollutants are not subject to PSD permitting requirements, the analysis of cumulative effects to air quality in this PEIS considers the contribution of both major and minor sources of air pollution in the western U.S., including and Alaska.

Water Quality

Water quality is regulated and/or monitored through various permitting and regulatory programs administered by the USEPA, and state and local regulatory agencies. These programs have been established to protect against the significant degradation of water quality associated with specific human and development activities. In evaluating the cumulative effects to water quality, collective impacts associated with regulated and non-regulated activities and naturally occurring events are considered.

Wetlands

Wetland impacts are mitigated through SOPs, permits, and approvals issued at the project implementation stages (if needed), and under Section 404 of the Clean Water Act, administered by the USACE, and state certification programs to protect wetlands and ensure no net loss of wetlands, where practical.

Essential Fish Habitat

The amended Magnuson-Stevens Act requires federal agencies that authorize, fund, or conduct activities that may harm Essential Fish Habitat to work with NOAA Fisheries to develop measures that minimize damage to EFH. By providing EFH conservation recommendations before an activity begins, NOAA Fisheries may help prevent habitat damage before it occurs, rather than restoring habitat after the fact, which is less efficient, unpredictable, and often more costly. An analysis of EFH effects is provided as Appendix A in the *Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Biological Assessment* (USDI BLM 2005b).

Threatened and Endangered Species

The Endangered Species Act of 1973, and the PEIS and PER scoping process, are appropriate vehicles to identify species that are potentially at risk from the incremental cumulative effects of activities that may occur under the PEIS and PER. Effects on listed species identified for the analysis area by NOAA Fisheries and the USFWS under Section 7 of the ESA are covered by this cumulative analysis. The potential effects on each of the other species identified through scoping have also been reviewed and included, as appropriate.

Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* and an accompanying Presidential memorandum require each federal agency to make the consideration of environmental justice part of its mission. The existing demographics (race and income) and subsistence consumption of plants and animals, and mitigating measures and their effects are presented.

Consultation and Coordination with Indian Tribal Governments

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments,* requires consultation with tribal governments on "actions that have substantial direct effects on one or more Indian tribes." Representatives of the BLM have met with local tribal governments to discuss subsistence issues relating to the PEIS and PER (see Chapter 5, Consultation and Coordination), and have established a dialogue on environmental justice with these communities.

Other Information Considered in Cumulative Effects Analysis

The assessment of cumulative impacts from vegetation treatment activities also considered the following information and assumptions:

- BLM herbicide application rates would be at, or below, the lowest identified labeled application rates allowed by the USEPA.
- Mitigation and SOPs identified in PEIS would be more stringent than those required by the USEPA.
- The BLM would comply with existing and future regulations, including FLPMA.

Ground-disturbing activities on public lands are conducted only after any necessary site-specific NEPA analysis has been completed. Such analyses are required to describe the cumulative impacts of the site-specific alternatives on adjacent lands and resources, and on the watershed. This provides opportunities to detect and minimize cumulative environmental effects that cannot be specifically determined at the broad level of this PEIS.

Subsequent analyses will help to assure that the incremental and interactive effects on public lands would continue to be considered when implementing the selected alternative. Ground-disturbing actions will be conducted only after site-specific NEPA analysis, if required, which also must analyze the effects of the activity on adjacent lands and resources. Thus, the intent is that managers will design, analyze, and choose the locations and types of site-specific activities that minimize cumulative environmental effects which cannot be described at the broad scale of this PEIS.

Analysis of Cumulative Effects by Resources

Air Quality

Cumulative impacts to air quality could result from the emissions of particulates associated with fire use, and particulates, hydrocarbons, and other byproducts of combustion associated with the use of equipment. Indirect impacts from air emissions include impacts to human health and global climate change. These impacts may be regionally additive (e.g., increased concentrations of specific pollutants) or synergistic (e.g., chemical reactions that form ozone). Technology has played an important role in reducing air emissions from engine operation, and an important reason for conducting prescribed burns is to better control smoke emissions and to reduce future smoke emissions associated with wildfire.

Past Effects and Their Accumulation

The cumulative effects of pollutant-producing activities in the past have led to deterioration in air quality in the western U.S. Detailed information about the historic and existing air quality for the area covered by this PEIS is only available for monitoring sites and for criteria pollutants. In the undeveloped regions of public lands, ambient pollutant levels are expected to be low, and probably negligible in remote areas. On public lands on the Alaska North Slope and much of the remaining portions of Alaska, air quality is relatively pristine (USDI BLM 2005e). In general, locations in the treatment area with high ambient pollutant levels are areas that support commercial and industrial land uses (areas with large-scale mining operations, lumber mills, power plants, oil and natural gas extraction, etc.) and local population centers (areas with automobile exhaust, residential heating, etc).

Despite increases in human population and industrialization, emissions of principal air pollutants in the U.S., after peaking in the 1970s and early 1980s, have generally declined or held steady during the past 2 decades due to more stringent air quality regulations and improvements in pollution control technology (USEPA 2005). Particulate matter is the principal pollutant of concern, from a public health perspective, that is generated by fire. Emissions of particulate matter from all sources have trended lower since the 1970s. However, PM emissions nationwide have shown a close relationship with the number of acres burned annually by wildfire. Since 1990, PM emissions associated with wildfire have ranged from 145,000 tons in 1995 to 1.2 million tons in 2002; the number of acres burned by wildfires in 1995 was one-third the number of acres burned in 2002. The level of PM associated with slash and prescribed burning, however, has trended downward since the 1970s, and in 2001 (165,000 tons) was about half the level of the early 1990s. Based on an estimate of emissions generated by current vegetation treatment activities (primarily from fire and mechanical treatments; see Table 4-4 in PER), BLM treatment activities have accounted for less than 0.5% of criteria pollutant emissions nationwide.

Future Effects and Their Accumulation

Under the action alternatives, emissions associated with fire use and other treatment methods would be greater than under the No Action Alternative. Still, emissions associated with BLM vegetation treatment activities would comprise less than 1% of total criteria pollutants generated nationwide. If the BLM were to achieve its goal of treating about 2 million acres annually using fire, annual emissions of PM from fire use on public lands would be similar to the total amount of PM emissions currently produced in the U.S. from prescribed fire use, but would be only 1/6th the amount of PM produced by wildfires annually in recent years (USEPA 2005).

Although modeling was not done as part of the PER and PEIS to assess cumulative effects from use of fire and other treatment methods, modeling was done as part of a programmatic assessment of vegetation treatments in the Interior Columbia Basin (USDA Forest Service and USDI BLM 2000). Based on this assessment, the proposed increase in the amount of prescribed burning conducted for forest and rangeland management on Forest Service- and BLM-administered lands over the 100-year planning period would be expected to reduce the amount of wildfire activity for the project area by about 16%. In addition, the analysis revealed that wildfire impacts on air quality may be significantly greater in magnitude than emissions from prescribed burning. The lower emissions from prescribed fire were attributed to prescribed burning techniques that reduce emissions, as well as smoke management plans that federal, state, and tribal agencies have implemented that permit prescribed fires only during meteorological periods favorable to dispersion. If the number of wildfires is reduced over time, air quality impacts from smoke should also be reduced.

Air quality modeling suggested that PM emissions from prescribed burning, when considered alone, may not cause widespread regional-scale exceedances of the NAAQS based on the cumulative impacts from all sources of air pollution on ambient air. This modeling analysis also assumed that local analysis would be done to assess the possibility for localized exceedances of the NAAQS caused by prescribed burning emissions. Local analysis would also be done for activities conducted by the BLM under this PEIS.

It can be assumed that state smoke management meteorologists would consider the cumulative effects of emissions from other sources (such as road dust and agricultural dust and burning) during the development of daily smoke management instructions, and that state smoke management program managers would consider these sources during development of the smoke management plan submitted for approval (as a component of the state smoke implementation plan) to the USEPA.

The Forest Service modeled several scenarios to predict the long-term effect of treating more acres and/or targeting treatments in the WUI, on regional air quality and the condition of the land (Hann et al. 2002). The model assumed that mechanical and hand cutting would be important treatment options, in addition to use of fire, in the WUI where air quality and other considerations could limit the use of fire. Based on this analysis, air quality generally improved as the number of acres treated annually increased, and improvement in air quality was most noticeable when treatments were targeted at high priority western U.S. WUI landscapes. Thus, the proposed action, which includes over 4.3 million acres of fire use and mechanical treatments, in addition to 1.7 million acres of treatments using other methods, would be expected to provide greater improvement in ecosystem function and air quality than is projected under current treatment methods.

The increased use of prescribed fire proposed by the BLM parallels national trends. The National Wildfire Coordinating Group Fire Use Working Team sanctioned an interdisciplinary and interagency working framework for coordinating development of modeling and data systems to support balancing the increased use of prescribed fire in the context of reducing local and regional impacts of fires on air quality (Sandberg et al. 1999; USDA Forest Service and USDI BLM 2000). A number of modeling and data system enhancements are currently under development by the Joint Fire Sciences Program of the USDA Forest Service and the USDI. These systems include the modeling of meteorological conditions and smoke dispersion. The Forest Service and BLM also have developed a data system to support prescribed burning and to assist states with emissions tracking under their respective state smoke management plans. The use of more sophisticated models during the implementation of prescribed burning, together with enhanced monitoring of emissions, will help minimize possible impacts from the use of prescribed fire. The inherent limitations of any model used at the programmatic scale highlight the importance of the cooperative development and use of operational smoke management models by the states, with assistance by the BLM, Forest Service, and USEPA.

Most emissions on public lands in Alaska are associated with wildland fire and fire use for resource benefit, and oil and gas exploration and development on the North Slope in the National Petroleum Reserve – Alaska (USDI BLM 2005e). Long term, fire emissions would likely remain near current levels. Emissions on the North Slope are expected to decrease as the result of an overall downward trend in oil production; therefore, any possible contribution from local sources to air quality and Arctic haze would be reduced. Greater reliance on technologies that reduce the need for permanent roads and pads, and reduce the size of the facility footprint, would also result in lower levels of PM emissions. Arctic haze has the potential to increase as Asian economies grow. Until air pollution concentrations in Asia and Europe begin to decline, Arctic haze is likely to persist or get worse.

Contribution of Treatment Alternatives to Cumulative Effects

As discussed under Air Quality in Chapter 4 of the PER, the majority of emissions would be associated with the use of fire, and to a lesser extent, with mechanical treatments. Manual, biological control, and herbicide treatments would contribute only small amounts of pollutants to the air. These emissions would accumulate and the amount of emissions released into the environment would be related to the number of acres treated and type of treatment. Exceedances of NAAQS, however, should not occur under any alternative, and under all alternatives vegetation treatments would account for less than 1% of pollutants generated nationwide.

The cumulative effects of all projects affecting the North Slope of Alaska in the past generally have caused little deterioration in air quality, which remains better than that required by national standards. The amount of air pollutants generated should remain near current levels, and approximately 50% less than emission levels in the late 1980s (USDI BLM 2005e). Improvements in air pollution control technology would also help to reduce emissions from current levels.

Soil Resources

Past Effects and Their Accumulation

Cumulative impacts to soils on public lands and throughout the western U.S. have occurred from human-caused disturbance factors, including natural resource extraction, grazing, road construction, timber harvesting, OHV and other recreation use, agriculture, development, as well as natural disturbances. More recently, large-scale, uncharacteristic wildfires have increased the number of landscapes with declining soil productivity through reduction in effective vegetative ground cover and loss of root strength, which has resulted in increased soil erosion rates. Soils in the western U.S. are generally stable in wilderness areas, but in other locations soils are at varying levels of decreasing productivity depending on soil types and intensity of management (USDA Forest Service and USDI BLM 2000). Determining the exact status of soil condition for any given area is difficult because of the lack of inventory and monitoring data. In general, greater declines in soil productivity are directly associated with greater loss of soil from erosion and displacement, loss of soil organic matter, changes in vegetation composition, removal of whole trees and branches, and increased bulk density from compaction.

Soil productivity may currently be higher in areas where fire has been suppressed and where organic matter and vegetation have not been removed. However, the unnaturally high amounts of vegetation and large woody material put these areas at risk for uncharacteristic fire intensity and severity, which can lead to decreased soil productivity because of high rates of erosion, loss of organic matter, woody material, and nutrient reservoirs.

In Alaska, non-oil and gas activities associated with villages, towns, and military sites have disturbed soils on public lands. In some areas, the loss of soil and erosion would be temporary, lasting only a few years. Where soils have been covered by infrastructure or removed as part of mining or other soil removal activities, this loss of soil and soil productivity are likely to persist into the indefinite future. Since the 1970s, oil and gas exploration and development have been the dominant soil-disturbing activities associated with public, other federal, state, tribal and private lands on the North Slope. On the North Slope, direct impacts to soil and soil productivity persist on over 12,000 acres (USDI BLM 2005e). Another 18,000 acres of indirect impacts have occurred, some of which persist today.

Future Effects and Their Accumulation

As discussed earlier in this chapter, vegetation treatments could occur on 6 million acres. Loss of vegetation and soil disturbance associated with use of treatment equipment could cause some loss of soil functions and process and soil productivity on nearly all treated land. However, the design and implementation of watershed level restoration treatments by the BLM and other federal agencies with large land holdings in the West are assumed to achieve effects similar to those occurring under historical disturbance regimes (USDA Forest Service and USDI BLM 2000). The disturbance effects resulting from restoration activities are predicted to have less impact and be less severe than fire effects and erosion cause by past fire exclusion and traditional management activities. Monitoring and evaluation, integrated with adaptive management and sustainable use practices, would result in adjustment of treatment design and implementation to reduce soil disturbance to levels similar to historic conditions.

Studies in forested and rangeland environments have suggested that landscapes that contain native plant communities in natural mosaic patterns and have relatively uninterrupted natural disturbance regimes provide favorable conditions for soil functions and processes that contribute to long-term sustainability of soil productivity (Munn et al. 1978, Cannon and Nielsen 1984, and Hole and Nielsen 1970 *cited in* USDA Forest Service and USDI BLM 2000). In addition, reduction in the spread of exotic and invasive vegetation is also expected to help maintain soil productivity and function. Forests and rangelands with conditions outside the historical range of variability are most vulnerable to accelerated nutrient loss from management activities or wildfire.

In recent years, a number of policies, programs, and initiatives have been proposed to restore soil productivity and improve the health of ecosystems by the BLM and other federal, state, and local land management entities to meet nationwide and regionwide conservation goals. These include the *National Fire Plan*, *Healthy Forests Restoration Initiative*, this PEIS, the Interior Columbia Basin Ecosystem Management Project, the Great Basin Restoration and Conservation of Prairie Grasslands initiatives, the sage-grouse conservation program, and the program to treat invasive vegetation on Forest Service lands in the Pacific Northwest (USDA Forest Service and USDI BLM 2000, USDA Forest Service 2005, USDI BLM 2005c). The success of these policies and programs to restore healthy ecosystems will in part reflect future funding levels, and in part reflect our understanding of soil processes and our ability to develop and implement vegetation management projects that are effective and lead to long-term improvement in soil and other ecosystem resources. Much of the focus of these efforts is on reducing hazardous fuels and the wildfire activity in the West. In addition, conservation programs and best management practices to reduce soil loss in agricultural areas have occurred during the past several decades. Although gains in soil productivity have been slow, improvement has been observed.

Changes in disturbance regimes, especially changes resulting from fire suppression, timber management practices, and livestock grazing over the past 100 years have resulted in moderate to high departure of vegetation composition and structure and landscape mosaic patterns form historical ranges. Approximately 42% of rangeland on public lands is achieving desired condition. However, this is an increase from 38% in 1996. In a study of the Interior Columbia Basin, approximately 92% of federally-administered lands had none to low soil disturbance. Nationwide, the estimated average annual loss of soil due to erosion associated with rainfall and wind on nonfederal lands has decreased by about a third from levels in the early 1980s; similar trends were seen in western states (National Resources Conservation Service 2000). These data suggest a need for improvement in soil productivity and rangeland conditions over the West, but suggest that long-term improvement in soil productivity in the West can occur under careful stewardship of lands.

Contribution of Alternatives to Cumulative Effects

Based on the number of acres treated, short-term impacts to soil function and productivity would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated under Alternatives D and E would be similar and short- and long-term effects would be similar, while Alternative C would be intermediate between these alternatives and the Preferred Alternative. Treatments would occur on about 2% of public lands annually under the Preferred Alternative. Short-term effects could accumulate, but if treatments were successful, a countervailing effect of long-term improvement in soil function and productivity should more than offset short-term losses.

Water Resources and Quality

Watersheds are natural divisions of the landscape and the basic functioning unit of hydrologic systems. The BLM conducts monitoring of watersheds on public lands and bases the success of its treatments on the condition of watersheds and their subbasins (USDI BLM 2005c). Stream flow regimes and water quality can be affected by modifications to watershed processes occurring from both natural disturbances and land management activities. Water quality and quantity are key components of wetland and riparian habitat and can also have substantial influence over the health of fish and other aquatic organisms. They are components over which the BLM has some degree of influence on public lands (USDA Forest Service and USDI BLM 2000).

Section 303(d) of the Clean Water Act requires that water bodies violating state water quality standards and failing to protect beneficial uses be identified and placed on a 303(d) list. The delisting of 303(d) listed streams is a priority of the BLM. Nonpoint source pollution, which is the largest source of water quality problems on public lands, comes from diffuse or scattered sources rather than from an outlet, such as a pipe, that constitutes a point source. Sediment is a nonpoint source of pollution that results from activities such as grazing and timber harvest, and from erosion associated with wildfires and the spread of noxious weeds. Erosion and delivery of eroded soil to streams is the primary nonpoint source pollution problem of concern to the BLM.

Past Effects and Their Accumulation

Problems associated with water quality in the western U.S. were first recognized in the 19th century when mining in California was polluting the water so greatly that crops could not be grown. Exploration and development of oil resources later contributed to water quality concerns, especially in California, Oklahoma, and Texas. New sources of pollution arose in the 20th century, including pollutants associated with agriculture (e.g., fertilizers, pesticides, and animals wastes), industry, and other human activities (e.g., sewage, household cleaning products, pollutants associated with automobiles). In 1999, the USEPA released its first ever national index on the quality of the nation's watersheds. The USEPA also conducted an assessment of general groundwater quality (based on concentration of TDS). Based on these assessments, 21% of the watersheds have serious problems. In the West, watershed water quality is poor to moderate over many areas (based on concentration of TDS for groundwater), primarily in areas associated with agricultural activities. Thus, actions that further deteriorate water quality or watershed health need to be carefully evaluated before being implemented on public lands (Wright 2002).

Minor cumulative effects to water resources have occurred on public lands in Alaska. Cumulative effects to water resources from oil and gas exploration, gold placer mining, and other development have included: 1) disturbance of stream banks and beds or lake shorelines; 2) melting of permafrost (thermokarst erosion); 3) temporary blockages of natural channels and floodways during construction of roads and pipelines that resulted in the disruption of drainage patterns; 4) increased erosion and sedimentation in rivers and lakes; 5) the removal of water from lakes for ice roads and pads; 6) spills; 7) removal of gravel from riverine pools and lakes; and 8) extensive erosion of off-road trails (USDI BLM 2005e).

The Clean Water Act of 1972 was intended to solve many of the nation's water pollution problems, but has had only modest success. In 1972, a third of the nation's rivers were safe for fishing and swimming. That number improved to over 50% in the 1980s, but began to fall in the 1990s. The primary cause for deteriorating conditions in the 1990s was agricultural and municipal wastes rather than industrial wastes. (The standard for classifying deteriorating conditions has also changed over that time.) An estimated 14.1 million Americans drink water that contains agricultural pesticides in amounts that would exceed the acceptable concentrations for food products (Wright 2002).

Past land management activities on public and other federally-administered lands in the western U.S. have contributed to deterioration in water quality. The spread of invasive plant species is one factor that degrades hydrologic function. In addition, hazardous fuels buildup can lead to catastrophic wildfires that adversely impact water resources and quality. Changes in hydrologic function have occurred as a result of changes in flow regimes due to dams, diversions, and surface water and groundwater withdrawal, and as a result of changes in channel geometry due to sedimentation and erosion, channelization, and installation of roads and railroads. Large amounts of wetland and riparian habitat, which function to cleanse water and recharge groundwater aquifers, have been lost in the West due to agriculture and urbanization.

During the early years of the BLM, most resource conservation and management was focused on rangelands. An increased emphasis on wetland and riparian habitat protection began in the 1960s with the passage of the Water Resources Research Act and Water Resource Planning Act (1965), which allowed the BLM to increase watershed research and planning. Much of the early work consisted of identifying lands in the critical stages of erosion (Muhn and Stewart 1988). In the 1970s, in response to concerns over rangelands and various land-use practices on public lands, FLPMA was passed (1976) and the BLM began preparing allotment management plans to better manage livestock and other natural resources. Today, the BLM's annual budget for wetland and riparian management is nearly $22 million. Program priorities include identifying priority watersheds on which to focus restoration efforts, with special emphasis on watersheds that contain habitat for sage-grouse. The BLM spent an additional $13 million in FY04 assessing the condition of watersheds and conducting restoration efforts in those areas that are less than properly functioning (USDI BLM 2005c).

Even with these efforts, 25% of wetlands on public lands in the lower 48 states are not functioning properly (USDI BLM 2005d), while 52% of riparian areas are considered non-functional, or functioning at risk. The poorest functioning riparian areas are found in the southwest and Montana, while most riparian areas in Alaska, Colorado, and Utah function properly. High sediment and turbidity levels and high temperatures are the primary reasons for listing as water quality limited (USDA Forest Service and USDI BLM 2000; USDI BLM 2005c). In addition to water quality and flow concerns, many wetlands and streams have lost the capability to support salmonids and other aquatic organisms.

Future Effects and Their Accumulation

Despite spending nearly $1 trillion to improve water quality since the enactment of the 1972 Clean Water Act, the United States has no adequate database for water quality. Water quality monitoring is done by state and federal agencies, local governments, tribes, and others, and among which there is wide variance in the extent and types of monitoring (Hayward 2005). Additionally, the nature of the resource presents challenges because the effects of both natural and manmade contaminants vary greatly according to specific water conditions. Researchers must account for water source, velocity, volume, depth, pH, photosynthetic activity, seasonal variations, and even time of day to accurately measure water quality. Thus, predicting the extent and magnitude of future effects to water resources and quality is difficult.

In its *2001 Annual Performance Plan* (USDI BLM 2000e), the BLM committed to 1) implementing water quality improvement prescriptions on public lands in 20% of watersheds within priority sub-basins that do not meet state/tribal water quality standards; 2) achieving proper functioning condition or an upward trend in wetland/riparian areas in 80% of priority watersheds by cooperating with the Forest Service and other land management agencies to restore degraded wetland and riparian areas; and 3) achieving an upward trend in the condition of uplands within 50% of priority watersheds by reducing the spread of weeds and reintroducing fire into specific landscapes. Generally, high priority watersheds are those that have impaired water bodies.

Based on a 2005 Office of Management and Budget Program Assessment Rating Tool, the BLM had met or was making measurable progress toward meeting these goals. The OMB assessment did note that the BLM was challenged by the need to meet multiple land use objectives, such as allowing oil and gas development that may conflict with restoration objectives (Office of Management and Budget 2005).

Based on information provided by field offices, the BLM would treat about 300,000 acres for watershed improvement, and another 30,000 acres to improve wetland and riparian area functions and values. Treatments targeted for watershed and wetland and riparian area functions and values are not proposed for Alaska. Efforts to restore natural disturbance regimes, reduce the potential for catastrophic wildland fire, and manage and control of noxious weeds and other invasive vegetation would help to reduce erosion and sedimentation and restore native plant communities. In addition, the ability of the BLM and other resource-protection entities to use new herbicides, such as fluridone and imazapic, to control weeds would benefit public lands with minimal risk to drinking water, human health, and fish and wildlife.

Efforts to protect and restore wetland and riparian areas on public lands have improved the functional quality of these areas on public lands, a trend that is likely to continue. For example, the percentage of wetland and riparian areas that lacked the characteristics necessary for high function has decreased by about 10% since 1996 (USDI BLM 1997, USDI BLM 2005d). As a result, the loss of riparian and wetland functions and values over portions of the West should slow or stabilize. In addition vegetation treatment programs proposed by the BLM, and Forest Service, and similar efforts by other agencies and private entities (e.g., Ducks Unlimited, Nature Conservancy) to protect and preserve watersheds and water resources, should improve water resources and quality over the long term. In the Interior Columbia Basin, proposed treatment efforts could improve aquatic habitat capacity by 50% over 100 years. (USDA Forest Service and USDI BLM 2000).

Gravel mining, construction of roads, permanent drill pads, and water use from lakes during the winter months would be the major contributors to water resource impacts in Arctic Alaska. Impacts from activities such as gold mines in placer gravels, deteriorated OHV trails, and fires and fire control are the major contributors in the rest of the state. Because of the abundance of water resources in Alaska, the overall cumulative impact to water resources on public lands in Alaska would probably be small in magnitude and most impacts would be local in nature.

Contribution of Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to hydrologic function and water quality would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated under alternatives D and E, and their associated short- and long-term effects would be similar, while Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects could accumulate, but if treatments were successful, a countervailing effect of long-term improvement in water resource and quality should more than offset short-term losses.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often an important first step in improving watershed health because the anthropogenic activities that are causing degradation or preventing recovery are reduced or eliminated. Livestock grazing and OHV use are often cited as factors that cause loss of wetland and riparian habitat function and watershed degradation; by prohibiting livestock from entering wetland and riparian areas, and placing limits on OHV activity, improvement in watershed function can be expected (Kauffman et al. 1997). However, the BLM would have to balance watershed protection with the multiple use requirements under FLPMA. As discussed in Chapter 2, Vegetation Treatment Programs, Policies, and Methods, passive restoration would be considered first when developing restoration management plans, and would be used to the extent possible within the constraints of FLPMA.

Regardless of the alternative chosen, there would be an accumulation of loss of water resources and quality under all alternatives over the short term, but the rate of loss would be expected to slow from historic levels long term.

Wetland and Riparian Areas

Under natural conditions, wetland and riparian plant communities have a high degree of structural and species diversity, reflecting past disturbances from floods, fire, grazing, and fish and wildlife use (Gregory et al. 1991). Since European settlement, many wetland and riparian areas have been drained or altered and their functions and values lost or reduced. The Clean Water Act (1972) and Executive Order 11990, *Protection of Wetlands and Floodplains* (1977), identified the importance of wetland and riparian areas and directed federal and state agencies to focus more attention on the health of these areas. As a result of legislative and policy guidance, the BLM and other land management entities have spent considerable effort and money to restore wetland and riparian functions and values during the past several decades.

Past Effects and Their Accumulation

Cumulative impacts to wetland and riparian areas on public lands and throughout the western U.S. have occurred from human-caused disturbance factors, including natural resource extraction, recreation, dams and diversions, road construction, agriculture, urbanization, and fire exclusion. An estimated 53% of wetlands present at the time of colonization in the lower 48 states have been lost in the U.S., but less than 0.1% in Alaska. The USFWS estimates that about 117,000 acres of wetlands were lost annually between 1985 and 1995 (Wright 2002), while the USEPA has estimated wetland losses on non-federal rural lands at approximately 70,000 to 90,000 acres annually (Washington State Department of Ecology 2005).

During the past 150 years, much of the remaining wetland and riparian habitat in the lower 48 states has become degraded. BLM surveys show that about 25% of wetlands and 52% of riparian habitat on public lands outside of Alaska lack characteristics necessary for "high" functioning condition (USDI BLM 2005d).

Essentially 100% of the riparian and 98% of the wetland areas on public lands in Alaska are high functioning. The spread of invasive plant species is one factor that degrades wetland and riparian function. In addition, hazardous fuels buildup can lead to catastrophic wildfires that adversely impact wetland and stream habitat. Within riparian woodlands, the abundance of mid-size trees has increased while other size categories have decreased, primarily due to fire exclusion, increasing the risk of wildfire and reducing the value of these habitats to fish and wildlife. Within riparian shrublands, there has been extensive conversion to riparian herblands and increases in exotic grasses and forbs, primarily because of processes and activities associated with excessive livestock grazing. This conversion has made these shrublands more susceptible to fire and reduced their value to fish and wildlife (USDA Forest Service and USDI BLM 2000).

During the early years of the BLM, most resource conservation and management was focused on rangelands. An increased emphasis on wetland and riparian habitat protection began in the 1960s with the passage of the Water Resources Research Act and Water Resource Planning Act (1965), which allowed the BLM to increase watershed research and planning. Much of the early work was spent identifying lands in the critical stages of erosion (Muhn and Stewart 1988). In the 1970s, in response to concerns over rangelands and various land-use practices on public lands, FLPMA was passed (1976) and the BLM began preparing allotment management plans to better manage livestock and other natural resources on public lands. Today, the BLM's annual budget for wetland and riparian management is nearly $22 million. Program priorities include identifying priority watersheds on which to focus restoration efforts, assessing the condition of wetland and riparian areas, and conducting restoration efforts in those areas that are less than properly functioning.

Future Effects and Their Accumulation

The rate of loss of wetland and riparian habitat in the West has slowed, and on public lands there has been some improvement in the functional quality of these areas. For example, the percentage of wetland and riparian areas in the lower 48 states that lacked the characteristics necessary for high function has decreased by about 10% since 1996 (USDI BLM 1997, USDI BLM 2005d). Vegetation treatment programs proposed by the BLM and Forest Service, and similar efforts by other agencies and private entities (e.g., Ducks Unlimited, The Nature Conservancy) to protect and preserve wetland and riparian habitat, should restore wetland and riparian habitat and health over the long term. In the Interior Columbia Basin, proposed treatment efforts could improve aquatic habitat capacity by 50% over 100 years. (USDA Forest Service and USDI BLM 2000).

Efforts to restore natural disturbance regimes, reduce the potential for catastrophic wildland fire, and control noxious weeds and other invasive vegetation should help to reduce erosion and sedimentation and restore native plant communities. In addition, the ability of the BLM and other resource-protection entities to use new herbicides, such as fluridone, to control aquatic weeds would benefit lakes and ponds and the aquatic organisms that use these habitats. In Alaska, early detection and control of weeds would be effective in protecting wetland and riparian habitat, as the state does not yet face a severe weed problem as in the lower 48 states (Hebert 2001).

Contribution of Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to wetland and riparian area function and productivity would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and short- and long-term impacts, under alternatives D and E would be similar, while Alternative C would be intermediate between these alternatives and the Preferred Alternative. Treatments would occur on about 30,000 acres of wetland and riparian habitat annually under the Preferred Alternative. Short-term effects could accumulate, but if treatments were successful, a countervailing effect of long-term improvement in wetland and riparian area function and productivity should more than offset short-term losses.

Herbicide treatments would not be allowed under Alternative C. Therefore, control of some aquatic weeds, including giant salvinia, hydrilla, and milfoils could be difficult, as mechanical and other treatment methods would be less effective. Under alternatives C and D, it could be difficult for the BLM to adequately treat remote areas and large weed infestations to benefit aquatic organisms. Thus, the risk of loss of aquatic habitat and habitat function in more remote areas could be greater under these alternatives than under the other alternatives.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often a critical first step in successful riparian or wetland area restoration because the anthropogenic activities that are causing degradation or preventing recovery are reduced or eliminated. Livestock grazing is often cited as a factor that causes loss of wetland and riparian habitat function; by prohibiting livestock from entering these areas, improvement in habitat function can be expected (Kauffman et al. 1997). However, the BLM must balance wetland and riparian habitat protection with the multiple use requirements under FLPMA, and therefore the BLM modifies the timing and duration of grazing to reduce potential impacts rather than implements total exclusion whenever possible. As discussed in Chapter 2, Vegetation Treatment Programs, Policies, and Methods, passive restoration would be considered first when developing restoration management plans, and would be used to the extent possible within the constraints of FLPMA.

Regardless of the alternative chosen, there would be an accumulation of loss of wetland and riparian functions and values under all alternatives over the short term, but the rate of loss would be expected to slow from historic levels.

Vegetation

Historically, ecosystems on public lands were comprised of a mosaic of vegetation types adapted to the natural disturbances, including climate, fire, flood, and geological events. They were dynamic and resilient, tending to return to some developmental pathway when disturbed or changed. However, ecosystems have biological or physical limits that, if exceeded as a result of natural or human causes, can lead to deterioration in ecosystem health. If these limits are exceeded for extended periods of time, the characteristics of the ecosystem can change, often substantially, to the detriment of the ecosystem.

Past Effects and Their Accumulation

North America has been occupied by Native peoples for at least 12,000 years (USDI BLM 2005e). Contrary to the beliefs of European emigrants arriving in the western U.S. in the 18^{th} century, western lands at that time were not pristine wilderness but ecological systems in which humans were an active component. American Indians used fire as a tool to manage vegetation. However, these fires were usually of low intensity and frequent, and had only minor impact on the landscape (USDA Forest Service and USDI BLM 2000).

As Euroamericans moved west, they reshaped ecosystems to meet their needs. They cleared forests for agriculture and grazed livestock, fragmenting landscapes and changing plant and animal species composition. As people settled areas, they built homes and other structures, and began suppressing fires to protect their property. The resultant fire exclusion promoted aging forests and shrublands, insect and disease outbreaks, an overaccumulation of fuel, and a consequent increase in fire severity and intensity. The disruption of natural fire cycles in fire-adapted ecosystems became the dominant agent of change that initiated an increased wildland fire risk (Hann et al. 2002).

Most rangelands have experienced significant changes in fire regimes during the past 150 years. Due to reductions in herbaceous cover and increased dominance of woody species, some rangelands have experienced a lengthening of the fire return interval. Other rangelands have experienced shorter fire return intervals, primarily as a result of wildland fire disturbances that created conditions favorable for exotic species' invasions.

On many rangelands, overgrazing by livestock in the late 19th and early 20th centuries reduced grass cover and scarified soil. Previously, wildland fire had maintained grasslands by rejuvenating decadent grasses and killing young woody species that might have seeded between fire occurrences. The decrease in grass cover caused by overgrazing provided open sites for the establishment of woody species. While woody species increased, herbaceous cover decreased. Because combustible vegetation became patchier, fire frequency also decreased on these sites.

Later in the 20th century, organized fire suppression further contributed to the invasion of grasslands by woody species and the increased density of woodlands and shrublands. Many rangeland sites lost much of their herbaceous ground cover. On some sites, this loss of ground cover resulted in increased wind and water erosion. Erosion further reduced herbaceous cover, perpetuating the cycle of degradation. When fire eventually burned these sites, it was generally severe due to hotter fires burning for longer periods of time caused by larger amounts of fuel.

During the 20th century, many of these rangelands also became havens for non-native species establishment. Invasive herbaceous non-native species affect rangeland fire regimes much differently than invasive woody species. Many non-native annual plant species dry out earlier than native perennials, prompting a longer annual flammable period. The longer flammable season, coupled with denser ground cover typical of these non-native species, triggers much more frequent fire. In many cases, each time a fire occurs, additional opportunities for non-native species establishment ensue. The result is a cycle of ecosystem degradation and costly, unwanted wildland fires.

Fire exclusion and historical logging practices altered forest structure, species composition, and associated fire regimes. Fire suppression efforts began influencing forest structure and composition more than 100 years ago. In the absence of fire, understory trees became much denser. In many areas, understories shifted to species that were more shade-tolerant and less resistant to fire and drought cycles. As these forests aged, resistance further declined and they became increasingly susceptible to insect and disease outbreaks. As a result, wildland fires in these degraded forests burned more severely and became more difficult to control.

Natural reseeding and well-intentioned, aggressive planting programs also helped create dense stands of smaller trees and brush where forests of large trees had once existed. Although mechanical thinning and slash treatment programs were planned for many of these plantations, funding for these activities did not keep pace with the need to reduce stand density.

Today, forest structure on significant portions of federal lands has shifted to a dominance of these small, more closely spaced trees. As these stands age, they become susceptible to, and provide fuel for, intense wildland fire (USDA Forest Service and USDI BLM 2000).

In some forests and woodlands, logging, grazing, and unnaturally severe fires have also contributed to increases in non-native plants, insects, and pathogens. The invasion of non-native plants has caused various impacts to ecosystems, including displacement and endangerment of native species, reduced site productivity, and degraded water quality.

Non-native species have greatly increased fuel loadings in some areas, resulting in more frequent and more severe unwanted wildland fire. Throughout the continental United States, non-native invasions have significantly altered fire regimes. In contrast, Alaska's fire regimes have not been significantly altered by these influences.

Since the 1970s, the interior West's population has increased more rapidly than the country at large. As human populations continue to grow in the WUI, even more people and their property will be at risk from unwanted wildland fires. The vegetation in many of these interface areas where wildland fire now poses the greatest threat to human lives and values evolved with fire.

Actions taken by the BLM and other land management agencies to restore watersheds and ecosystem health can reverse the trend of increasing risk of unwanted wildland fire and deteriorating land health. For example, in 1986, the BLM reported that only 34% of public land was in excellent or good condition (Forest Service 1989). Today, approximately 42% of public land is considered to be in excellent or good condition (USDI BLM 2005d).

Future Effects and Their Accumulation

Treatments that remove hazardous fuels from public lands would be expected to benefit the health of plant communities in which natural fire cycles have been altered. Treatments that restore and maintain fire-adapted ecosystems, through the appropriate use of mechanical thinning, fire, and other vegetation treatment methods would decrease the effects of wildfire on plant communities and improve ecosystem resilience and sustainability. Treatments should also reduce the incidence and severity of wildfires across the western U.S. (USDA Forest Service and USDI BLM 2000). Treatments that control populations of non-native species on public lands would be expected to benefit native plant communities by reducing the importance of non-native species and aiding in the re-establishment of native species.

Over half of treatments would occur in the Temperate Desert Ecoregion. Much of this ecoregion is comprised of grasslands and shrublands that have altered fire regimes and have suffered catastrophic fires during the past decade, and are dominated by downy brome and other invasive species. Recovery to pre-fire conditions could take decades to centuries. Treatments would provide a better mix of habitats so that vegetation would be more resilient to disturbance and sustainable in the long term. Treatments would reduce the encroachment and density of woody species in shrublands and/or herblands. Treatments would slow the spread of weeds and increase the number of acres dominated by bunchgrasses and other important forage species for wildlife and livestock. As a result, plant communities that have declined substantially in geographic extent from historical to current periods (e.g., big sagebrush and bunchgrasses) would increase.

Given the current rate of urbanization and degradation of privately-owned lands and limited funding available to restore public and other publicly-owned lands, the extent of weeds and other exotic and undesirable plants would continue to increase, but the rate of expansion would slow (USDA Forest Service and USDI BLM 2000). Based on modeling done for development of the cohesive strategy and assuming vegetation treatment funding remains near current levels, the cumulative number of acres of site degradation within 15 years from severe wildland fires and invasive plants would triple from current levels. However, even in that short time frame, risk to watersheds would only increase by one-fifth under the proposed program (equal weighting of treatments in the WUI and non-WUI), and would remain static if more emphasis was given to restoring natural fire regimes and healthy ecosystems in the non-WUI (67% of treatments in non-WUI; Hann et al. 2002). Modeling done for treatments of BLM- and Forest Service-administered lands in the Interior Columbia Basin, which encompasses much of the Pacific Northwest, showed that over a 100-year analysis period, there was a decrease in vegetation types that are most susceptible to fire, insect, and disease risks, and an increase in vegetation that is more resilient to these risks (USDA Forest Service and USDI BLM 1996).

Contribution of Treatment Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to vegetation would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and the effects to vegetation, would be similar under Alternatives D and E. Effects to vegetation under Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects from treatments and other human causes would accumulate, but if treatments were successful, a countervailing effect of long-term improvement in the ecosystem health could offset short-term losses.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often considered a critical first step in successful restoration of degraded areas since anthropogenic activities that are causing degradation or preventing recovery are halted. Under Alternative E, recovery of vegetation through passive management is expected to take longer than under alternatives A, B or D, where active management through treatments such as seeding with native species, establishing intermediate vegetation to control erosion, and use of pre-emergent herbicides to prevent weed establishment would be expected to promote faster recovery.

The risks to non-target vegetation from use of herbicides could be less under Alternative E than under the other herbicide use alternatives because ALS-inhibiting herbicides would not be used under Alternative E. ALS-inhibiting herbicides are effective at very low doses and could drift onto and harm non-target vegetation. The risk of herbicide drift affecting plants would be less under alternatives D and E than under the other herbicide treatment alternatives, as aerial treatments are prohibited under Alternative D, and discouraged under Alternative E.

Regardless of the alternative chosen, there would be an accumulation of loss of native vegetation function. Over the long term, treatments should restore native vegetation and natural fire regimes and benefit ecosystem health.

Fish and Other Aquatic Organisms

Fish, the dominant aquatic vertebrate in the analysis area, constitute a key component of aquatic systems on public lands. Fish are a critical resource to humans and as such have influenced the development, status, and success of social and economic systems in Alaska and the western U.S. Aquatic organisms such as insects and other aquatic invertebrates provide food for fish. The health of fish and other aquatic organisms is often indicative of the health of the watershed. Fish and other aquatic organisms are often more sensitive than humans and wildlife to herbicides and other chemicals in their environment, and thus can be an indicator of the concentrations of these pollutants in aquatic bodies.

The BLM administers lands directly affecting almost 117,000 miles of fish-bearing streams and 3 million acres of reservoirs and natural lakes (USDI BLM 2005c). These habitats range from isolated desert springs of the Southwest to large interior rivers and their numerous tributaries throughout the Pacific Northwest and Alaska. Today, the rapid expansion of invasive species and build-up of hazardous fuels across public lands are threats to ecosystem health and one of the greatest challenges in ecosystem management.

Past Effects and Their Accumulation

Cumulative impacts to wetland and riparian areas that provide habitat for aquatic organisms on public lands and throughout the western U.S. have occurred from human-caused disturbance factors, including natural resource extraction, recreation, fire exclusion, construction of roads, dams, and hydropower facilities, agriculture, and urbanization. Use of wetland and riparian areas by livestock and wild horses and burros has degraded habitat values, as well as natural disturbances. Water withdrawal from ditches and diversions have impacted fish habitat on public and other lands. Overfishing has been blamed for the declines in some fish populations (USDA Forest Service and USDI BLM 2000).

Although the number of acres of wetland and riparian habitat lost on public lands since colonization is unknown, it is estimated that 53% of wetlands present at the time of colonization in the lower 48 states have been lost in the U.S. (Wright 2002). The condition of much of the remaining habitat has become degraded since that time. BLM surveys show that about 25% of wetlands and 52% of riparian habitat on public lands outside of Alaska lack characteristics necessary for "high" functioning condition (USDI BLM 2005d). A proper functioning wetland or riparian area has the necessary physical and structural components to dissipate stream energy associated with high water flows, as well as conditions that support a diverse and healthy population of fish and other aquatic organisms.

The spread of invasive plant species is one factor that degrades habitat for aquatic organisms. In addition, hazardous fuels buildup can lead to catastrophic wildfires that can also adversely impact wetland and stream habitat. Within riparian woodlands, the abundance of mid-size trees has increased while other size categories have decreased, primarily due to fire exclusion, increasing the risk of wildfire and reducing the value of these areas to aquatic organisms. Within riparian shrublands, there has been extensive conversion to areas dominated by exotic grasses and forbs, primarily because of processes and activities associated with excessive livestock grazing pressure. This conversion has made these areas more susceptible to fire and reduced their value to aquatic organisms (USDA Forest Service and USDI BLM 2000).

Activities in Alaska, including oil and gas development and subsistence and recreational fishing, have impacted fish and other aquatic organisms on public lands These effects have accumulated, but do not appear to have adversely affected fish populations to a great extent. The permitting process and the regulatory environment for protecting fish have improved over time and are generally effective. Proper construction and placement of bridges and culverts have greatly reduced effects but have not eliminated them. Little is known about the effects of water withdrawals from lakes on fish. Some fish have been harmed or killed during water extraction, but these numbers have been small and have not accumulated (USDI BLM 2005e).

As discussed under Wetland and Riparian Areas, during the early years of the BLM, most resource conservation and management was focused on rangelands. An increased emphasis on wetland and riparian habitat protection began in the 1960s. In the 1970s, in response to concerns over rangelands and various land-use practices on public lands, FLPMA was passed (1976) and the BLM began preparing land use plans to better manage livestock and other natural resources on public lands. Land use plans set goals and objectives for natural resource management and include identifying priority watersheds on which to focus restoration efforts, with special emphasis on watersheds that contain habitat for sage-grouse. In addition, the BLM is assessing the condition of wetland and riparian areas, and conducting restoration efforts in those areas that are less than proper functioning. The BLM has restored about 160,000 acres of wetlands, and about 1,000 miles of stream habitat. Federal monitoring and restoration efforts are supported by state and tribal fish and wildlife agencies, and by private conservation organizations.

Future Effects and Their Accumulation

The rate of loss of wetland and riparian areas has slowed with the passage of federal, state, local regulations that strive to protect wetland and riparian habitat. There has been some improvement in the functional quality of wetland and riparian areas on public lands, a trend that is likely to continue. For example, the percentage of wetland and riparian areas that lacked the characteristics necessary for high function has decreased by about 10% since 1996 (USDI BLM 1997, USDI BLM 2005d). As a result, the loss of riparian and wetland functions and values over portions of the West should slow in the future.

Efforts to restore natural disturbance regimes, reduce the potential for catastrophic wildland fire, and the management and control of noxious weeds and other invasive vegetation would help to reduce erosion and sedimentation and restore native plant communities.

Restoration of native vegetation should improve riparian habitat and moderate stream temperatures and water flows. In addition, the ability of the BLM and other natural resource management agencies to use aquatic herbicides to control aquatic weeds would benefit lakes and ponds and the aquatic organisms that use these habitats.

Modeling done for the Interior Columbia Basin assessment predicted that vegetation treatments proposed by the BLM and Forest Service would improve the habitat capacity for fish and other aquatic organisms, including threatened and endangered salmon, but that fish populations may be slow to respond to improved habitat conditions. Fish inhabit streams found on and off public lands and streams cross multiple jurisdictions, including private land, along their entire course. In many cases the condition of the stream habitat off of public lands and on private or other jurisdiction lands is unknown and could be of lower quality. A portion of most populations is harvested each year. Competition with non-native fish may limit the ability of native species to access or fully utilize available habitat. Perhaps most importantly, dams and other diversions found in the Columbia River, Colorado River, and most other major rivers in the West also limits access to upriver habitats and alter occupied habitats for certain anadromous fish and other species. Thus, restoration of native vegetation and natural ecosystems may be most immediately beneficial to resident fish rather than migratory fish that must travel off of public lands to meet part of their life requisites (USDA Forest Service and USDI BLM 2000).

Much of the water-related impacts to water resources on public lands in Alaska would be associated with oil and gas development, mining, and other development. Development would include an increased number of ice roads and new pipelines, spills of hazardous materials, and habitat disturbance. Potential impacts to fish would be related to water withdrawal and direct habitat loss or indirect disturbance associated with construction of facilities.

Contribution of Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to the health and productivity of aquatic organisms would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated under alternatives D and E and their associated short- and long-term effects would be similar, while Alternative C would be intermediate between these alternatives and the Preferred Alternative. Treatments would occur on about 30,000 acres of wetland and riparian habitat annually under the Preferred Alternative, but aquatic organisms would also benefit from upland treatments located near aquatic habitats. Short-term effects could accumulate, but if treatments were successful, a countervailing effect of long-term improvement in habitat for aquatic organisms should more than offset short-term losses.

Because herbicide treatments would not be allowed under Alternative C, control of some aquatic weeds, including giant salvinia, hydrilla, and milfoils, could be difficult as mechanical and other non-herbicide treatment methods are less effective. Under Alternative B, the BLM's ability to use four new chemicals (fluridone and diquat for aquatic applications, and imazapic and Overdrive® for terrestrial applications), and new herbicides as they become available, would provide new capabilities to the BLM for controlling problematic invasive species and would provide benefits to wetland and riparian areas if invasive species were controlled or eliminated. Under alternatives C and D, it could be difficult for the BLM to adequately treat remote areas, or large weed infestations to benefit aquatic organisms. Thus, the risk of loss aquatic habitat and habitat function in more remote areas could be greater under these alternatives than under the other alternatives.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often considered a critical first step in restoration because the anthropogenic activities that are causing degradation or preventing recovery are reduced or eliminated. Passive restoration for aquatic habitats would likely entail mitigation and management of terrestrial-based activities, which could directly or indirectly affect habitat quality. As discussed in Chapter 2, Vegetation Treatment Programs, Policies, and Methods, passive restoration would be considered when developing restoration management plans, and would be used to the extent possible within the constraints of FLPMA.

Regardless of the alternative chosen, loss of aquatic habitat and values would accumulate under all alternatives over the short term, but the rate of loss would be expected to slow from historic levels.

Wildlife Resources

Public lands sustain an abundance and diversity of wildlife and wildlife habitat. Wildlife are found in areas where their basic needs—food, shelter, water, reproduction, and movement—are met (Anderson 2002). In general, the greater diversity of habitats in an area, the more species of wildlife that an area can support. Some species, however, have special behaviors and physical traits that allow them to successfully compete with other animals in only one or a few habitats and limits their distribution.

As discussed in Chapter 3, several structural features make some habitats better for wildlife than others. These features include: 1) structure, 2) vertical layers, 3) horizontal zones, 4) edge, 5) and special features. The more of these features that are present, the more niches, or places in which animals can live (Cooperrider et al. 1986).

Historically, landscapes provided a continuous mosaic of vegetation types adapted to climatic and natural disturbance regimes. Plant communities were dynamic and resilient, tending to return to some developmental (successional) pathway after a disturbance. Although structural complexity varied depending upon the characteristics of the dominant vegetation (e.g., forestlands tend to be more structurally complex than grasslands), even structurally "simple" habitats provided numerous niches for wildlife to exploit. For example, grasslands may provide only one or two strata, or levels, of vegetation for wildlife to use, but still contain a diversity of wildlife species (Payne and Bryant 1998).

At the ecoregion level, habitats showed little change over decades or even hundreds or thousands of years. However, at the landscape level (1,000 to 100,000s of acres; Paige and Ritter 1999) and stand level (1 to 1,000s of acres), vegetation and habitats were in constant flux, changing and adapting to natural perturbations in the environment. Disturbances consisting of infrequent, high-intensity events (such as drought, flood, and major fire) interspersed with frequent, low intensity events (wildlife grazing, low intensity burns, disease) constantly shaped and modified the environment. As a result, habitat types varied over time and space and resulted in different species groups being dominant at different times depending upon the characteristics of the habitat.

Past Effects and Their Accumulation

North America has been occupied by Native peoples for at least 12,000 years. As humans settled the West, they altered succession and introduced disturbance processes to which many native plants and animals were not evolved. The following examines direct and indirect human-related effects on wildlife habitat loss, modification, and fragmentation, and on wildlife health. These effects have resulted in death and harm to wildlife that has accumulated since the arrival of man in North America.

Habitat Loss. Approximately 21% of land in the western states (excluding Alaska) has been converted to intensive uses—urbanization, agriculture, and pastureland—that provide fewer benefits for wildlife than undisturbed habitats or habitats subjected to less intensive uses (Wright 2004). Although wildlife find food and shelter in these highly modified habitats, they generally provide fewer habitat values and are less structurally complex than the habitats they replace. Therefore, they support fewer wildlife species and numbers.

Conversion of lands to more intensive uses caused injury and mortality to wildlife, primarily less mobile species that lived near the surface, and species that depended on special habitat that was lost during conversion. Large numbers of wildlife were displaced, and many of these animals died because they could not find food, shelter, or other life requisites, or were unable to successfully compete with species found in their new environs. As urbanization and development has intensified in the West during the past several decades, it has not been uncommon to see displaced coyote, bear, deer, and other wildlife in urbanized settings after their native habitats have been developed for housing and other human needs. Some of these animals prey upon dogs, cats, and other domestic animals, or upon vegetation used for landscaping, and must be captured, removed, and in some case euthanized, to reduce this problem. Loss of habitat is also an important factor contributing to the increase in the number of species listed as threatened or endangered in recent years (see BA prepared for this PEIS; USDI BLM 2005b).

Lands developed for agricultural, urban, and industrial uses were often some of the most productive lands in terms of resource values and wildlife habitat. Once converted to these uses, the habitat values they provided and wildlife they supported were lost. The loss of wetland and riparian areas in the West is a good example of productive habitats that have been lost or modified from development. Even where wetlands and riparian areas still exist, they have often been converted to other uses. For example, much of the remaining wetland habitat in central and northern California has been converted to agricultural uses (e.g., rice production). Although these areas provide habitat for waterfowl and other wildlife, their food, cover, and other habitat values are usually less than they were before the conversion.

Industrial activities, such as mining, can substantially modify or eliminate habitat within and near the development footprint. Dams and water diversions have been constructed on most major rivers in the West. Where streams and rivers that once supported a productive riparian ecosystem were dammed, the riparian ecosystem became inundated by large lakes or reservoirs that provided some habitat for wildlife, but were generally not as productive as they once were.

Not all species are harmed by conversion of land to more intensive uses. Numerous species are adapted to urbanized environments. Even native species that can readily adapt to change, or find their needs met by the modified habitat, may thrive. For example, deer, elk, geese and songbirds have benefited by the conversion of lands to urban, agricultural, and recreational uses. These species find food and water at bird feeders, in pasturelands, at golf courses and other parks, and in cornfields and other croplands. In some cases, species that use developed habitats may benefit from reduced predation pressure, as their predators are unable to adapt to the new surroundings.

Habitat Modification. Most of the remaining 79% of lands that were not converted to more intensive land uses still have undergone some modification that has reduced their value to wildlife. An analysis of habitat condition in the Interior Columbia Basin showed a general downward trend in habitat value from historical conditions for nearly all habitat types evaluated in the study (USDA Forest Service and USDI BLM 2000). This study also showed that species that rely upon older forests, sagebrush, and grassland habitats have been most affected by loss and modification of habitat in the region; similar losses of these habitat types have been seen throughout the western U.S. (Payne and Bryant 1998, Paige and Ritter 1999, Smith 2000). Factors that have modified habitat in the West include grazing by domestic livestock and wild horses and burros, timber management, fire suppression, and invasion by weeds and other unwanted vegetation.

Grazing. Excessive grazing pressure has modified wildlife habitat over many areas in the West. Wetland and riparian areas, in particular, have suffered from heavy domestic livestock and wild horse and burro grazing pressure (USDA Forest Service and USDI BLM 2000). Livestock grazing can remove vegetation used by wildlife for food and cover, and locally trampled wildlife hiding and breeding habitats. Domestic livestock removed much of the native grasses in the Great Basin by the early 20th century, and today, less than 1% of the sagebrush steppe in the region remains untouched by livestock (Paige and Ritter 1999). Livestock selectively choose grasses and forbs due to palatability and avoid browsing on sagebrush, which can have a toxic effect on the microorganisms in their rumen (Young 1994). Grasses and forbs provide food and cover for sage-grouse and other sagebrush-dependent species, and loss of this habitat through grazing and other uses has led to reduced numbers of these species (Paige and Ritter 1999). Encroachment of western juniper into grasslands, which has been attributed to heavy grazing and fire suppression, has been detrimental to grassland-dependent wildlife. In areas with sparse vegetative cover, such as the Subtropical Desert Ecoregion, livestock can remove much of the available forage. Livestock often compete with native wildlife, and in some areas wild horses and burros, for forage.

Timber Management. Since the 1800s, millions of acres of timber have been harvested in the West. Historically, preferred timber species were often the more valuable shade-intolerant species such as ponderosa pine, western white pine, and western larch, and the larger trees. Many stands were harvested using even-aged harvest techniques, such as clearcutting, which promoted conversion of forests to shade-intolerant trees that usually had single-storied canopies and lacked vertical structure (Payne and Bryant 1998). Species that depended upon late seral forest habitat or a mosaic of forest types, such as northern spotted owl, white headed woodpecker, white-breasted nuthatch, and western grey squirrel, declined in numbers. Deer and elk thrived in intensively managed forests, as dense even-aged stands provided good hiding cover (although poor snow intercept-thermal cover), and were often in close proximity to recently-harvested clearcuts that provided grasses, forbs, and shrubs for forage. The checkerboard system of clearcutting also increased edge (a place where two habitat types meet, such as a forestland and shrubland), to the benefit of edge species, including most game species, but to the detriment of forest-interior species (Payne and Bryant 1998).

Fire Exclusion. During the past 100 years, fires have become less frequent and more intense in the western U.S. (Agee 1993; Lyon et al. 2000a). Exceptions to this general trend have occurred in grassland and shrubland habitats that have been invaded by exotic annual grasses, where fire frequency has increased beyond natural fire cycles. Intense wildfires likely harm or kill more wildlife than less intense fires, and are more likely to destroy large areas of habitat, potentially eliminating "islands" of habitat that may provide the only remaining refuge for some species (Lyon et al. 2000b).

Lack of frequent non-lethal burns has resulted in an increase in stand density, an increase in shade tolerant species, and encroachment of invasive species and trees into grasslands. In forests, nearly uniform stands of dense, mid-seral trees limit the amount of light that can reach the understory, preventing growth of understory shrubs, grasses, and forbs (Payne and Bryant 1998). These changes not only resulted in habitat loss for species that require open old-growth stands and early seral stages, they also led to conditions that result in large, severe fires in the future. Fire suppression has benefited some species, such as northern spotted owl in parts of its range, but has made them more susceptible to harm by a large fire (Thomas et al. 1990).

Dense stands of mid-seral trees are often lacking in special habitat features that are found in more mature forests. For example, early- and mid-seral forest are less able to capture snow in their branches than more mature trees. Where large trees capture snowfall in their large branches during winter, rather than letting it accumulate on the ground, shrubs and other forage are more readily available to deer and other browsers, and animals are able to travel through the snow without difficulty.

Changes in rangeland habitat, either from fire suppression that allows shrubs and trees to invade grasslands, or from high fire frequency that has encouraged the growth of non-native annual weeds, has impacted rangeland species such as sage-grouse, Brewer's sparrow, and sage sparrow (Paige and Ritter 1999). Encroaching shrubs and trees crowd out grasses and forbs used by wildlife, while annual weeds provide little forage value or habitat structure for wildlife. Declines in big game winter range, density of nesting raptors, and non-game bird abundance have also been observed in areas dominated by downy brome (USDA Forest Service and USDI BLM 2000).

Invasive Species. Euroamerican settlement facilitated the invasion and spread of invasive plants. Weeds and other invasive species are able to colonize disturbed (downy brome) and relatively intact (spotted knapweed, yellow starthistle, and leafy spurge) sites, reproduce and grow quickly, and outcompete native species for water and nutrients. The construction of roads and ROW have facilitated the spread of weeds. Noxious weeds and other exotic plants harm wildlife by reducing the amount of high quality forage and habitat complexity in an area from levels needed to support an abundance and diversity of wildlife (Payne and Bryant 1998). Invasive species can also increase sedimentation and surface water runoff to the detriment of amphibians and other aquatic species whose habitats may be impacted. Pinyon-juniper woodlands have encroached into grasslands over much of the West, to the detriment of edge species and ground-nesting and foraging species. However, the expansion of these species has also benefited wildlife, as pinyon-juniper woodlands provide forage for wintering deer, and in some areas, support more bird species than forest and sagebrush communities (Payne and Bryant 1998).

Habitat Fragmentation. From historical to current periods, there has been an increase in fragmentation of larger habitats into smaller "islands" of habitat and a loss of connectivity within and between blocks of habitat, especially in lower elevation forests, shrublands, and riparian areas (USDA Forest Service and USDI BLM 2000). All of the factors discussed above have contributed to the fragmentation of habitats in the West.

In general, the smaller the island of habitat, the fewer the number of species that can be supported, since larger areas support a greater diversity of vegetation types and microhabitats. Larger areas are also able to support uncommon species that live at low population densities. In addition, small islands, on average, support small populations, which are more likely than large populations to go extinct (Hunter 1990). This risk of extinction is a factor of concern for several TES species that are restricted to small islands of habitat. A catastrophic wildfire or other major habitat-disturbing event could make the habitat unsuitable for some TES species, leading to their extinction. For example, pygmy rabbits in Washington State are restricted to a few small areas of sagebrush habitat in central Washington surrounded primarily by agricultural land. A major fire event or disease would likely eliminate the population (McAllister 1995).

Fragmentation isolates sedentary and less mobile animal populations, or populations with restricted habitat requirements, and reduces their ability to disperse across the landscape, potentially leading to long-term loss of genetic exchange. Fencing for livestock often prevents the free movement of wildlife. Even where habitats are contiguous, human disturbance (e.g., roads, noise) and development can discourage wildlife from moving between adjacent areas, effectively fragmenting habitat.

Public land settlement policies have, in part, contributed to the fragmentation of habitats across the West. Public lands in many states outside of Nevada are often scattered and take on checkerboard, jigsaw, and patchwork patterns as a result of public land policies pursued by the country prior to the BLM's founding in 1946. As a result, blocks of public land are often isolated and surround by agricultural or other lands. From a wildlife perspective, these blocks act as islands, and some species may be unwilling or unable to travel between blocks of public land or other suitable habitat (Muhn and Stewart 1988). In contrast, there are also large tracts of contiguous public lands in the West that provide habitat connectivity for many species, including sage-grouse, deer, elk, and numerous migratory bird species.

Wildlife Health. Human-related activities are responsible for the death and injury of wildlife each year. Hunting removes large numbers of animals each year. Approximately 409,000 hunters used public lands in FY 2001 (USDI BLM 2005d). Hunting did not adversely affect populations of most species, but overharvest of other species, including American bison, pronghorn antelope, and wild turkey, nearly led to their demise.

Thousands of animals are killed each year by automobiles and other vehicles, and from flying into powerlines and other elevated structures associated with ROWs, wind-power generating facilities, transmission towers, and other structures. Wildland and prescribed fire kill or harm animals, with animals with limited mobility living above ground being most vulnerable (Lyon et al. 2000b).

Disturbance associated with public recreation, including public-use facilities and OHV use, has displaced wildlife or impacted their activity patterns and habitat use, and likely led to some deaths or reduced animal health. The use of pesticides, especially organochlorine pesticides such as DDT, have caused death, sickness, and poor reproduction in birds and other wildlife, especially prior to the 1980s when the public became more aware of these issues. Diseases that spread from domestic animals to wildlife (e.g., rabies) can also contribute to the loss or harm of wildlife.

Future Effects and Their Accumulation

The objective of future management will be on restoring native vegetation in fire-adapted ecosystems to benefit wildlife and their habitats. Treatments that reduce hazardous fuels on public lands, control the spread of non-native plant species, and restore natural fire regimes would benefit most wildlife. Those species that have adapted to, or have exploited, habitats that have developed as a result of fire suppression and weed spread may decline in numbers. However, modeling conducted during development of the cohesive strategy, and for the Interior Columbia Basin assessment, suggest that it will take decades to centuries for major habitat changes to occur (USDA Forest Service and USDI BLM 2000; Hann et al. 2002).

Loss of Habitat. Vegetation treatments will do little to slow the loss of habitat in the West. Population growth in the West will likely continue to exceed that of the rest of the country, placing new demands on undeveloped land to meet human-related needs, including urbanization, agriculture, and recreation. As a result, more wildlife will be lost or displaced as lands are converted to uses that do not support historic species or numbers of wildlife, and it is likely that many displaced animals will perish. It is also possible that loss of habitat could lead to the extirpation of species, although the provisions of the ESA should minimize this risk. Most habitat loss would occur on privately-owned lands, although public lands will continued to be developed for mining, oil and gas, recreation, roads and other uses as authorized under FLPMA.

Habitat Modification. The basic premise of the vegetation treatment program is to manage ecosystems to maintain viable populations of native and desirable non-native plant and animal species. This goal would be accomplished by using fire and other treatments to reduce hazardous fuels and the risk of catastrophic fire, to reduce or eliminate weeds and other invasive plants, and to promote conditions that favor the restoration and development of native vegetation. While treatments would not stem the loss and modification of vegetation and wildlife habitat that occurs on private lands, they would improve ecosystem health on public lands and improve habitat for wildlife that historically used treatment areas.

Over half of treatments would occur in the Temperate Desert Ecoregion. Much of this ecoregion is comprised of grasslands and shrublands that have altered fire regimes and have suffered catastrophic fires during the past decade, and are dominated by downy brome and other invasive species. Treatments are also targeted at evergreen woodlands, primarily to slow the encroachment of pinyon-juniper and other woodland species into grassland habitats.

There is currently greater awareness, than there was historically, on the part of the BLM and other federal land management agencies, and the public, on the effects of livestock, wild horses and burros, timber management practices, and other land disturbing activities, such as mining and fluid minerals development, on wildlife habitat. Better management of human-related disturbance factors through application of site-specific mitigation, SOPs, reclamation and rehabilitation, and monitoring, will continue to benefit wildlife habitat.

Habitat Fragmentation. Factors that contribute to habitat fragmentation on and off public lands will continue, increasing the likelihood of local extinctions of wildlife and loss of species diversity; these risks are greatest on privately-owned lands. Vegetation management that creates a mosaic of native vegetation within larger continuous areas of similar habitat would be beneficial to "interior" and wide-ranging species. Efforts to restore native vegetation in disturbed areas would help to link islands of habitat, as would forest treatments focused on thinning, rather than clearcutting, timber. Closing and revegetating little-used or abandoned roads and removing fencing and other barriers to movement would encourage the movement of wildlife among habitats and facilitate genetic exchange among populations. Treatments that reduce the risk of catastrophic fire and spread of weeds would result in more continuous stands of similar vegetation and a reduced likelihood that islands of good habitat would be surrounded by less desirable habitat (e.g., a patch of native riparian sagebrush surrounded by a continuous stand of downy brome).

In addition, efforts by the BLM and Forest Service to consolidate landholdings through land tenure adjustments, such as land exchanges with other federal agencies and private landowners to create larger blocks of common ownership, would help to reduce habitat fragmentation and improve management of federal and private lands.

Other Human-related Factors. Hunting and other disturbance factors that have impacted wildlife in the past are likely to continue. However, current management of game populations and enforcement of hunting laws has reduced the risk of major declines in the numbers of game species from historic levels. Development and implementation of land use and project-level plans that consider the effects of OHVs and other disturbance factors, road closures, screening of facilities, and other SOPs to minimize disturbances would benefit wildlife. Although the amounts of herbicides used by the BLM and Forest Service to treat vegetation would increase in response to proposed treatment programs, the risks to wildlife should remain near current levels, or decline, as both agencies move towards used of less toxic chemicals to treat vegetation.

Contribution of Treatment Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to wildlife and habitat would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and the effects to wildlife and habitat would be similar under alternatives D and E. Effects to wildlife and habitat under Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects from treatments and other human causes would accumulate, but a countervailing effect of long-term improvement in the ecosystem health and wildlife habitat would offset short-term losses with success and maintenance of treatments over the long term.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often considered a critical first step in successful restoration of degraded areas since anthropogenic activities that are causing degradation or preventing recovery are halted. Under Alternative E, recovery of vegetation and wildlife habitat through passive management is expected to take longer than under the other herbicide treatment alternatives, where active management through treatments such as seeding with native species, establishing intermediate vegetation to control erosion, and use of pre-emergent herbicides to prevent weed establishment would be expected to promote faster recovery.

The risks to wildlife from use of herbicides could be less under Alternative E than under the other herbicide use alternatives because ALS-inhibiting herbicides would not be used under Alternative E. ALS-inhibiting herbicides are effective at very low doses and could drift onto wildlife and harm them. The risk of herbicide drift affecting wildlife and their habitats would be less under alternatives D and E than under the other herbicide treatment alternatives, as aerial treatments are prohibited under Alternative D, and discouraged under Alternative E.

Regardless of the alternative chosen, there would be an accumulation of loss of native vegetation and healthy ecosystem function. Over the long term, treatments should restore native vegetation and natural fire regimes and benefit ecosystem health and wildlife and their habitats.

Livestock

Approximately 165 million acres of public lands are open to livestock grazing, with use levels established by the Secretary of the Interior and administered through the issuance of grazing permits/leases. The majority of the grazing permits issued by the BLM involve grazing by cattle, with fewer and smaller grazing permits for other kinds of livestock which would include primarily sheep and horses. Livestock grazing leases and fees contribute $12 million annually to the U.S. Treasury, and ranching is an important economic and social component of many rural communities (USDI BLM 2005c). There are over 12.7 million active animal unit months that could be authorized for use on public lands. The ability of public lands to support healthy populations of domestic livestock is important to the livelihood of livestock producers.

Past Effects and Their Accumulation

Livestock grazing management in the past, in particular prior to the Taylor Grazing Act, has been recognized to impact public lands and may be a contributor to the loss of native species and degradation of ecosystem health that vegetation treatments are designed to restore. Urbanization has also reduced the amount of private land that is available to livestock. Loss of native vegetation and deterioration in ecosystem health on public land due to changes in fire regimes, and increases in lands dominated by noxious weeds and other invasive vegetation, have also contributed to reductions in the ability of public lands to support livestock grazing. Even though livestock grazing itself is a factor for some of these changes, increases in other human-caused factors such as mineral extraction and recreation have also affected vegetation communities or resulted in conflicts that reduce the ability of these public lands to support livestock grazing. Where human activities and wildland fire have disturbed the land, weeds and other unwanted species have taken over and dominated landscapes in some cases (USDA Forest Service and USDI BLM 2000). It is estimated that downy brome alone covers over 11 million acres in the West, and that leafy spurge covers 3 million acres (Lajeuness et al. 1998). Weed species often provide little nutritional value to livestock, with some species being toxic to various groups at different times.

Future Effects and Their Accumulation

The focus of management in the future is on restoring ecosystem processes and maintaining livestock populations in balance with the health of rangelands. Many of these treatments will require rest from livestock grazing and will therefore result in temporary reductions in livestock grazing. In the long term, treatments that remove hazardous fuels from public lands would be expected to benefit the health of plant communities in which natural fire cycles have been altered. Treatments that restore and maintain fire-adapted ecosystems, through the appropriate use of mechanical thinning, fire, and other vegetation treatment methods would decrease the effects from wildfire to communities and improve ecosystem resilience and sustainability. Treatments should also reduce the incidence and severity of wildfires across the western U.S. to the benefit of livestock (USDA Forest Service and USDI BLM 2000).

Vegetation treatments would provide a better mix of habitats so that vegetation would be more resilient to disturbance and sustainable in the long term. Treatments would reduce the encroachment and density of woody species in shrublands and/or herbaceous species in rangelands. Treatments would slow the spread of weeds and increase the number of acres dominated by bunchgrasses and other important forage for livestock. Although the number of acres impacted by weeds and other exotic and undesirable plants would continue to increase, the rate of increase should slow (USDA Forest Service and USDI BLM 2000, USDI BLM 2001).

In addition, the BLM will continue efforts to bring livestock populations in balance with the condition of rangelands. Where feasible, the BLM will incorporate the use of livestock as part of the overall weed management program, and improvements will be made to the grazing management program and grazing regulations (see *Proposed Revisions to Grazing Regulations for the Public Lands Final EIS*; USDI BLM 2004). Although these efforts should benefit the livestock industry, it is projected that there will be a slow, but steady loss in availability of public lands for livestock grazing (USDA Forest Service 1989, USDA Forest Service and USDI BLM 2000).

Contribution of Treatment Alternatives to Cumulative Effects

Based on the number of acres treated, short-term impacts and long-term improvements to domestic livestock would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and the effects to these animals, would be similar under alternatives D and E. Effects to livestock under Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects from treatments and other human causes would accumulate, but if treatments were successful, a countervailing effect of long-term improvement in the ecosystem health and the ability of public lands to support more livestock could offset short-term losses.

Alternative E places greater emphasis on passive restoration through the elimination or reduction of uses on public lands than the other alternatives. Livestock grazing is often cited as a factor contributing to loss of resource function and degradation of rangeland quality. By reducing the number of livestock entering degraded areas, improvement in ecosystem health can be expected (Kauffman et al. 1997). Thus, the number of livestock able to graze on public lands could be less under this alternative than under the other alternatives.

The risks to non-target vegetation from use of herbicides could be less under Alternative E than under the other herbicide use alternatives because ALS-inhibiting herbicides would not be used. ALS-inhibiting herbicides are effective at very low doses and could drift onto non-target vegetation, where a potential impact could occur, depending upon the species composition of the non-target site and the ALS-inhibiting herbicide selected. The risk of herbicide drift affecting livestock would be less under alternatives D and E than under the other herbicide treatment alternatives, as aerial treatments are prohibited under Alternative D, and discouraged under Alternative E.

Regardless of the alternative chosen, there would be an accumulation of loss of rangeland forage for livestock. Over the long term, these resources should improve and enable public lands to support populations of livestock at or above current levels.

Wild Horses and Burros

The Wild Free Roaming Horses and Burros Act of 1971 provides protection for all wild horses and burros on federal lands and provides guidance for their management as a wildland species. At the time the Act was passed, approximately 17,000 wild horses occupied federal lands designated for their protection. By 1980, the number of wild horses had increased to 65,000 to 80,000 (USDI BLM 2005f). As a result of this increase, impacts to vegetation, water, and soil from wild horses and burros increased, especially in heavily used areas. Loss of native vegetation, especially grasses and some shrubs, due to wildfires and invasive plants further reduced available forage and increased competition among wild horses and burros, livestock, and wildlife for dwindling resources. The loss of native vegetation and degradation of ecosystems has impacted wild horses and burros and has likely reduced herd productivity on some herd management areas. At the same time, wild horses and burros have adversely impacted vegetation, although efforts to reduce herd populations in recent years have reduced these effects (USDI BLM 2001c).

Past Effects and Their Accumulation

The wild horses that roam the West are feral descendants of domestic stock brought to North American by European colonists. No native wild horses existed in North America at that time, even though horses evolved in North America, and spread to Eurasia about 2.5 to 3 million years ago. The last remaining native horses persisted in North America until about 8,000 to 10,000 years ago, when they became extinct. Climate change, change in vegetation, and perhaps overexploitation by Native Americans may have contributed to the horse's demise in North America. (USDI BLM 2005f).

The Spaniards reintroduced horses and burros into North America during the 1500s. By the 1800s, more than 2 million wild horses roamed western North America. Population growth resulted from successful reproduction in the wild, and from escape or abandonment of domestic horses brought to the frontier by trappers, settlers, miners, and other immigrants. Wild burro herds also increased as individuals escaped from shepherds and miners. At the same time, the available open range began to shrink as livestock, fences, farms, ranches, and roads proliferated. Wild horses were shot to reduce competition with livestock, or rounded up and sold for use as draft animals, military mounts, and food. Burros were less persecuted because they tended to graze lands that were too barren and dry for livestock to use (USDI BLM 2001c, 2005f).

The Taylor Grazing Act of 1934 authorized the formation of the Grazing Service (a precursor to the

BLM) and empowered the Service to responsibly manage grazing pressure on federal rangelands. This step accelerated the capture and removal of wild horses and burros, which were primarily used as pet food. Lucrative European markets for horsemeat emerged, as did domestic markets for use of horsemeat in pet and chicken feed. By the 1950s, the number of wild horses dropped to less than 20,000. In addition, professional horse-catchers often used brutal methods to capture and transport wild horses for sale to slaughterhouses. Public concern developed over the falling population and inhumane treatment of animals (USDI BLM 2005f).

In response to concerns over the plight of wild horses and burros, the Wild Horse Annie Act was passed in 1959 that prohibited hunting or harassment of wild horses on public lands using motorized vehicles or aircraft, although enforcement was difficult. In the Wild Free Roaming Horses and Burros Act of 1971, Congress stated that free-roaming horses and burros were living symbols of the historic and pioneer spirit of the West; that they contributed to the diversity of life forms within the Nation and enriched the lives of the American people; and that these horses and burros were fast disappearing from the American scene. Congress mandated that wild free-roaming horses and burros be protected from capture, branding, harassment, or death (USDI BLM 2005f). Responsibility for management primarily fell upon the BLM and Forest Service.

Under protection, herds thrived and increased to over 65,000 by 1980. Unlike wildlife, which are hunted, and livestock, which are managed under a permit system, there were no controls on wild horse and burro populations. In absence of control, populations increase by 15 to 20% annually.

The BLM strives to manage wild horses and burros as wildland species, not as livestock. Typically, the BLM does not feed or water the animals, but does intervene during extreme drought, fire, or freezing weather, and may relocate animals or remove them from the range during extreme conditions. For example, more than 3,500 animals were removed from public lands in 2000 due to extreme drought conditions and placed in long-term holding facilities (USDI BLM 2001c).

Wild horses and burros are managed in herd management areas, where the BLM tries to balance the number of animals with the available resources needed by the animals for survival. Land managers consider the number of animals, rangeland health, and other desired rangeland uses in developing an appropriate management level. Wild horse advocates express concern about keeping numbers too low to maintain genetic diversity. Sportsmen and ranchers want the number of wild horses and burros reduced because they compete with wildlife and livestock for food (USDI BLM 2001c).

Urbanization has reduced the amount of private land near public land that is available to wild horses and burros. Paved highways, traffic, cross-fencing, and livestock gates impede herd movements and reduced the amount of land available for wild horses and burros. Loss of native vegetation and deterioration in ecosystem health on public land during the past 100 years due to changes in fire regimes, increases in lands dominated by weeds and other noxious vegetation, and other human-caused factors, have also increased competition for dwindling plant resources by these animals and further contributed to the loss and degradation of native plants. Livestock and wild horses and burros often congregate in areas with better forage or water, including wetland and riparian areas, and cause substantial damage. As native habitats are damaged, they provide new areas for invasive weeds, perpetuating the downward trend in land health.

Thus, humans and wild horses and burros have contributed to rangeland degradation. About 45% of public lands are not functioning properly and unable to provide optimal forage production and other life requisites needed to support larger populations of wild horses and burros. Still, this is an improvement from conditions in the 1980s, when more than two-thirds of public lands were in unsatisfactory condition (National Wildlife Federation and Natural Resources Defense Council 2001). Part of this success is the result of the Rangeland Reform initiative, the setting of new standards for public land health, and greater effort on the part of the BLM during the past 2 decades to protect public lands from damage.

Although wild horses and burros occur in 10 states, most animals are found in Nevada (51%) or Wyoming (12%), in the Temperate Desert Ecoregion. Almost 70% of Fire Regime Condition Class 3 acres are also found in this ecoregion, as are many of the acres dominated by downy brome. Thus, rangeland conditions in many areas where wild horses and burros are found are degraded. To reduce damage to rangeland ecosystems, the BLM began to reduce wild horse and burro numbers beginning in the 1980s. By 1996, there were about 40,000 wild horses and burros on public lands. Today, there are about 37,000 animals on public lands, with another 24,000 animals in holding facilities (USDI BLM 1997; 2005c, d).

Future Effects and Their Accumulation

The focus of management in the future will be on restoring native ecosystem processes and keeping wild horse and burro populations in balance with the health of rangelands. Treatments that remove hazardous fuels from public lands would be expected to benefit the health of plant communities in which natural fire cycles have been altered. Treatments that restore and maintain fire-adapted ecosystems, through the appropriate use of mechanical thinning, fire, and other vegetation treatment methods would decrease the effects from wildfire to communities and improve ecosystem resilience and sustainability. Treatments should also reduce the incidence and severity of wildfires across the western U.S. to the benefit of wild horses and burros (USDA Forest Service and USDI BLM 2000).

Treatments would provide a better mix of habitats so that vegetation would be more resilient to disturbance and sustainable in the long term. Treatments would reduce the encroachment and density of woody species in shrublands and/or herblands. Treatments would slow the spread of weeds and increase the number of acres dominated by bunchgrasses, Indian ricegrass, western wheatgrass, and other important forage species of wild horses and burros. As a result, plant communities that have declined substantially in geographic extent from historical to current periods (e.g., big sagebrush and bunchgrasses) would increase. Although the number of acres impacted by weeds and other exotic and undesirable plants would continue to increase, the rate of increase should slow (USDA Forest Service and USDI BLM 2000, USDI BLM 2001c).

The BLM will continue management efforts to keep wild horse and burro populations at appropriate management levels in balance with the condition of rangelands. This will require continued removal and adoption of animals, and continuing efforts to develop a fertility control agent for these animals. Over 56,000 wild horses and burros were removed from public lands during FY 2000 to 2004. The number of animals found in the Temperate Desert Ecoregion has declined by about 5,000. However, populations on public lands may need to be reduced from about 37,000 to 25,000 animals to bring populations in balance with their habitat. As a result, effects to wild horses and burros from habitat degradation will continue to accumulate, since animals in degraded areas are less healthy, and the number of animals that can be supported by degraded ecosystems will be less than the number that could be supported in more healthy ecosystems (USDI BLM 2001c, 2005f).

Contribution of Treatment Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to the wild horses and burros would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and the effects to these animals, would be similar under alternatives D and E. Effects to wild horses and burros under Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects from treatments and other human causes would accumulate. A countervailing effect of long-term improvement in the ecosystem health and the ability of public lands to support more wild horses and burros would offset short-term losses through successful treatments meeting desired objectives.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often considered a critical first step in successful restoration of degraded areas since anthropogenic activities that are causing degradation or preventing recovery are halted. Foraging by wild horses and burros is often cited as a factor contributing to loss of resource function and degradation of rangeland quality. By maintaining the number of wild horses and burros on public lands at levels in balance with rangeland productivity, improvement in habitat function would be expected (Kauffman et al. 1997).

The risks to non-target vegetation from use of herbicides could be less under Alternative E than under the other herbicide use alternatives because ALS-inhibiting herbicides would not be used. ALS-inhibiting herbicides are effective at very low doses and could drift onto non-target vegetation and degrade the forage quality of the vegetation in the impacted area. The risk of drift affecting wild horse and burro health would be less under alternatives D and E than under the other herbicide treatment alternatives, as aerial treatments are prohibited under Alternative D, and discouraged under Alternative E.

Regardless of the alternative chosen, there would be an accumulation of loss of rangeland habitat for wild horses and burros. Over the long term, these resources should improve and enable public lands to support populations of wild horses and burros at or above current levels.

Paleontological and Cultural Resources

Paleontological Resources

Paleontological resources (plant and animal fossils) are nonrenewable. Since paleontological material is buried, the location of plant and animal fossils is predictable only to a limited degree, and most fossil localities remain unknown, making assessment of cumulative impacts difficult. In many settings, paleontological resources are well protected by nature, in that they are so deeply buried and completely encased in sediments or rock that virtually nothing can impact them aside from excavation. In other instances, they are located on or near the ground surface and are very susceptible to impacts.

Once paleontological resources are impacted or displaced from their natural context, the damage is irreparable and cumulative. Paleontological resources are found over much of the West. Except perhaps for mechanical treatments and fire use, vegetation treatment methods do not present a substantial threat to paleontological resources.

Past Effects and Their Accumulation. Most paleontological material is typically buried considerably deeper than archaeological material and is therefore not regularly encountered by chance. However, some fossiliferous formations, particularly in the arid West, crop out at or near the surface and may have surface expressions or eroded material as "float." Natural and human activities that cause ground disturbance have likely impacted near-surface paleontological resources throughout the West. Paleontological research and excavation, necessary for the recovery of scientific data, have contributed to the displacement of paleontological resources. Past exploration and development of the West led to legal and illegal collecting and inadvertent damage, especially prior to the 1970s when there was less concern for protecting these resources. As awareness for the importance of these resources has increased, and as state and federal regulations have been put in place that require surveys for and prohibit the removal of paleontological resources, the cumulative loss of paleontological resources has slowed.

Future Effects and Their Accumulation. Most paleontological material is exposed as a result of natural erosion. Typically, erosion occurs as a result of the action of flowing water, but also can occur as a result of wind, seasonal freezing and thawing, ground subsidence, and the movement of soil down slopes. Natural erosion, and its impact on paleontological resources, is difficult to assess because in most cases it is regarded as discovery rather than a negative impact to the resource. Some of the most important paleontological resources are associated with river bank cuts and drainages.

An estimated 305,000 to 932,000 acres could be disturbed from herbicide treatments during the next 10 to 15 years. Of this increase, about half would be treated using ground-disturbing equipment, and of these, only a small portion would involve substantial ground disturbance that could impact paleontological resources. An additional 1.7 to 5.1 million acres could be impacted by other vegetation treatment methods, including 4.3 million acres by fire use and ground-disturbing equipment. These treatment methods pose the greatest risks to paleontological resources, either through direct harm to resources, or indirectly as a result of soil erosion and other soil disturbances that could result from treatments. In addition, population growth and development in the West have resulted in land impacts that disturb soil. These actions have the potential to add to the cumulative loss of paleontological resources. Site reclamation would not reduce this loss, as paleontological resources would have already been lost during site disturbance and development.

New innovations in technology that reduce the amount of surface disturbance associated with development on public and private lands, and enforcement of regulations that require the assessment and protection of paleontological resources before ground-disturbing activities can occur, would contribute the future protection of paleontological resources and slow their cumulative loss. Assessments to identify and protect paleontological resources in proposed treatment areas should minimize or avoid the loss of these resources. In addition, vegetation treatments that restore natural fire regimes and native plant communities, and improve ecosystem health, would lead to conditions that would slow soil erosion and reduce risk of fire, slowing the loss of paleontological resources.

Contribution of Alternatives to Cumulative Effects. The potential for cumulative impacts to paleontological resources from vegetation treatment would be least under the No Action Alternative and greatest under the Preferred Alternative based on the number of acres that would be impacted by ground-disturbing activities. Other treatment alternatives would be intermediate between these two. Most equipment would disturb only the upper few inches of soil, and in many cases, would be confined to existing disturbed areas such as roadways, trails, and other ROWs. All treatment methods could cause indirect loss of paleontological resources as a result of erosion and soil disturbance, but these effects would be minimal. Potential effects would be further reduced because the BLM has surveyed, or would conduct future surveys, for paleontological resources to lessen the chance they would be impacted by treatment activities. Thus, there would be a negligible cumulative loss of paleontological material on public lands due to vegetation treatment methods under all alternatives.

Cultural Resources and Traditional Lifeway Values

Cultural resources, including archaeological and historic sites and materials as well as traditional cultural properties, have a very limited ability to absorb cumulative impacts. Cultural resources, which are non-renewable resources, risk being destroyed by erosion, construction, excavation, data collection, and looting, or through the removal of artifacts from their surrounding contexts, movement of the material such that it loses context, or the removal or re-deposition of artifacts and their surrounding context to another location. Cultural properties, including camps, cabins, hunting and fishing sites, graves, and areas of particular religious or traditional importance, lose their integrity, and thus their potential eligibility for the National Register of Historic Places, when they become degraded as a result of natural or human disturbance processes, or when the people who value these places can no longer access them, thus losing their cultural connection to the site over time.

Past Effects and Their Accumulation. Prior to European settlement, Native American and Alaska Native tools, pottery, artwork, religious artifacts, and other cultural resources were subject only to the effects of the natural environment, such as the forming, deforming, and destroying of resources and sites, and the effects of human activity, such as Native people reusing found objects and materials. Later, as Europeans settled in North America, settlers collected, harmed, or destroyed cultural resources and sites and displaced Native peoples. Under the influence of inspired leaders, however, traditional Native cultures have survived (Garbarino and Sasso 1994, Zimmerman and Molyneaux 1996).

As settlement continued in the West, more lands were developed and additional cultural resources were destroyed, taken, or lost. On public lands in the western U.S., grazing, timber removal, and mineral extraction were activities that likely caused the greatest loss of cultural materials due to land disturbance, especially until the 1960s with the passage of National Historic Preservation Act (1966) and NEPA (1969).

Historically, Alaska Natives were geographically widespread and technologically capable people who lived in dispersed, small communities based on family and social connections (USDI BLM 2005e). Life in the northern subarctic revolved around the caribou, or reindeer, while the Inuit and Aleut hunted waterfowl, marine mammals, including whales, and fish. Alaska Natives had intermittent contact with Russian, American, British, and Norwegian traders, explorers, missionaries, and government representatives in the early 1800s. This contact intensified when commercial whaling north of the Bering Strait began in the 1850s. Activities which have had the greatest affect on cultural resources in Alaska, and particularly in public lands along the Arctic Coast, are most likely linked to both oil development and military activity, given that public lands on the Arctic North Slope were designated as a Naval Petroleum Reserve in 1920. Alaska also was a theatre of war during World War II, and remnants of military bases and other Cold War-related facilities remain today and are considered historic resources.

The inadvertent loss of cultural materials was slowed by the passage of the National Historic Preservation Act and NEPA (1969), which mandated the identification of cultural resources potentially affected by developments and mitigation of the impacts. In addition, these developments resulted in the discovery of many previously undocumented cultural resources. The Archaeological Resources Protection Act of 1979 added additional protections for cultural resources on public or Native-owned lands. In addition, the Native American Graves Protection and Repatriation Act of 1990 provided protection for Native human remains, sacred objects, and associated funerary objects on federal and Native-owned lands.

Future Effects and Their Accumulation. Cultural resources are distributed unevenly across the western states and Alaska. Areas with high probabilities of prehistoric and historic use are generally predictable, but specific subsurface cultural resources are often unknown until some sort of disturbance occurs, making it difficult to assess the cumulative impacts to cultural resources. The more surface and subsurface disturbance that occurs, the larger the area affected and the greater the possibility that cultural resources will be impacted. Because of their surface or near-surface stratigraphic contexts, cultural resources are not well protected by soil and vegetation, and are vulnerable to any surface or subsurface-disturbing activity.

The buildup of hazardous fuels and spread of noxious weeds and other invasive vegetation have increased the risk of wildfire and displacement of plants and animals that are important to Native peoples for their traditional lifeway values. Although fire is being reintroduced to undeveloped areas in the West that were historically burned by Native peoples to maintain early successional plant species and improve habitat for game species, natural disturbance regimes have not been restored over much of the West and encroachment by nonnative species into natural ecosystems continues, to the detriment of many native species of importance to Native peoples.

Resource extraction, livestock grazing, motorized recreation, and other land disturbing activities would increase the potential of impacting cultural resources. However, federal regulations and management policies are likely to remain in effect that require the identification of cultural resources and mitigation of impacts prior to most ground-disturbing activities, including those associated with vegetation treatments. An increase in the number of acres treated to restore native vegetation and natural fire regimes, and to promote ecosystem health could have short-term impacts on access to traditional resources by Native peoples. For example, herbicide or fire use treatments could prohibit use of traditional areas by Native peoples until areas were safe to enter and resources were suitable for use.

Contribution of Alternatives to Cumulative Effects. As with paleontological resources, the potential for cumulative impacts to cultural resources from the use of herbicides and other treatment methods would be least under the No Action Alternative and greatest under the Preferred Alternative, based on the number of acres that would be impacted by ground-disturbing activities. Other treatment alternatives would be intermediate between these two. Most ground-based equipment would disturb only the upper few inches of soil, and in many cases, would be confined to existing disturbed areas such as roadways, trails, and ROWs. Cultural resources on the surface should be discovered during pretreatment surveys. All treatment methods could cause indirect loss of cultural resources as a result of erosion and soil disturbance, but these effects should be minimal. Potential effects would be further reduced because the BLM has inventoried, or would conduct inventories, for cultural resources in treatment areas to lessen the chance that they would be impacted by BLM vegetation treatment activities. Thus, there should be a negligible cumulative loss of cultural resources on public lands due to herbicide and other vegetation treatment methods under all alternatives.

Based on number of acres treated using herbicide and non-herbicide treatment methods, short-term impacts to vegetation, and habitats used by fish and wildlife, important to Native peoples would be greatest under the Preferred Alternative and least under the No Action Alternative. However, as the long-term objective of treatments is to restore native plant communities and habitats, including those of traditional importance to Native peoples, the greatest benefits should accrue under the Preferred Alternative. In addition, as the herbicides proposed for use by the BLM are less harmful to non-target vegetation, fish and wildlife, and humans than most currently-available herbicides used by the BLM, and any future herbicides used by the BLM would also likely have low risk. The Preferred Alternative and Alternative D should have fewer cumulative impacts than the other herbicide-use alternatives.

As long as surveys and inventories were completed prior to vegetation treatments in areas that are likely to have cultural resources and lifeway values, the effects on those resources would be minimized. The accidental discovery or damage to sites, presently known or unknown, would damage those sites to some extent, but would also require measures to recover or record the remaining material, adding that information to the archaeological record.

The National Historic Preservation Act requires federal agencies to take into account the effects of a proposed action on properties included in, or eligible, for the National Register of Historic Places (also known as historic properties) before approving or funding the action. The Act also requires federal agencies to complete a cultural resources survey prior to any federal action and ground-disturbing activities that occur on federal lands, and in some cases on private land if there is a clear link between the activity on federal lands and private lands. This is most relevant to cooperative projects involving federal agencies and private landowners to reduce hazardous fuels or invasive species on commingled land jurisdictions, and ensures the protection of cultural resources goes beyond just the federal component. The BLM's guidelines and policies require that all effects to identified historic properties and other cultural resources identified during surveys must be mitigated to the satisfaction of the land manager and the State Historic Preservation Officer.

Standard operating procedures and agency guidance as identified in manuals and handbooks (see Table 2-6 of the PEIS and Table 2-4 of the PER) would reduce the likelihood of impacts to cultural resources.

Visual Resources

Humans have had a profound effect on landscapes across the western U.S. and Alaska. While much of Alaska is still primarily a natural landscape with scenic qualities that have not substantially changed by humans, changes to the landscape in the lower 48 states have been substantial (USDA Forest Service and USDI BLM 1997; USDI BLM 2005e). Much of this change reflects past land management goals that focused on resource allocation, as commodity production took precedence over custodial protection of land. Since the 1970s, however, concern for ecosystem conditions has gained importance and is reflected in a greater effort by federal, state, tribal and other land stewards to restore ecosystems to near historic conditions. The objective of these efforts is to provide continued, predictable flows of resources, including visual resources, that contribute to both traditional and current human demands and values (USDA Forest Service and USDI BLM 1997).

Past Effects and Their Accumulation

Scenic quality, a measure of the visual appeal of the land, is rated based on landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. Sensitivity levels, which are measures of public concern for scenic quality, consider the types of users of the area, the amount of use, public interest in the area, adjacent land uses, and whether the area is classified as a special area. As landscapes are modified by human factors, impacts to scenic quality occur and visual effects may accumulate on a particular landscape based on levels of activity and degree of modification. For example, an area of high mining interest may display modified landscapes in form and color due to waste dumps, open pits and other facilities. Efforts to mitigate these effects by designing waste dumps to mimic landforms and rehabilitation with vegetation cover often reduce these effects concurrently and over time to a point the modifications may be substantially unnoticeable in the long term. Contrary to the some common perceptions, lands in the western U.S. were not pristine wilderness prior to settlement by non-Indian emigrants, but ecological systems in which humans had been an active component. American Indians used fire as a tool to manage vegetation to provide better forage for game animals, to encourage growth of plants used for food, and in ceremonial events (USDA Forest Service and USDI BLM 1997). As European settlers moved into the West, impacts to the natural landscape accelerated. With population growth came an increase in extraction of minerals and other resources, agriculture, road construction, urbanization, and similar types of development that have the potential to adversely impact the visual qualities of the landscape. In addition, timber harvesting and livestock grazing, the introduction of exotic species, and the exclusion of fire have resulted in substantial changes to the landscape, succession and disturbance regimes, and associated vegetation composition, structure, and pattern.

The systematic exclusion of fire from western ecosystems began in the early 1900s to reduce the threats to lives, property, and timber from fire. The result over time was a change from seral, fire-adapted species to more fire-susceptible species that often formed dense, unhealthy stands that were subject to large-scale fires and disease outbreaks. Dead and dying trees from insect infestations, and browned and blackened areas from wildland fire, have become common visual characteristics of western landscapes during the last several decades. Where human activities and wildland fire have disturbed the land, weeds and other unwanted invasive species have taken over and dominated landscapes (USDA Forest Service and USDI BLM 1997). It is estimated that downy brome alone covers over 11 million acres in the West, and that leafy spurge covers 3 million acres (Lajeuness et al. 1998). In other cases, some invasives species spread into pristine areas independently of human activities or wildland fire due to competition and adaptability. Regardless of the cause, anthropogenic or by natural processes, these species may provide seasonal visual contrast to native vegetation, particularly downy brome during summer and fall when it turns brown and dies while most native plant species are still green. In other cases, when some invasive plant species flower (e.g. purple loosestrife, leafy spurge), they provide scenic contrast to a landscape and may seasonally enhance the scenic qualities of an area.

Livestock grazing has also had a visual impact on the landscape of public lands. Historically, a wide variety of ungulates grazed and browsed throughout the West. These animals were wide ranging and their foraging patterns were closely aligned with the plant phenology. Cattle and sheep were introduced in large numbers to the West during the 1800s, and by the late 1800s and early 1900s cover of native grasses was substantially modified by extensive grazing. As a result of the many human activities that have occurred on public lands, changes to disturbance regimes, and other land disturbances, 66% of public and forest lands are substantially modified from historic patterns (USDA Forest Service and USDI BLM 1997).

Several initiatives that have begun in recent years to benefit public lands and their visual characteristics include Range Reform, the National Landscape Conservation System, Great Basin Restoration Initiative, Sage-grouse Habitat Conservation Strategy, and the Prairie Grasslands Conservation Initiative. In addition, Congress has acted positively in the past with the passage of the Taylor Grazing Act, Wilderness Act, Wild and Scenic Rivers Act, Federal Land Management and Policy Act, Public Rangelands Improvement Act, and Wild and Free Roaming Horse and Burros Act, to ensure that public lands and their uses are balanced, conserved, and protected. All of these statutes and initiatives are designed to bring improved management to critical natural systems under the BLM's jurisdiction and to address conservation at the landscape level and will lead to improved visual characteristics on public lands.

Future Effects and Their Accumulation

The proposed vegetation treatments would affect visual resources by changing the scenic quality of the landscape. Vegetation treatments would kill or harm vegetation in the applied area, resulting in a more open, browned or blackened landscape until new plants were to grow in the area. Treatment areas would vary in terms of their visual appeal prior to treatment and their distance from human activity, as well as in terms of the resulting public sensitivity to the pre- and post-treatment visual character of the area. The effects of vegetation treatments on the visual quality of the landscape would be most notable to travelers, sightseers, and residents for the first year to several years following treatment, particularly in treated areas located near major roads or residential areas.

The BLM's treatment program would focus on near-term vegetation management to improve the likelihood of moving toward or maintaining ecosystem processes that function properly in the long term (50 to 100 years or more from now) and require less treatment in the future to maintain. Through long-term passive management to reduce disturbance factors (e.g., limitations on OHVs, reduction in grazing activity), and active management of forestlands and rangelands (e.g., use of fire, weed removal), landscapes that have been degraded in the past will gradually restore to a mosaic of plant community types that are more diverse and visually appealing.

In its *2001 Annual Performance Plan* (USDI BLM 2000), the BLM committed to the following activities that would restore the health and enhance the visual qualities of public lands:

- Clean up abandoned mine and hazardous waste sites.
- Implement water quality improvement prescriptions on public lands in 20% of watersheds within priority sub-basins that do not meet state/tribal water quality standards.
- Achieve proper functioning condition or an upward trend in wetland/riparian areas in 80% of priority watersheds by cooperating with the Forest Service and other land management agencies to restore degraded wetland and riparian areas.
- Achieve an upward trend in the condition of uplands within 50% of priority watersheds by reducing the spread of weeds and reintroducing fire into specific landscapes.

Based on a 2005 Office of Management and Budget (OMB) Program Assessment Rating Tool, the BLM had met or was making measurable progress toward meeting these goals. The OMB assessment did note that the BLM was challenged by the need to meet multiple land use objectives, such as allowing oil and gas development that may conflict with restoration objectives (Office of Management and Budget 2005).

In addition, the BLM will continue to pursue initiatives and planning efforts to preserve and protect intact landscapes and restore degraded lands. In addition to the initiatives listed above, the BLM, through land use planning, provides support to the National Landscape Conservation System; Congressionally-designated National Conservation Areas and Monuments; and wilderness and special areas, including Areas of Critical Environmental Concern by identifying appropriate goals, objectives, and management actions, with public input, to preserve and conserve special public land values.

Other federal, state, tribal, and local agencies, and private conservation groups have also increased their commitment toward improving land health, and therefore, the visual characteristics of lands in the western U.S., including Alaska. Their ability to improve land health will depend on future funding and competing demands on land resources. Given the population growth in the western U.S., and the need to provide food and other resource commodities, visual impacts to lands in the western U.S. will continue to accumulate over the long term. At the same time, continual implementation of Congressional and administrative policies towards resource conservation and enhancement will provide some countervailing effect to these long term changes.

Contribution of Treatment Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to the visual qualities of public lands would be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and the effects to visual resources, would be similar under Alternatives D and E. Effects to these resources under Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects from treatments and other human causes would accumulate, but be off-set in the long-term through the countervailing effect of treatment success and long-term improvement in the health and visual characteristics of the land.

The risks to non-target vegetation from use of herbicides could be less under Alternative E than under the other herbicide use alternatives because ALS-inhibiting herbicides would not be used under Alternative E. ALS-inhibiting herbicides are effective at very low doses and any drift onto non-target vegetation could temporarily and locally degrade the visual qualities of the affected area.

Regardless of the alternative chosen, there would be an accumulation of loss of visual resources. Longer term, these resources should improve and slow the cumulative loss.

Wilderness and Special Areas

The toughest challenge facing the BLM and other federal wilderness land stewards is to keep wilderness wild, and (as stated in the Wilderness Act of 1964) "affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable" (Hendee and Dawson 2002). The invasion of wilderness ecosystems by noxious weeds and other nonnative plant species is of great risk to wilderness. Some species have been introduced to wilderness areas by pack stock, or livestock that are specifically brought into wilderness areas, or wild horses and burros that may travel in and out of wilderness areas. Native migratory wildlife, in particular birds, can also be vectors for spreading nonnative seeds on their fur, or in their droppings as they migrate through wilderness. Hikers may also bring in weed seeds on their clothing. In addition, efforts to control and remove invasive species can sometimes cause additional changes beyond restoring the preexisting "wild" conditions.

Past Effects and Their Accumulation

There are numerous threats to wilderness and special areas. These include: 1) exotic and nonnative species; 2) wildland fire suppression; 3) loss of water and deterioration in water quality; 4) fragmentation and isolation of wilderness as ecological islands; 5) loss of threatened and endangered species; 6) deterioration in air quality; 7) livestock grazing; 8) motorized and mechanical equipment trespass and use; 9) increasing commercial and public recreation use; 10) adjacent land uses; and 11) urbanization and encroachment. Wilderness and special areas comprise about 4% of lands in the U.S. As wilderness and special areas often represent the last remaining pieces of many ecosystems, wild conditions, and natural landscapes that have either disappeared or have been altered, these threats could have a profound effect on the values of wilderness and special area values now and in the future (Hendee and Dawson 2002). Loss of wilderness values associated with these threats has accumulated in the past and will continue to do so into the future.

Vegetation treatments primarily would address threats 1 through 6. Exotic and nonnative species are a direct threat to wilderness. Noxious weeds often outcompete native species and spread rapidly, altering native ecosystems to the detriment of wilderness. Secondary impacts can then result from control efforts, such as mechanical methods and fire use. Although treatments are usually implemented with the intent of restoring native conditions, sometimes management actions cause other perturbations to the ecosystem.

Fire prevention and suppression are altering the natural fire frequency of fire dependant ecosystems, leading to changes in ecosystem function and structure. As discussed in Vegetation, fire suppression has led to an accumulation of fuel loads, as well as forest stands dominated by dense concentrations of shade-tolerant trees, that contribute to larger and more intense wildfires. The use of fire and other treatment methods to reduce hazardous fuels and the risk of wildfire should improve ecosystem function on public lands. However, benefits to wilderness and special areas may be minimal because treatments are primarily targeted toward the WUI and priority watersheds, rather than toward wilderness and special areas. In addition, the public is often not receptive to the "let burn" approach and use of fire and other treatments (especially mechanical) in these areas because they disturb the sense of solitude and wilderness.

Water resources in wilderness and special areas are threatened. In some cases, water storage facilities in wilderness and special areas that were built before passage of the Wilderness Act continue to be used today. The quality of water in some wilderness streams may be affected by runoff from grazed areas and other pollutant sources within and outside of wilderness and special areas.

Because of their small size (42% of all wilderness areas in the U.S. are 10,000 to 50,000 acres, and the average size of wilderness areas administered by the BLM is 42,000 acres), most wilderness areas are ecological "islands" that are vulnerable to outside influences. A large fire or infestation of weeds can substantially alter the characteristics of wilderness. Without connectivity to other wilderness areas, it is often impossible for low-mobility species, species with narrow habitat requirements, or species with large home ranges to find enough habitat within the wilderness to survive, or to survive a major fire or other threat to survival.

Polluted air is a threat to wilderness and special areas because of its physical and biological impacts and its accompanying reduced visibility. The wilderness experience can be greatly diminished for visitors to wilderness areas near urban sources of air pollution. Treatments involving the use of fire in wilderness areas would contribute to these impacts.

The remaining threats listed can affect wilderness when they weaken the natural conditions, processes, and variability that were historically part of a wilderness or special area. Most of these threats will increase over time, and their impacts to wilderness resources and values will accumulate.

Future Effects and Their Accumulation

Vegetation treatments would be most effective in reducing threats to wilderness and special areas from 1) exotic and nonnative species 2) wildland fire suppression; 3) water quality; 4) fragmentation and isolation of wilderness as ecological islands; 5) loss of threatened and endangered species; and 6) air quality.

The goal of wilderness fire management would be to restore fire to its natural role in the wilderness ecosystem. Although benefits would accrue from fire management—reduce hazardous fuels, improve wildlife habitat, and create a mosaic of vegetation types—the intent of management would be to restore naturalness. In larger wildernesses, land managers also aim to try and perpetuate landscapes and landscape processes. However, there are limits to fire management. As mentioned earlier, fires can impact regional air quality, escape from within the wilderness and threaten people and property, and alter habitat to the detriment of threatened and endangered species. Mechanical and manual treatments can disturb solitude, while chemical treatments can affect plant, animal, and human health and impact the wildness of an area.

In wilderness and special areas, where noxious weeds and other invasive species are limited to small areas, it may be possible to control weed infestations with minimal tools. Introducing and establishing competitive plants is also needed to for successful management of weed infestations and the restoration of desirable plant communities (Jacobs et al. 1999). The degree of benefit would depend on the success of these treatments over both the short and long term. Successful management would also require knowledge of the source of weeds and implementation of controls to minimize future spread of weeds onto wilderness and special areas.

Increasing recreational use of wilderness and special areas, which is projected to occur in the 21st century, will put greater pressure on wilderness ecosystems, resources, and values, especially in areas located near major population centers. The BLM, Forest Service, and other federal land management agencies with wilderness protection responsibilities work closely to protect and enhance wilderness values. However, disturbances outside of wilderness boundaries, including urbanization and agriculture, could further isolate some wilderness areas. Approximately 86% of wilderness acres administered by the BLM are achieving wilderness character as specified by statute, and about 73% of wilderness study areas are meeting their heritage resource objectives (USDI BLM 2005c). Although impacts to wilderness areas from altered fire regimes and spread of weeds should slow as treatments restore ecosystems and historic fire regimes, loss of wilderness values may be inevitable from other threats identified above which are outside of the agency's control and would continue to accumulate over the long-term.

Contribution of Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to the wilderness and special areas should be greatest under the Preferred Alternative, and least under the No Action Alternative. The number of acres treated, and the effects to wilderness and special areas, would be similar under Alternatives D and E. Effects to these resources under Alternative C would be intermediate between these alternatives and the Preferred Alternative. Short-term effects from treatments and other human causes would accumulate, however, a countervailing effect of long-term improvement in the function of wilderness and special areas from successful treatments would offset short-term losses.

Several components of Alternative E pertain to wilderness and special areas (see Appendix G of the PEIS). As discussed in the other resource sections, fewer acres would be treated under this alternative than under the other treatment alternatives. While fewer negative and positive impacts would be likely than under the other alternatives, an increased emphasis on ecosystem-based management techniques under Alternative E would tend to decrease the short-term negative benefits and possibly increase the long-term positive benefits associated with this alternative.

Under Alternative E, except for treatment of small infestations without motorized equipment, treatments would be prescribed within designated wilderness or wilderness study areas only after the spread of invasive species from outside these areas was effectively halted. Under the other treatment alternatives, however, actions could be taken to control invasive species within wilderness and special areas before control over invasive species populations outside special areas. The BLM policy is to treat infestations where they are found and to prevent their further spread. By not treating an infestation in a wilderness or other special area until the larger invasive species problem outside of the area is addressed, invasive species populations within wilderness and special areas could grow beyond an effectively treatable level.

The five herbicides (chlorsulfuron, imazapic, imazapyr, metsulfuron methyl, and sulfometuron methyl) that would not be approved under this alternative are some of the least risky herbicides with respect to human health (see Human Health and Safety section). In addition, the ERAs predicted no risk to fish and terrestrial wildlife from most of these herbicides (chlorsulfuron, imazapic, sulfometuron methyl), and a few cases of low risk (imazapyr, metsulfuron methyl), suggesting that the elimination of these herbicides would not likely benefit wildlife and could indirectly harm wildlife in wilderness and special areas if more toxic herbicides were used in their place (see Wildlife Resources section). The other herbicides proposed for use by the BLM pose risks to non-target species that are similar to those associated with these five herbicides; therefore, it is uncertain whether this use restriction would actually reduce risk to non-target plants. Thus, avoidance of ALS-inhibiting herbicides might provide few, if any, benefits to wilderness and special areas and special area users.

Regardless of the alternative chosen, there would be an accumulation of loss of wilderness values and other special area values. Over the long term, these values should improve and slow any cumulative loss from other threats.

Recreation

The BLM's long-term goal for recreation is to provide opportunities to the public for environmentally responsible recreation. Public lands host over 68 million visitors annually. Over 4,000 communities with a combined population of 23 million people are located within 25 miles of public lands. Although much of the focus of the recreation program is on providing visitor services, the BLM's most daunting challenge is to manage travel on public lands. Technological advances in modes of transportation, coupled with the explosion of growth of this activity, have created a management challenge to meet these needs while protecting land resources (USDI BLM 2005c). As identified during scoping, the public recognizes the potential for travel access routes to spread weeds and for off-road travel activities to degrade land, leading to conditions that favor the establishment and spread of weeds and other unwanted vegetation.

Cumulative effects to recreational resources would result from past and future activities that have long-term effects on solitude, naturalness, or primitive/unconfined recreation. Short-term or transient loss of an area's naturalness and solitude from such impacts as temporary roads and noise from equipment would not be cumulative. Therefore, their contribution to the cumulative impacts would be "momentary."

Past Effects and Their Accumulation

Although the BLM showed interest in recreational activities on public lands in the 1940s and 1950s, it was not until 1961 that the BLM developed a recreation management handbook, and not until 1963 that the agency began an inventory to identify recreation sites and facilities (Muhn and Stewart 1988). Between 1963 and 1968, the number of recreational visits to public lands more than tripled, and over the next decade visits nearly doubled to about 50 million visitors annually.

With population growth in the western U.S. came an increase in extraction of mineral and other resources, agriculture, road construction, urbanization, and similar types of development, which have altered western landscapes and reduced the amount of land available for recreation. Timber harvesting and livestock grazing, the introduction of exotic species, and the exclusion of fire have also resulted in substantial changes to the landscape, succession and disturbance regimes, and associated vegetation composition, structure, and pattern that have impacted the quality of the recreation experience (USDA Forest Service and USDI BLM 1997). The effects of OHV loss on soil and vegetation were first brought to public attention in the late 1960s in the California deserts, and eventually led to the development of a management program for OHV use on public lands and establishment of the Imperial Sand Dunes National Recreation Lands (Muhn and Stewart 1988). OHV and other travel-related activities continue to present challenges for land managers.

Wildfires and the spread of weeds have led to the cumulative loss of recreational resources, although these losses are not irreversible. Wildfires are capable of causing substantial damage to large areas of recreational resources and require long periods of time for recovery. During the recent wildfires that swept through the Great Basin, not only were traditional recreation activities affected, but some special events were altered or cancelled. Signs were destroyed, hiking and camping areas burned over, wildlife and game displaced, and the scenery in the Great Basin marred (USDI BLM 1999). Noxious weeds and other invasive vegetation adversely impact the scenic and recreational qualities of public lands. They displace native vegetation to the detriment of fish and wildlife sought by wildlife viewers, hunters, and fishermen. Given the increase in the number and magnitude of wildfires during the past decade, and a weed population that grows by 1,000 acres a day on public lands, losses of recreational opportunities continue to accumulate (USDI BLM 2005c).

In recent years, several initiatives have been introduced to provide additional recreation opportunities, and including the National Landscape Conservation System, Great Basin Restoration Initiative, Sage-grouse Habitat Conservation Strategy, and the Prairie Grasslands Conservation Initiative. All of these initiatives are designed to bring improved management to critical natural systems under the BLM's jurisdiction and to address conservation at the landscape level. Continued implementation of these initiatives will lead to improved recreational opportunities on public lands.

Future Effects and Their Accumulation

As urbanization of the West continues and the American public's desire to recreate increases, public land recreation areas will experience greater usage. Although the satisfaction rating of visitors to public lands is presently 94%, increased usage will inevitably increase the expectations of the public regarding the quality of their recreation experience (USDI BLM 2005c). The trend towards greater limits on public access to privately-held forestlands and hunting and fishing lands, due to concerns by landowners over public safety, litigation, vandalism, and damage to natural resources and commodity products (e.g., timber) produced on these lands, will put additional pressure on public lands to meet the recreational needs of Americans.

Vegetation treatments would have short-term cumulative effects. There would be some scenic degradation, as well as distractions to users (e.g., noise from machinery), from treatments. In addition, there would be some human health risks to recreationists associated with exposure to herbicides or smoke from fire. Some areas would be off-limits to recreation activities as a result of treatments, for periods ranging from a few hours to days, or even one full growing season or longer, depending on the treatment. In most cases, recreationists would be able to find alternative sites offering the same amenities or experiences, although a lessened experience could result from more concentrated use in these alternative sites. The effects of herbicide treatments and fire use on fish and wildlife could have indirect negative impacts on recreational activities such as fishing, hunting, and wildlife viewing. For example, aerial application of an herbicide over a large area could adversely affect these types of recreation activities by harming or displacing fish and wildlife species. Vegetation treatments could also impact scenic views, particularly those located next to roads, or fire treatments that produce smoke. The effects of vegetation management on the visual quality of the landscape are discussed further in Visual Resources.

The BLM's treatment program would focus on near-term vegetation management to improve the likelihood of moving toward or maintaining properly functioning ecosystems in the long term (50 to 100 years or more from now). Through passive management to reduce disturbance factors (e.g., closure of roads, reduction in grazing activity), and active management of forestlands and rangelands (e.g., use of fire, weed removal), the BLM hopes to restore a mosaic of plant community types that are more diverse and visually appealing than those in lands that are not functioning properly. Vegetation treatments that reduce hazardous fuels, restore natural fire regimes, and control weeds and other invasive vegetation would slow the loss of recreational opportunities and the reduction in quality of the recreation experience. In addition, treatments that reduce the risk of wildfire would reduce the likelihood of recreationists being displaced from their favorite hunting, fishing, and camping sites by wildfires. Treatments in public use facilities (e.g., campgrounds, visitor centers) could have short-term impacts, but would enhance the visitor experience and ensure continued high-satisfaction ratings from visitors long term.

Contribution of Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to recreation resources on public lands would be greatest under the Preferred Alternative, and least under the No Action Alternative. However, based on visitor use days, the number of visitors to public lands in those states where the majority of treatments would take place as a percentage of all visitors to public lands is small in relation to the number of acres treated in those states (USDI BLM 2005d), suggesting that effects to recreationists could be less than expected based on treatment acreage.

Alternative E places greater emphasis on passive restoration than the other alternatives. Passive restoration is often a critical first step in successful restoration of degraded areas since anthropogenic activities that are causing degradation or preventing recovery are halted. OHVs are often cited as a factor contributing to loss of resource function and degradation of scenic quality. By controlling OHV use, improvement in recreational values can be expected (Kauffman et al. 1997). However, the BLM would have to balance resource protection with the multiple use requirements under FLPMA. As discussed in Chapter 2 of the PER, Vegetation Treatment Programs, Policies, and Methods, passive restoration would be considered when developing restoration management plans, and would be used to the extent possible within the constraints of FLPMA.

Regardless of the alternative chosen, there would be an accumulation of loss of recreation resources. Longer term, these resources should improve and slow the cumulative loss.

Social and Economic Values

The western U.S., including Alaska, is more sparsely populated than the rest of the U.S., containing about 32% of the total U.S. population, but comprising approximately 65% of the total land area. However, population growth between 1990 and 2000 averaged over 16%, which was slightly higher than the national average. Many of the western states exceeded the national average, with growth rates of 20% or higher during this time period.

The western U.S. contains a large percentage of the nation's minority populations, including over 60% of the nation's Hispanics and American Indians, and over 50% of the nation's Asian/Pacific Islanders. In particular, Arizona, California, New Mexico, and Texas contain large Hispanic populations, which comprise from 25% to over 40% of the total population in each of these states. Over 15% of Alaska's population is comprised of Alaska Natives. Federal agencies must also be cognizant of the needs of these peoples when formulating management decisions. Executive Order 12898, Environmental Justice, requires that federal agencies address the environmental justice of their actions on minority populations and on low-income populations.

Population growth can stimulate economic growth and provide economic diversification. However, development for a growing population is encroaching on previously undeveloped areas near public lands. Growth also increases demands on public lands for timber, minerals, livestock grazing, and other commodities, and for recreation and roads. Because public lands and open space are an important component of the western landscape, they are valued by westerners, who expect the BLM to manage public lands to ensure their protection and enhancement. These conflicting demands can make it challenging for BLM land managers to meet the multiple need requirements under FLPMA, while still preserving the natural characteristics of the landscape.

Agency social and economic policy has long emphasized the goal of supporting rural and tribal communities by promoting the continued production of goods and services from public lands for those communities deemed dependent upon timber harvest and processing, mineral extraction, and livestock forage. In addition, the BLM promotes the use of services provided by communities in support of BLM management activities (e.g., firefighting and herbicide applications; USDA Forest Service and USDI BLM 2000, USDI BLM 2005c).

Past Effects and Their Accumulation

Population. Population growth rates in much of the West exceed those of the rest of the country. Nevada, Arizona, Idaho, and Utah have been among the fastest growing states in the U.S. in recent years; between 1970 and 2000, Nevada's population grew 309% while the rest of the country grew only 38%. This growth has placed increasing demands on public lands and other open spaces for recreation, and to provide the natural resources needed to support growth in this region and in the world.

Population growth has been highest in the WUI. The increasing population migration to rural areas with a high quality of life is expected to continue as our country moves toward a more service-based economy (USDA Forest Service and USDI BLM 2000). Growth in the WUI, however, has increased the risk of wildfire to people and property, and has impacted fish and wildlife habitat use and movements among public lands, rural areas, and the WUI.

Environmental Justice. The western U.S. contains a large percentage of the nation's minority populations. These populations use public lands, and Native Americans and Alaska Natives depend upon public lands for food and other traditional lifeway values. Large numbers of individuals also derive work from public lands in the forestry, mining, oil and gas, and service sectors. Native American, Alaska Native, and Hispanic populations increased at 2 to 4 times the rate of growth of the population as a whole during the past decade, suggesting that ever greater numbers of minorities use public lands for pleasure and work and have been affected by vegetation treatment and other activities.

Employment and Income. Over 23% of the nation's employment opportunities, amounting to over 40 million jobs, are located in the western U.S. (Table 3-17). Employment in the trade and services industries accounts for over half of the total jobs. Industries related to natural resources, such as agriculture and mining, are important sources of employment and represent nearly one third of the nation's agricultural services, forestry, and fishing jobs. Recreation and tourism associated with public lands provide many jobs and are accounted for in the services sector. Changing federal land uses have affected the number and types of jobs associated with public and other federal lands. For example, jobs associated with the timber industry have declined as the amount of timber harvested on federal lands has declined in recent years, while recreation employment has increased. In addition, some industries, including timber harvesting and wood products manufacturing, and mining, have become more mechanized, reducing employment opportunities over time. Vegetation treatments have likely had minimal impact on employment and income in the West. However, increased federal budgets for wildland fire suppression and to restore natural fire regimes have increased employment and income in communities that have supported these efforts.

Perceptions and Values. Survey research shows differences in the opinions of residents of small, rural towns and residents of larger urban areas. Residents of urban areas tend to more concerned about environmental protection, be less sympathetic to local economic impacts, and have greater trust in the federal government and environmental organizations than do residents of rural areas (Harris and Associated 1995 *cited in* USDA Forest Service and USDI BLM 2000). Rural residents want less government intrusion into their lives, and believe that current government policies tend to favor the environment too much over jobs. Rural residents seek a balance between the environment and jobs, enjoying the open spaces and clean air and water that public and other federal lands provide, while still wanting jobs so that they and their children will be able to remain in the community. In recent decades, federal land management policies have discouraged employment in some sectors (e.g., forestry), while promoting employment in others (e.g., oil and gas and other mineral exploration and development). However, some of the values that rural westerners associated with public lands, including clean air and native vegetation, have been lost or degraded by the increase in number and severity of wildfires and spread of noxious weeds and other invasive vegetation.

Revenues. Mineral leases, recreation and grazing fees, and sale of timber are important sources of revenue to the federal government, although the contribution of each to the U.S. Treasury fluctuates in response to the national and global economy and national and local policies. For example, the amount of revenue collected from mineral leases and permits and recreation fees in FY 2004 was about 4 times that of 1996, which reflected national energy policies, higher energy prices, and increases in the recreating population. In contrast, in 2004 timber sale revenues were 4 times less, and grazing fee collections were about 15% less, than in 1996. Timber sale reductions reflect policies that have discouraged timber harvesting on federal lands in response to concerns over the loss of forest wildlife, including the northern spotted owl, and forest habitat, including mature and old-growth forests. Livestock use reductions reflect continuing resource damage and implementation of protections for federally-listed plant and animal species (USDA Forest Service and USDI BLM 2000).

Expenditures. The BLM makes payments to counties to compensate them for the non-taxable status of federal lands in their jurisdiction. Generally, there is a per acre payment associated with the county population, (payments in lieu of taxes, or PILT) and an additional revenue-sharing payment based on revenues received from the sale of timber, grazing fees, recreation fees, special use permits, and other uses. There is concern in counties over the potential loss of revenue if changes in federal land uses cause a decline in timber harvest or other resource revenue. However, since 1996, payments have doubled, with the largest gains seen in states with an active mining and oil and gas industry (e.g., Alaska and Nevada).

Effects on Private Property. The value of rural property has increased in recent years as the population has increased and more people are able to move to rural areas or buy second homes for recreation, retirement, or as investment property. In some areas, however, it is likely that recent wildfires have depressed home values, either because of the future risk of fire, or from land degradation associated with recent fires.

Future Effects and Their Accumulation

Population. None of the proposed treatment methods being analyzed is likely to cause substantive changes to existing patterns and trends in population or demographic conditions in the western states. In particular, it would be unlikely that vegetation treatment would either exacerbate or counteract the trend toward out-migration from small rural communities. Effects of growth upon the landscape would continue to accumulate.

Environmental Justice. As Hispanic, Native American, and Alaska Native populations grow, the likelihood of these groups using public lands is likely to increase. With increasing levels of treatment, the possibility that any significant effects associated with vegetation treatments that could disproportionately affect these minority populations increases. However, there are no data to suggest that there is any relationship between treatment areas and areas of low income or minority population because treatment areas are widely scattered across the landscape. The BLM is proposing to use new herbicides that are less harmful than many currently-available herbicides, and would likely use even safer herbicides in the future. This could reduce health risks to minority groups and to the general public on a per-acre basis.

Employment and Income. Based on an assessment done for the BLM and Forest Service for the Interior Columbia Basin, recreation and tourism associated with public lands are expected to show little change during the next decade (USDA Forest Service and USDI BLM 2000). If fuel prices remain high, fewer people may travel to public lands for recreation. Jobs associated with the timber industry could increase as more timber is harvested to restore natural fire regimes and reduce the risk of wildfire. Employment in mining and oil and gas industries would reflect the global economy. However, as much of the available and potential oil and gas and minerals in the U.S. are located on public lands, and the need for these resources is likely to continue to grow, these industries will continue to be important employers in the West.

Perceptions and Values. The treatment alternatives would be associated with a range of stakeholder perceptions and values. For example, individuals who have an aversion to chemical use in the environment could find all of the alternatives undesirable. Alternatively, individuals with a much greater concern about wildfires or the effects of invasive species would likely favor the most efficient means of attacking vegetation problems that could lead to catastrophic fires. As the number of acres treated could increase 3-fold from current levels, it is likely that both groups would be affected by treatments. Some westerners have philosophical issues with government ownership and management of large land areas, but they might be somewhat encouraged by plans to employ private contractors for some of the treatment work and would presumably favor the most efficient means possible to reduce fire risk to protect and maintain range productivity.

Revenues. Certain commercial activities that occur on public lands could be adversely affected by vegetation treatments in the short term, such as OHV tours or guide and outfitter operations. Vegetation treatments would not directly affect mineral resources and vegetation treatments would be unlikely to cause significant reductions in BLM revenues generated from mineral leases. Vegetation treatments to reduce fire risk in forested areas would serve to protect commercially valuable timber from loss through catastrophic fire. (USDA Forest Service and USDI BLM 2000).

Vegetation treatments could necessitate some site closures to grazing activities during treatments and for a suitable recovery period afterward, usually two growing seasons, both for effectiveness of the treatment and, for some methods, for safety of the livestock. Treatments that require temporary rest from grazing would result in a reduction in forage for livestock in that area, necessitating finding alternative forage sources on private or other lands which could lead to increased costs for the livestock operator while maintaining revenue. Livestock grazing activity in the Interior Columbia Basin on lands administered by the BLM and Forest Service is projected to decline about 1% annually to ensure protection of rangeland habitats and TES species. It is likely that alternatives sources of forage will become more scarce as population growth leads to greater use of private pasturelands for crop production and urban uses.

Recreation-based businesses such as outfitters, bait shops, OHV sales and repair shops, fish and hunting shops, and outdoor gear and equipment rental shops are direct beneficiaries of recreation use of public lands. Other services such as gas stations, restaurants, and hotels that are frequented by recreationists also benefit. Temporary closures of recreation areas due to treatments would reduce revenues from these sources. As discussed above, recreation activity on public lands is expected to remain near current levels over the next decade.

Expenditures. Vegetation treatments would require a large commitment of financial resources by the BLM, which would vary by treatment method, location, terrain and other factors. Using guidance from the Healthy Forests Initiative, the National Fire Plan, and the 10-Year Comprehensive Strategy Implementation Plan, the USDA and USDI are proposing to spend $757 million during FY 2006 for wildland fire management. Of this, nearly $500 million would be spent on hazardous fuels treatments, $27 million on land rehabilitation, and $14 million on forest health management (USDI BLM 2005c). In addition, funding to conduct additional vegetation treatments would come from other program budgets within both agencies for program-specific treatments. These benefits would accumulate in the communities where the funds were spent. Over $900 million was spent to control wildland fire during 2004 and based on modeling done for the cohesive strategy, even greater sums may be needed in the future to manage wildfire risk (Hunn et al. 2002; USDI BLM 2005c).

A major component of vegetation treatments as proposed under the National Fire Plan and 10-Year Comprehensive Strategy Implementation Plan is to promote community assistance. In FY 2004 alone, assistance with fuel hazard treatments, risk assessment plans, and other wildfire preparedness was given to over 14,000 communities by the USDA and USDI. The agencies also initiated approximately $140 million in contractual actions.

Effects on Private Property. Vegetation treatments could affect private property in the vicinity of public lands, particularly parcels adjacent to treatment areas. Over the short term, there would be minor risks for property damage associated with treatments because it is possible that some treatment effects would extend beyond BLM boundaries onto private property. Long term, treatments that reduce the risk of loss of property to wildfire and improve the scenic and recreational values of public lands should increase property values near public lands.

Contribution of Treatment Alternatives to Cumulative Effects

Based on the number of acres treated, short-term adverse impacts and long-term improvements to socioeconomic resources would be greatest under the Preferred Alternative, and least under the No Action Alternative. The other three alternatives would be intermediate between these two. However, the contribution of treatment actions to the economy of the western U.S. would be minor.

Human Health and Safety

When addressing cumulative impacts to human health and safety, the impacts to individuals conducting vegetation treatments, as well as the effects of these treatments (or lack of treatment) on the welfare of the public must be considered. In addition, it must also be acknowledged that vegetation treatments to improve ecosystem resilience and promote the welfare of the public are a cooperative effort among federal, tribal, state, and county land-management agencies, as well as other local and private cooperators. The bulk of the responsibility, however, falls upon the BLM and Forest Service because of the large amounts of public land they administer in the WUI. Finally, it must be taken into consideration that it will take many years before measurable results are achieved.

Past Effects and Their Accumulation

Risks to public health in areas in close proximity to public lands include risks from occupational injury and death, from exposure to industrial pollutants, including pesticides and herbicides, from cancer, and from wildfire.

Occupational Risks. In 2003, more than 29.2 million nonfatal injuries were reported in the United States. Some chronic injuries are directly linked to the nature of the work performed. For example, vibration syndrome affects a large proportion of workers using chippers, grinders, chainsaws, jackhammers, or other handheld power tools, causing blanching and reduced sensitivity in the fingers. Noise-induced hearing loss may also affect production workers who are exposed to noise levels of 80 decibels or more on a daily basis. Since 1992, the nonfatal injury rate has decline by about 34% (Centers for Disease Control and Prevention 2005).

The occupational fatality rate in 2003 was approximately 4.0 fatalities per 100,000 employed. The fatality rate for the agriculture, forestry, fishing, and hunting sector was the highest, at 31.2 fatal industries per 100,000 workers. The mining sector had the second highest rate, at 26.9 fatalities per 100,000 employed. The largest number of fatal work injuries resulted from transportation incidents, which accounting for 42% of workplace fatalities in 2003 (U.S. Department of Labor Bureau of Labor Statistics 2004b). In 1994, the occupational fatality rate was 5.3 per 100,000 employed. During the past decade, the trend in the fatality rate has steadily declined (Centers for Disease Control and Prevention 2005). Deindustrialization and greater emphasis on safety in the workplace are factors often cited as accounting for the downward trend in occupation injury risk in the U.S. (Loomis et al. 2003).

Only minor injuries have occurred to workers involved in vegetation treatment activities on public lands during the past decade. As discussed under Human Health and Safety in the PER, there are minor risks to workers from treating vegetation, primarily associated with the operation of heavy equipment and power tools, and the use of fire and herbicides. Workers would follow SOPs to minimize the risk of injury when treating vegetation, including using protective equipment, and using herbicides with low health risks to reduce the incidence of injury or harm in the workplace.

Cancer Risks. Based on the data shown in Table 3-25, cancer accounted for between 13 and 33% of all deaths in the treatment states in 2001. Nationwide, cancer accounts for approximately 23% of all fatalities (National Center for Health Statistics 2004). In the western U.S., cancer mortality rates are generally highest in counties in western and southern Nevada and northern California, and lowest in counties in Utah, central Colorado, and northern New Mexico (Devesa et al. 1999). Cancer rates increased during most of the 20th century, but began to decline in the 1990s for the leading causes of cancer (Wingo et al. 2005). Improved detection and treatment, along with healthier lifestyles, are believed to account for the declining rates.

Several herbicides used by the BLM could cause cancer in workers and the public based on exposure scenarios evaluated in HHRAs done for earlier EISs. These include 2,4-DP, asulam, atrazine, bromacil, and simazine (see Tables 4-31 and 4-32). With the exception of atrazine, cancer risks were only predicted for accidental exposure scenarios. In the case of atrazine, cancer risks were predicted for maximum and accidental exposure scenarios (USDI BLM 1991a). Except for bromacil, these chemicals have not been used by the BLM since at least 1997, and bromacil is used on less than 1% of acres treated using herbicides. Thus, it is unlikely that herbicide treatments on public lands have caused cancer in workers or the public.

Exposure to Pollutants. Exposure to industrial pollutants and toxic chemicals, including those produced by industries operating on public lands (e.g., mining, oil and gas), is a public health concern. The Toxics Release Inventory (TRI) is the principal source of data for analyzing the amount of toxic chemicals used in American industry. Although data for recent trends in toxic emissions are confusing due to differing data reporting requirements, the overall trend in toxic emissions since 1988 is downward, a sign of increasing efficiency and dematerialization of our economy (Hayward 2005).

Air pollutants have the potential to impact the health of people using or living near, public lands. The USEPA has identified criteria pollutants that affect air quality and human health (see Air Quality in Chapter 3). Despite increases in human population and industrialization, emissions of principal air pollutants in the U.S., after peaking in the 1970s and early 1980s, have generally declined or held steady during the past 2 decades due to more stringent air quality regulations and improvements in pollution control technology (USEPA 2005).

Particulate matter is the principal pollutant of concern, from a public health perspective, for activities occurring on public lands. Nationwide, emissions of particulate matter from all sources have trended lower since the 1970s. However, PM emissions have shown a close relationship with the number of acres burned annually by wildfire. Since 1990, PM emissions associated with wildfire have ranged from 145,000 tons in 1995 to 1.2 million tons in 2002; the number of acres burned by wildfires in 1995 was one-third the number of acres burned in 2002. The level of PM associated with slash and prescribed burning, however, has trended downward since the 1970s, and in 2001 (165,000 tons) was about half the level of the early 1990s. Based on an estimate of emissions generated by current vegetation treatment activities (primarily fire and mechanical treatments; see Table 4-4 in PER), BLM treatment activities have accounted for less than 0.5% of criteria pollutant emissions nationwide.

Herbicides contain chemical compounds that are harmful to human health. Most of the herbicides used by the BLM do not pose a risk to human receptors when applied at the typical application rate. At the maximum application rate, however, more herbicides, in a greater number of exposure scenarios, have the potential to adversely affect human health. Aerial applications of herbicides pose a greater risk to the public due to off-site drift than ground applications, as herbicides applied at greater distances from the ground are able to drift farther from the target application area. Spot applications would be less likely to pose a risk to downwind receptors than boom/broadcast applications. However, spot applications would be more likely to pose a risk to workers charged with applying the herbicide because they are likely to come into contact with the herbicide.

Nationwide, the annual amount of herbicide use has declined from an estimated 620 million pounds of active ingredient in 1982 to 553 million pounds in 2001, although the amount of herbicide use has remained relatively steady since the late 1980s. The amount of other pesticides used has also declined by about 15% during the same period (Donaldson et al. 2004).

Vegetation treatment activities by the BLM, Forest Service, and other agencies, for agricultural and other uses have contributed to the release of harmful materials into the environment. As discussed above, prescribed fire use has steadily increased during the past decade and has contributed to PM emissions. Heavy equipment, transport vehicles, and power tools have also contributed minor amounts of PM and other pollutants into the atmosphere. Herbicide use by the BLM, Forest Service, agricultural operations, and others has steadily increased, but these users have emphasized the use of less toxic herbicides with shorter half-lives and that do not bioaccumulate, and have kept application rates as low as possible, to minimize the amount of toxic material released into the environment while still meeting treatment goals. In addition, these users have increased passive treatments and non-herbicide treatments, such as biological control, to minimize the use of herbicides in vegetation control.

Risks from Wildfire. Wildfires cause the loss of life and property. According to the National Interagency Fire Center (2005), 20 people died from wildland fire accidents in 2004. During 2000 to 2003, 98 individuals died from wildland fire accidents, including agency personnel, contractors, volunteers, and private individuals. The largest number of fatalities was associated with burnovers (47%), use of a vehicle or ground-based mechanical equipment (19%), or use of aircraft (13%). During 2004, wildland fires resulted in the loss of 314 primary structures on lands near BLM- or Forest Service-administered lands (USDI BLM 2005c).

Growth in the western U.S. has exceeded that of the rest of the country, and while the region remains more rural than the rest of the country, over 23 million people now live within 25 miles of public lands (USDI BLM 2005c). As wildfires have become more severe, the associated risks to life and property within the WUI have increased. Because of concern about this risk, the BLM stepped up efforts to reduce hazardous fuels in the WUI from 164,000 acres in 1991 to over 490,000 acres in 2004. Despite these efforts, over $98 million was spent by the BLM in 2004 on fire control, much of this amount in the WUI.

Future Effects and Their Accumulation

Occupational Risks. It is projected that incidence of occupational injury and death will continue to decline as our nation moves to a more service-oriented economy. Occupations with higher risk of injury and death will continue to be associated with rural areas and public lands; risks in these areas will likely be greater than in more urbanized areas. However, continued improvement in equipment and emphasis on workplace safety should help to reduce risks of occupational injury and death in the West.

Mechanical treatments and herbicide use pose the greatest risk to worker health from treatment activities. The number of acres treated using herbicides and mechanical methods will increase 3-fold under the proposed action. Thus, risks of injury associated with equipment could also increase 3-fold, and permanent injuries and loss of life could accumulate. It is likely that risk to workers from application of and exposure to herbicides would not be as great as currently occurs, as the BLM would place the greatest emphasis on use of herbicides that have low risk to humans. For example, three of the four herbicides proposed for use by the BLM would pose essentially no risk to humans under exposure scenarios modeled in the HHRA.

Cancer Risks. Cancer rates have declined for over a decade, and are likely to continue to do so with improvements in lifestyle and our ability to recognize and treat the underlying causes of cancer. Cancer risks for workers conducting fire and herbicide treatments on public lands could increase due to the increased number of acres treated. However, risks to workers would be lessened by improvement in equipment and treatment technologies and use of newer herbicides, including those proposed for use in this PEIS, that pose no cancer risk.

Exposure to Pollutants. The trend in pollutant emissions is expected to continue to decrease nationwide. For example, the USEPA projects that emissions from automobiles will decline by more than 80% over the next 25 years as Americans shift to more fuel efficient and less-polluting vehicles and use fuels that have been developed to reduce emissions. Industrial pollution is also expected to decline as our economy becomes more service-based (Hayward 2005).

The proposed increase in use of fire by the BLM, Forest Service, and other federal and state land management agencies to restore natural fire regimes and reduce hazardous fuels could increase the amount of smoke, and therefore the incidence of health effects associated with PM and other harmful constituents of smoke, in the West. The Forest Service modeled several scenarios to predict the long-term effect of treating more acres and/or targeting treatments in the WUI on regional air quality and the condition of the land (USDA Forest Service and USDI BLM 2000). The model assumed that in the WUI where air quality and other considerations could limit the use of fire, mechanical and hand cutting would be important treatment options, in addition to use of fire. According to the model, air quality generally improved as the number of acres treated annually increased, and improvement in air quality was most noticeable when treatments were targeted at high priority western U.S. WUI landscapes. Thus, the proposed action, which includes over 4.3 million acres of fire use and mechanical treatments, in addition to 1.7 million acres of treatments using other methods, would be expected to provide greater improvement in ecosystem function and air quality than is projected under current treatment methods (see Air Quality).

Risks to the public and workers on or near public lands from exposure to herbicides could increase as a result of the 3-fold increase in herbicide use. To reduce this risk, the BLM would primarily use herbicides that have low risk to humans, including new herbicides proposed for use as part of this PEIS, and would continue to identify and make available to field offices herbicides that have lower risk to workers than currently-available herbicides.

Risks from Wildfire. In response to the threats of wildfire and invasive vegetation and noxious weeds, the President and Congress have directed the USDI and BLM, through implementation of the *National Fire Plan* (USDI and USDA Forest Service 2001), and the *Healthy Forests Restoration Act of 2003*, to take more aggressive actions to reduce catastrophic wildfire risk on public lands. The intent of these actions is to protect life and property, and to manage vegetation in a manner that provides for long-term economic sustainability of local communities, improved habitat and vegetation conditions for fish and wildlife, and other public land uses.

Treatment activities to reduce fire risk include timber harvest, thinning, prescribed fire, fuel reduction activities, greenstrips, brush reduction, and effective suppression efforts. While prescribed fire is not without risk, it is generally safer to burn under the controlled conditions of prescribed fire than to chance a wildfire when fuels are extremely dry and weather conditions are unfavorable.

The proposed treatment program would restore natural fire regimes and encourage the growth of native vegetation that is more resilient to wildfire, reducing the risk of wildland fire. If vegetation structure, species composition, and disturbance regimes return to near historical ranges, then disturbances should have effects that are similar to historical effects, which are less severe, and result in less fire danger, than occurs today. Because of the limitations on the types and amounts of treatments that can occur in the WUI, it may be more difficult to restore natural fire regimes in the WUI than on non-WUI lands, but long term, benefits to the WUI should accrue and the loss of life and property associated with wildfire should slow or begin to decrease (USDA Forest Service and USDI BLM 2000; USDI BLM 2005c).

An assessment of risks to people and property from varying levels and types of treatments was done for the cohesive strategy. Assuming funding levels remained static and two-thirds of treatments were targeted for the WUI, risks to people and property would remain near current levels after 15 years (Hann et al. 2002). If more funding was provided, it would be possible to substantially reduce the risk of loss of life and property.

Contribution of Treatment Alternatives to Cumulative Effects

As discussed above, short-term risks to human health are related to the types of treatments and methods used, and the number of acres treated. Based on number of acres treated, the greatest risk to human health would occur under the Preferred Alternative, and the least risk under the No Action Alternative. The other alternatives would likely be intermediate between these two.

Risks associated with fire use and mechanical, manual, and biological control treatments would be similar among the four action alternatives, which differ primarily in the types of herbicides available for use and number of acres treated. Risks associated with herbicide use could be less under alternatives C, D and E than the Preferred Alternative, because fewer acres would be treated and aerial spraying would be prohibited (Alternative D) or discouraged (Alternative E), or not allowed (Alternative C). The risk of off-site drift would be less under these alternatives, with no risk for Alternative C. Alternative E would prohibit use of ALS-inhibiting herbicides, some of which have less risk to humans than herbicides that would be allowed under this alternative. About one-third as many acres would be treated using herbicides under the No Action Alternative than under the other alternatives. However, the BLM would be able to use several herbicides (2,4-DP, asulam, atrazine, fosamine, mefluidide, and simazine) under the No Action Alternative that pose high risks to human health, but that would not be available for use under the other herbicide treatment alternatives.

Alternative E places greater emphasis on passive restoration than the other alternatives and would result in fewer risks or injuries to workers due to less emphasis on the use of mechanical, herbicide or fire treatments. Alternative E also focuses more hazardous fuels treatments in the WUI, and encourages practices to reduce vegetation near homes and to develop a defensible space in the WUI to reduce risks to people and property from wildfires.

Regardless of the alternative chosen, there could be an accumulation of injury or loss of human life from treatments, and there would be an accumulating loss of life and property from wildfires. Over the long term, restoration of natural fire regimes and improvement in ecosystem health should reduce risk to human health from activities originating on public lands and affecting public land users or those living near public lands.

Unavoidable Adverse Effects

This section summarizes the unavoidable adverse effects that would occur under the actions considered in the PEIS and PER. Unavoidable adverse effects would primarily be associated with the use of herbicides and fire.

Air Quality

An increase in emissions of air pollutants would occur as a result of all the action alternatives. However, the limits to air quality standards would not be exceeded under any of the alternatives (see A*ir Quality Modeling for BLM Vegetation Treatment* Methods [ENSR 2005m] and *Annual Emissions Inventory for BLM Vegetation Treatment Methods* [ENSR 2005a] that are found on the CD that accompanies the PEIS and on the BLM website at http://www.blm.gov.

Soil Resources

Regardless of the method used to remove vegetation, vegetation treatments would potentially result in adverse impacts in the short term through increased rates of erosion and reduced water infiltration, leading to loss of soil and reduced soil productivity. The degree of these effects would vary by region depending upon differences in climate, landform, hydrology, soil, vegetation, and land use. In the western U.S., the combination of hydrologic characteristics, steep topography, and slow vegetative growth make soil erosion a serious concern in many regions (Kennard and Fowler 2005).

Vegetation treatments could also result in disturbance to biological soil crusts, which could reduce soil quality and ecosystem productivity. The extent of impacts to biological soil crusts would be dependent on the intensity and kind of disturbance and the amount of area covered. The duration of the effects would vary, but biological soil crust recovery rates typically are much slower than the recovery of vascular vegetation.

Water Resources and Quality

An increase in soil erosion and surface water runoff could result from vegetation removal, which could lead to stream bank erosion and sedimentation (Ott 2000). Rates of runoff would be influenced by precipitation rates, soil types, and proximity to the treated area. All vegetation removal activities could disturb the soil and reduce the amount of vegetation binding to soil, potentially causing erosion and increased sedimentation. The removal of vegetation would decrease the amount of rainfall captured by plants, detritus, and soil, potentially leading to increased stormwater flows, runoff velocity, and sedimentation. Herbicides have the potential to directly impact surface water quality or leach through the soil and impact groundwater quality.

Wetland and Riparian Areas

An increase in soil erosion and surface water runoff could result from vegetation removal, which could lead to streambank erosion and sedimentation in wetlands and riparian areas (Ott 2000). Rate of runoff would be influenced by precipitation rate, soil type, and proximity to the treated area. All vegetation removal activities could disturb the soil and reduce the amount of vegetation binding to soil, potentially causing erosion and increased sedimentation of wetlands and riparian areas. Sediments can impact plants within wetland and riparian areas by reducing the amount of sunlight reaching plants and slowing or stopping plant growth.

The removal of vegetation would decrease the amount of rainfall captured by plants, detritus, and soil, potentially leading to increased stormwater flows and runoff velocity in both ecosystems. Increased stormwater runoff can scour wetlands, modify their morphology, and affect the distribution and abundance of aquatic organisms within the area. Many species that use wetlands have evolved life-history strategies that depend upon stable conditions (i.e., stable water quality and quantity). For example, vegetation removal resulting in increased water flows to wetlands during the spring could flood the breeding sites of aquatic organisms that breed or lay eggs in moist soil, harming or killing eggs or juveniles.

A reduction in non-target aquatic vegetation could result in oxygen depletion as the vegetation began to decompose. Siltation of wetlands could reduce water quality and the amount of oxygen available to aquatic organisms. In addition, siltation could reduce the acreage of wetland and riparian habitat.

Vegetation

The proposed vegetation treatments would cause unavoidable short-term disturbances to vegetation communities by killing both target and non-target plants. The extent of these disturbances would vary by the extent and type of treatment. In many cases, the treatments would return all or a portion of the treated area to an early successional stage by freeing up resources such as light and nutrients for early successional species, such as annual grasses and forbs.

Fish and Other Aquatic Organisms

Terrestrial vegetation alteration or removal, either through treatment activities or natural occurrences such as catastrophic fire, could result in an increase in soil erosion and surface water runoff that could lead to streambank erosion and sedimentation in aquatic habitats (Ott 2000). Sediments can harm spawning habitat, make foraging more difficult for aquatic organisms, and harm breathing organs of aquatic animals. The effects of catastrophic fire in watersheds would be ameliorated through timely emergency stabilization activities that are usually implemented within the same season as the fire occurs and are designed to minimize erosion and siltation.

A reduction in non-target aquatic vegetation could result in oxygen depletion as the vegetation began to decompose. Siltation of wetlands could reduce water quality and the amount of oxygen available to aquatic organisms. In addition, siltation could result in a reduction in the acreage of wetland and riparian habitat.

Wildlife Resources

The proposed vegetation treatments could kill or harm wildlife and could cause unavoidable short-term adverse impacts to wildlife habitat and behavior. The extent of these disturbances would vary by the extent and type of treatment. In general, greatest adverse risks would be associated with the use of fire and herbicide treatments. If treatments are successful, species currently using sites that were restored could be displaced by species better adapted to restored sites.

Livestock

The proposed vegetation treatments could temporarily affect non-target vegetation that might provide forage, shelter, or other life requisites for livestock. Livestock could also be adversely impacted by herbicide treatments. Livestock, which consume large quantities of grass, have greater risk for harm than smaller wildlife or wildlife that feed on other herbaceous vegetation or seeds and fruits, because herbicide residue is higher on grass than it is on other plants (Fletcher et al. 1994; Pfleeger et al. 1996; see Appendix C). These potential impacts are usually mitigated because livestock can be removed from areas scheduled for treatment.

Wild Horses and Burros

The proposed vegetation treatments would adversely affect wild horse and burro populations by killing or harming non-target vegetation that might provide forage, shelter, or other life requisites for wild horses and burros. Wild horses and burros could also be impacted by herbicide treatments. Wild horses and burros, which likely consume large quantities of grass, have greater risk for harm than smaller wildlife or wildlife that feed on other herbaceous vegetation or seeds and fruits. However, harmful doses of herbicide would be unlikely unless the animal were to forage exclusively within the treatment area for an entire day, suggesting that smaller treatments would be more appropriate for herd management areas in cases where an herbicide has demonstrated risk to herbivores from the consumption of contaminated vegetation. In some cases, treatment areas can be designed to exclude use by wild horse and burros to reduce the likelihood of adverse impacts to the animals.

Paleontological and Cultural Resources

Paleontological Resources

The loss of paleontological resources has the potential to be adverse, especially if it results in the loss of scientifically important fossils. However, if surveys and inventories in areas of proposed ground-disturbing activities were conducted before work began, and avoidance of paleontological resource sites was possible, the incidence of impact would be greatly reduced and any impacts would be minimal. Use of SOPs would reduce the likelihood of impacts to paleontological resources.

Cultural Resources and Traditional Lifeway Values

Cultural resources are nonrenewable, so any effects would have some importance. Because the exact locations of all potential cultural resources sites are unknown, their disturbance cannot be entirely avoided. There are cultural resources on public lands that may relate to the entire span of human occupation, including locales relating to the first humans to enter the Western Hemisphere. Historic and prehistoric sites may be located anywhere within the treatment area and represent varied ages, cultures, and functions. Because soil forms slowly in the Arctic, sites in that region that are thousands of years old may be near the surface. If surveys and inventories for cultural resources in areas proposed for vegetation treatments were conducted before the work began, then the effects to cultural resources in these areas would be reduced or avoided. Timely intervention following the discovery of cultural resources would effectively mitigate many effects, either through site avoidance or data recovery. Archaeological excavation to recover scientific data under terms of an appropriate data recovery plan could result in the partial or total destruction of the site, although the recovered data would effectively mitigate for this destruction.

In many areas of the West, noxious weeds and other invasive vegetation grow together with more desirable vegetation used for traditional lifeway values, such as for food or basketweaving. Vegetation treatments in these areas would could also harm desirable plants, could discourage or prohibit Native peoples from using these areas, or in the case of herbicides, could potentially harm Native peoples harvesting plant materials in treated areas.

Visual Resources

The proposed vegetation treatments would not result in unavoidable adverse effects to visual resources over the long-term. In the short-term, vegetation treatments would kill or harm vegetation in the applied area, resulting in a more open, browned or blackened landscape until new plants were to grow in the area. While these effects are unavoidable, they are not considered adverse, as the vegetation would recover and lead to improved natural conditions. Treatment areas would vary in terms of their visual appeal prior to treatment and their distance from human activity, as well as in terms of the resulting public sensitivity to the pre- and post-treatment visual character of the area. The effects of vegetation treatments on the visual quality of the landscape would be most notable to travelers, sightseers, and residents for the first year to several years following treatment, particularly near major roads or residential areas.

Wilderness and Special Areas

The effects of fire on wilderness and special areas would depend on a number of factors, such as the vegetation type of the site, the condition of the site, and the particular unique quality of the site that requires special management. In general, sites with special qualities that could be destroyed by fire would be the most likely to experience significant adverse effects from fire treatments.

Use of mechanical treatment methods would adversely affect wilderness areas and wilderness study areas because vehicles and heavy equipment are incompatible with the "unspoiled" nature of wilderness. For this reason, mechanical treatments would only be allowed on a very limited number of sites where no other method was feasible (e.g., tamarisk removal) and in the few areas where mechanical treatments occurred in the past and repeat treatments were required.

Use of herbicides to treat undesirable vegetation could potentially affect the condition of wilderness areas and wilderness study areas by killing non-target native vegetation through imprecise application and/or drift. Since label directions, SOPs, and any additional wilderness restrictions will be followed during application of herbicides, there is little impact expected from drift due to imprecise application or other accidental scenarios. The degree of effects would depend on the application method, with spot applications less likely to cause adverse effects than aerial applications.

Recreation

There would be some scenic degradation, as well as distractions to public land users (e.g., noise from machinery), from treatments. In addition, there would be some human health risks to recreationists associated with exposure to herbicides (if use was allowed) or smoke from fire. These risks are discussed in more detail under Human Health and Safety. Finally, some areas would be off-limits to recreation activities as a result of treatments, from periods ranging from a few hours to days, or even one full growing season or longer, depending on the treatment. In most cases, recreationists would be able to find alternative sites offering the same amenities, although a lessened experience could result from more concentrated use in these areas.

The effects of herbicide treatments and fire use on fish and wildlife could have indirect negative impacts on recreational activities such as fishing, hunting, and wildlife viewing. For example, aerial application of an herbicide over a large area could adversely affect these activities by harming or displacing wildlife.

Social and Economic Values

Short-term closures or restrictions on public lands for certain vegetation treatments, such as implementation of herbicide use re-entry restrictions to protect public health or to restrict access by grazing animals until seeding or reseeding efforts are established (up to two growing seasons) are unavoidable. It is expected that communities that are particularly dependent on a single industry would be more susceptible to any potential adverse effects to employment or income due to vegetation treatment projects than other, more diverse, communities. In particular, ranching communities and recreation-dependent communities may be more affected than more diversified communities.

Limits on grazing activity on public lands could put additional pressure on often tight economic margins in ranching. Closures of treatment areas for extended periods of time could temporarily affect some recreational uses and commercial activities.

Human Health and Safety

All treatment methods have the potential to injure or kill workers or the public. The health and safety of workers could be at risk from exposure to herbicides; from working on uneven ground, broken terrain, and in dense vegetation; from use of hand and power tools; from inhalation of smoke; from exposure to falling debris; and from other accidental situations. Although workers would follow SOPs to reduce risks, not all risks could be avoided.

The public could be at risk from flying debris if they were near an area where manual or mechanical equipment was used. Risks could be avoided if a safe zone was established around work areas and the public did not enter this area. However, spray drift, and particulate matter, and other harmful materials associated with herbicides and fire could drift off public land and harm the public. Smoke risks would be minimized or avoided by following fire management plans and conducting burns during periods when meteorological conditions were favorable to reduce smoke impacts to the public. Herbicide drift would be minimized by using proper application equipment, using drift reduction agents, and spraying during periods with little or no wind.

Relationship between the Local Short-term Uses and Maintenance and Enhancement of Long-term Productivity

This section discusses the short-term effects of vegetation treatment activities, versus the maintenance and enhancement of potential long-term productivity of public land environmental and social resources.

Short term refers to the total duration of vegetation treatment activities considered in the PEIS and PER (about 15 years), whereas long term refers to an indefinite period beyond this period. The specific impacts vary in kind, intensity, and duration according to the activities occurring at any given time. Initial activities, such as herbicide and mechanical treatments and fire use, result in short-term, localized impacts. However, the overarching goal of the proposed vegetation treatments program is to restore natural fire regimes, vegetation, and ecosystems, which should benefit all resources in the long term.

Air Quality

Vegetation treatments would cause short-term degradation of air quality, with most degradation associated with fire use. As discussed earlier, much of the focus of treatments is to restore natural fire regimes and reduce the incidence and severity of wildfires. In general, wildfire impacts on air quality would likely be significantly greater than emissions from prescribed burning (USDA Forest Service and USDI BLM 2000), as a result of techniques to emissions during prescribed burns and smoke management plans that permit prescribed fires only during meteorological periods favorable to dispersion. Thus, proposed vegetation treatments should reduce smoke emissions associated with public lands over the long term.

In addition, state smoke management meteorologists would consider the cumulative effects of emissions from other sources (such as road dust, other federal vegetation management activities, and agricultural dust and burning) during the development of daily smoke management instructions. State smoke management program managers would also consider these sources during development of smoke management plans submitted for approval (as a component of the state smoke implementation plan) to the USEPA (USDA Forest Service and USDI BLM 2000).

Soil Resources

Although treatments would have short-term effects on soil condition and productivity, the disturbance effects resulting from restoration activities are predicted to have less impact and be less severe than fire effects and erosion caused by past fire exclusion, encroachment by invasive species and noxious weeds, and traditional management activities. Furthermore, monitoring and evaluation, integrated with an adaptive management approach, would result in adjustment of treatment design and implementation to reduce soil disturbance to levels similar to historical conditions.

Findings and comparisons of studies in forested and rangeland environments concluded that forest and range landscapes that resemble conditions within historical ranges of variability provide favorable conditions for soil functions and processes that contribute to long-term sustainability of soil productivity (Munn et al. 1978, Cannon and Nielsen 1984, and Hole and Nielsen 1970 *cited in* USDA Forest Service and USDI BLM 2000).

Substantial changes in disturbance regimes, especially changes resulting from fire suppression, timber management practices, and livestock grazing over the past 100 years, have resulted in moderate to high departure of vegetation composition and structure and landscape mosaic patterns from historical ranges on public lands. Restoration activities that move forests and rangelands toward historical ranges of variability would provide favorable conditions for soil functions and processes that contribute to long-term soil productivity levels at the broad scale (USDA Forest Service and USDI BLM 2000).

Water Resources and Quality

The BLM proposes a 3-fold increase from current levels in the number of acres treated overall, and a 4-fold increase in the number of acres treated in wetland and riparian habitats. Treatment of vegetation would cause a short-term increase in soil erosion and surface water runoff. Successful control of invasive plants, however, would lead to improved conditions in watersheds over the long term, with the greatest improvement likely to occur in degraded watersheds. The eventual growth of desirable vegetation in treated areas would moderate water temperatures, buffer the input of sediment and herbicides from runoff, and promote streambank stability. Ongoing efforts by the BLM to enhance vegetation would also help to increase the number of acres of watersheds that are functioning properly. Improvement of watershed and water resources and quality would also benefit salmonids and other species of concern that depend upon these habitats for their survival (USDA Forest Service and USDI BLM 2000).

Vegetation treatments that reduce hazardous fuels would benefit ecosystems by reducing the chances of a large, uncontrolled wildfire, which could result in the destruction of a large amount of high quality habitat that could lead to erosion, especially if followed by heavy rainfall. Hazardous fuels reduction would also decrease the likelihood that wildfire suppression activities would occur in or near aquatic habitats.

The BLM's ability to use four new chemicals (fluridone and diquat for aquatic applications, and imazapic and Overdrive® for terrestrial applications), and new herbicides as they become available, would provide new capabilities to the BLM for controlling problematic invasive species and would be less likely to contaminate water than many of the currently-available herbicides.

Wetland and Riparian Areas

Removal of vegetation could cause a short-term increase in soil erosion and surface water runoff and could impact wetland and riparian areas. Successful control of invasive plants in wetlands and riparian areas, however, would lead to improved conditions in these habitats over the long term. The eventual growth of desirable vegetation in treated areas would moderate water temperatures, buffer the input of sediment and herbicides from runoff, and promote bank stability in riparian areas. Ongoing efforts by the BLM to enhance wetland and riparian vegetation would also help to increase the number of miles of stream and acres of wetlands that are classified by the BLM as "Proper Functioning." Improvement of riparian and wetland habitat would also benefit salmonids and other species of concern that depend upon these habitats for their survival (USDA Forest Service and USDI BLM 2000).

Control of aquatic and riparian vegetation can improve habitat quality for fish and wildlife, improve hydrologic function, and reduce soil erosion. Non-native species, such as purple loosestrife, form extensive monotypic stands that displace native vegetation used by wetland animal species for food and cover (Bossard et al. 2000). Hydrilla is an aquatic species that forms large mats that fill the water column and can severely restrict water flow, leading to a decrease in habitat for fish and wildlife and water quality. Milfoils are an aquatic species that have spread widely over the western U.S. and have been found to alter the physical and chemical characteristics of lakes and streams. Much of the BLM's vegetation control efforts in wetland and riparian areas would focus on these species.

Vegetation

All treatments would have short-term adverse impacts to target vegetation, and in some cases non-target vegetation. Treatments that remove or control invasive vegetation could provide immediate benefits to non-target species, however, as these species would gain access to water and nutrients and experience enhanced vigor from reduced competition with invasive species.

Treatments that remove hazardous fuels from public lands would be expected to benefit the long-term health of plant communities in which natural fire cycles have been altered. The suppression of fire results in the buildup of dead plant materials (e.g., litter and dead woody materials), and often increases the density of flammable living fuels on a site. Treatments that restore and maintain fire-adapted ecosystems, through the appropriate use of mechanical thinning, fire use, and other vegetation treatment methods, would decrease the effects of wildfire on plant communities and improve ecosystem resilience and sustainability. Treatments should also reduce the incidence and severity of wildfires across the western U.S.

Treatments that control populations of non-native species on public lands would be expected to benefit native plant communities over the long term by aiding in the re-establishment of native species. The degree of benefit would depend on the success of these treatments over both the short and long term. Some treatments are very successful at removing weeds over the short term, but are not successful at promoting the establishment of native species in their place. In such cases, seeding and planting of native plant species would be beneficial.

Although modeling was not done as part of this PER to determine the long-term effects of vegetation treatments, modeling done for similar treatments proposed by the BLM and Forest Service in the Interior Columbia Basin showed that improvements in land condition would be slow. However, treatments would provide a better mix of habitats so that vegetation would be more resilient to disturbance and sustainable in the long term. Plant communities that have declined substantially in geographic extent from historical to current periods (e.g., big sagebrush and bunchgrasses) would increase. Although the extent of weeds and other exotic and undesirable plants would continue to increase, the rate of expansion would be slower (USDA Forest Service and USDI BLM 2000).

Fish and Other Aquatic Organisms

The removal of vegetation could lead to increased soil erosion and reduction in water quality, potentially affecting fish and other aquatic organisms short term. The eventual growth of desirable vegetation in treated areas would moderate water temperatures, buffer the input of sediment and herbicides from runoff, promote bank stability in riparian areas, and improve habitat for fish and other aquatic organisms. Improvement of riparian and wetland habitat would benefit salmonids and other species of concern that depend upon these habitats for their survival (USDA Forest Service and USDI BLM 2000).

Control of aquatic and riparian vegetation can improve habitat quality for fish and wildlife, improve hydrologic function, and reduce soil erosion. Hydrilla is an aquatic species that forms large mats that fill the water column and can severely restrict water flow, leading to a decrease in habitat for fish and wildlife and water quality. Milfoils are an aquatic species that have spread widely over the western U.S. and have been found to alter the physical and chemical characteristics of lakes and streams. The BLM's vegetation control efforts in wetland and riparian areas would focus on these species.

Vegetation treatments that reduce hazardous fuels would benefit aquatic organisms by reducing the chances of a large, uncontrolled wildfire, which could result in the destruction of a large amount of high quality wetland and riparian habitat, especially if followed by heavy rainfall. Hazardous fuels reduction would also decrease the likelihood that wildfire suppression activities would occur in or near aquatic habitats. Treatments that restore natural fire regimes and native vegetation near streams should ensure a steady supply of large woody debris that would provide habitat for aquatic organisms in the future.

Wildlife Resources

All treatments would have short-term adverse impacts to wildlife and their habitats, as discussed above. Treatments that improve habitat would provide long-term benefits to wildlife. Treatments that remove hazardous fuels from public lands and reduce the risk of large, intense wildfire would reduce future death and injury of wildlife and lead to improved habitat. Treatments that control populations of non-native species on public lands would be expected to benefit most wildlife over the long term by aiding in the re-establishment of native vegetation and restoring wildlife habitat to near historical conditions.

Although modeling was not done as part of this PER to determine the long-term effects of vegetation treatments, modeling done for similar treatments proposed by the BLM and Forest Service in the Interior Columbia Basin showed that improvements in habitat would be slow, perhaps not occurring for decades.

Livestock

The proposed vegetation treatments would affect the availability and palatability of vegetation over the short term. These impacts would begin to disappear within one to two growing seasons after treatment.

All treatments that successfully reduce the cover of noxious weeds and restore native vegetation on grazed lands would benefit livestock by increasing the number of acres available for grazing and the quality of forage. In addition, treatments would remove some noxious weeds (e.g., tansy ragwort, houndstongue, Russian knapweed, and St. Johnswort) that are harmful to livestock. The success of weed removal and restoration of native habitats would determine the level of benefit of the treatments over the long term.

Treatments that reduce the risk of future catastrophic wildfire through fuels reduction would also benefit livestock. Uncontrolled, high intensity wildfires can damage large tracts of rangeland, reducing its suitability for foraging in the short term. Wildfires typically occur during drought conditions, when burning rangeland magnifies the drought stress of forage species and hampers their recovery. Treatments that restore and maintain fire-adapted ecosystems, through the appropriate use of mechanical thinning, fire, and other vegetation treatment methods would decrease the effects of wildfire on rangeland plant communities and improve ecosystem resilience and sustainability.

Wild Horses and Burros

The proposed vegetation treatments would affect the availability and palatability of vegetation over the short term. These impacts would begin to disappear within one to two growing seasons after treatment.

All treatments that successfully reduce the cover of noxious weeds and restore native vegetation on grazed lands would benefit wild horses and burros by increasing the number of acres available for foraging and the quality of forage. In addition, treatments would remove some noxious weeds (e.g., tansy ragwort, houndstongue, Russian knapweed, and St. Johnswort) that are poisonous to wild horses and burros. The success of weed removal and restoration of native habitats would determine the level of benefit of the treatments over the long term.

Treatments that reduce the risk of future catastrophic wildfire through fuels reduction would also benefit wild horses and burros. Uncontrolled, high intensity wildfires can damage large tracts of rangeland, reducing its suitability for foraging. Wildfires typically occur during drought conditions, when burning rangeland magnifies the drought stress of forage species and hampers their recovery. Treatments that restore and maintain fire-adapted ecosystems, through the appropriate use of mechanical thinning, fire, and other vegetation treatment methods would decrease the effects of wildfire on rangeland plant communities and improve ecosystem resilience and sustainability.

Paleontological and Cultural Resources

Paleontological Resources

Because paleontological resources are nonrenewable, there is no difference between short-term and long-term impacts. The resource cannot recover from some types of adverse impacts. Once disturbed, the materials and information of paleontological deposits may be permanently compromised. Any destruction of paleontological sites, especially ones determined to have particular scientific value, would represent long-term losses. Furthermore, once paleontological deposits were disturbed and exposed, natural erosion could accelerate the destruction of fossils, and exposed fossils would be vulnerable to unauthorized collecting and digging. Any discoveries of paleontological resources as a result of surveys required prior to treatment would enhance long-term knowledge of the area and these resources.

Cultural Resources and Traditional Lifeway Values

Because cultural resources are nonrenewable, there is no difference between short-term and long-term impacts. Cultural resources cannot recover from most types of effects. Historic structures could benefit from preservation and stabilization associated with treatment efforts. However, once disturbed, an archaeological deposit could never be returned to its original context. Any destruction of cultural resource sites would represent long-term losses. Archaeological excavation to recover scientific data under terms of an appropriate data recovery plan could result in the partial or total destruction of the site, although the recovered data would effectively mitigate for this destruction. Any investigations of cultural resources made during inventories or investigations required prior to vegetation treatments would enhance knowledge of the history and early inhabitants of the region and serve to effectively mitigate further potential effects of activities in the area.

Vegetation treatments could have short-term impacts on vegetation used for traditional lifeway values, especially where herbicide drift impacted non-target vegetation, or treatments affected both target and non-target vegetation, as would occur with use of some types of herbicides (non-selective) and fire use. In addition, fire use and herbicide treatments could displace Native peoples from traditional use areas until it was safe to reenter, or desirable vegetation was reestablishing. However, long-term restoration of native plant communities and natural ecosystem processes to the benefit of traditional lifeway resources should compensate for the short-term losses in use.

Visual Resources

The proposed vegetation treatments would affect visual resources by changing the scenic quality of the landscape. In the short-term, for all treatment methods, impacts to visual resources would begin to disappear within one to two growing seasons after treatment. The regrowth of vegetation on the site would eliminate much of the stark appearance of a cleared area, and the area would develop a more natural appearance. Impacts would last for the longest amount of time in forests and other areas where large trees and shrubs were removed.

Over the long term, vegetation treatments would likely improve visual resources on public lands. Treatments that aim to rehabilitate degraded ecosystems, if successful, would result in plant communities dominated by native species (see Vegetation section for more information). Native-dominated communities tend to be more visually appealing and productive than areas that have been overtaken by weeds (e.g., areas supporting a downy brome monoculture), or that have been invaded by woody species (e.g., grasslands experiencing encroachment by conifer seedlings).

Wilderness and Special Areas

For all treatment methods, impacts to wilderness and sensitive area resources would begin to disappear within one to two growing seasons after treatment. The regrowth of vegetation on the site would eliminate much of the stark appearance of a cleared area, and the area would develop a more natural appearance. Impacts would last for the longest amount of time in forests and other areas where large trees and shrubs were removed. Benefits to plants and animals in terms of ecosystem function and improved forage and cover would occur as the treated area recovered.

Over the long term, vegetation treatments would likely improve resources on wilderness and special areas. Treatments that aim to rehabilitate degraded ecosystems, would result in plant communities that are dominated by native species (see Vegetation section for more information). Native-dominated communities tend to be more productive than areas that have been overtaken by weeds (e.g., areas supporting a downy brome monoculture), or that have been invaded by woody species (e.g., grasslands experiencing encroachment by conifer seedlings). Restored areas would also provide better habitat for fish and wildlife, including species of concern.

Recreation

There would be some scenic degradation, as well as distractions to users (e.g., noise from machinery), from treatments. In addition, there would be some human health risks to recreationists associated with exposure to herbicides (if use was allowed) or smoke from fire. Finally, some areas would be off-limits to recreation activities as a result of treatments. These effects would be localized and short term.

Developed recreation sites with public facilities would be treated in order to maintain the appearance of the area and to protect visitors from the adverse effects of unwanted vegetation (e.g. thistles, ragweed, and poison ivy). Some mechanical activities, such as mowing in visitor use areas or along ROW, would provide an immediate benefit in terms of improved appearance of vegetation. Long-term adverse effects on developed recreational facilities would be unlikely, as treatments are expected to improve native vegetation and the utility of these sites. In some cases, developed recreation sites could be temporarily closed during treatments.

Treatments that restore native vegetation, and natural fire regimes and other ecosystem processes, would be beneficial to recreationists. Treatments would improve the aesthetic and visual qualities of recreation areas for hikers, bikers, horseback riders, and other public land users; reduce the risk of recreationists coming into contact with noxious weeds and poisonous plants; increase the abundance and quality of plants harvested from public lands; and improve habitat for fish and wildlife sought by fishermen and hunters. These benefits would be long term and improve the productivity of land resources and their ability to provide recreational values.

Social and Economic Values

Vegetation treatments would adversely affect use of treated areas in the short term, and loss or restrictions on the use of treated lands could cause social and economic hardship to affected parties. However, individuals and industries involved in the restoration of native ecosystems on public lands would benefit.

Long term, most users of public lands, and those with interests near public lands, would likely benefit. An important goal of treatments is to restore ecosystem health so that public lands can provide sustainable and predictable products and services. In addition, treatments would reduce risk to communities by reducing the risk of catastrophic wildfire, improving ecosystem health to benefit recreationists and other public land users, and emphasize employment- and income-producing management activities near those communities most in need of economic support and stimulus. The enhancement in long-term productivity of public lands to provide for social and economic needs would in part reflect the success or failure or treatments, and the influence of outside forces (e.g., economy, lifestyle changes, climate) over which the BLM and other federal agencies have no control (USDA Forest Service and USDI BLM 2000).

Human Health and Safety

The proposed vegetation treatments could harm the health of workers and the public over the short term. Adverse reactions to smoke and herbicides could cause minor to severe discomfort to sensitive individuals, but most symptoms would go away in a few hours. If serious injury or death resulted from treatments, the effects to the health of the affected individual would be long term, or in the case of death, permanent.

All treatments that successfully reduce the cover of noxious weeds and restore native vegetation would help to restore natural fire regimes and improve ecosystem health. If treatments were successful, long-term improvement in fire regimes and ecosystem health would reduce the risk of wildfire and slow the spread of poisonous and other noxious weeds that are harmful or annoying to humans. As native vegetation was restored, it could be possible to reduce the number of acres treated with herbicides. Even if this were not possible, the ability to use several new herbicides evaluated in this PEIS, and new herbicides that may become available in the future that are effective and less harmful to humans than currently-available herbicides, should reduce the risk to humans from herbicides on a per acre basis.

Irreversible and Irretrievable Commitment of Resources

This section identifies irreversible and irretrievable commitments of resources that would occur from vegetation treatments. Irreversible or irretrievable commitments of resources refers to impacts or losses to resources that cannot be reversed or recovered. Examples are the extinction of a species or the permanent conversion of a vegetated wetland to open water. In the first case, the loss is permanent and not reversible under current genetic technology. In the second case, it is possible the open water could be drained, so while the initial loss of the vegetated wetland is irretrievable, the action could be reversible.

Air Quality

Air quality would be affected by all treatment methods, with fire use contributing the most to degradation of air quality. These effects would occur only during the period of the treatment activity and there would be no irreversible or irretrievable effects on air quality.

Soil Resources

Disturbance activities associated with current and proposed treatments could result in soil erosion and loss of soil and soil productivity. This loss of soil and soil productivity would be irretrievable on the disturbance area, although the soil could be available for use at some other location. However, at current treatment levels, noxious weeds and other invasive species, and the number and magnitude of wildfires, would likely increase and cause the loss of soil and soil productivity from affected lands. A benefit of increasing the amount of acres treated would be to slow the loss of soil and soil productivity due to invasive vegetation and wildfire and to restore soil structure and function on degraded sites as part of a larger goal to restore native ecosystem processes. As a result of these actions, soil formation in disturbed areas should re-establish over time.

Water Resources and Quality

An accidental herbicide spill or uncontrolled prescribed fire could cause damage to water bodies that could last for several months; the loss of use of the water resources in the affected area may be lost for a given time period. However, these impacts could be reversed if restoration treatments were successful and herbicides naturally degraded. Other treatments should not result in irreversible or irretrievable commitments of water resources.

Wetland and Riparian Areas

There would be no irreversible or irretrievable commitment of wetland and riparian resources. Although there would be short-term impacts to these resources from vegetation treatments, these impacts would not be irretrievable and would be reversed if restoration treatments were successful. In Alaska, it is possible that changes in the melting permafrost could cause subsidence that could last a long time and could be permanent.

Vegetation

Native vegetation and plant productivity that were lost as a result of treatments would be irretrievable in the short term until vegetation and vegetation communities re-established themselves, usually within several growing seasons. Native vegetation and plant productivity that were lost as a result of past land uses or WUI encroachment would be irretrievable over the long term. Treatments that improve rangeland and forestland ecosystem health and plant productivity would be expected to slow, and even reverse, the loss of native plant productivity and ecosystem health that currently occurs on public lands.

Fish and Other Aquatic Organisms

Several of the herbicides currently used, or proposed for use, by the BLM would have moderate to high risks to fish and other aquatic organisms under maximum application and accidental spill scenarios and could kill or injure aquatic organisms. Loss of control over a prescribed fire could also harm aquatic habitat and cause mortality or injury to aquatic organisms. These losses under accidental scenarios would be irretrievable and irreversible. Treatments would likely result in short-term habitat degradation and some reduction in populations of fish and other aquatic organisms. These effects, however, would be reversible, as habitats would improve and aquatic organism populations would respond to improved habitat conditions.

Wildlife Resources

Native wildlife and habitat productivity that was lost as a result of treatments would be irretrievable in the short term until native communities re-established themselves, usually within several growing seasons. Wildlife and their habitats that were lost as a result of past land uses or WUI encroachment would be irretrievable over the long term. Treatments that improve rangeland and forestland ecosystem health and plant productivity would be expected to slow, and even reverse, the loss of native plants and plant productivity and ecosystem health that currently occurs on public lands. Improvement in vegetation would translate into benefits for wildlife, except for those species that have adapted to or thrive in areas where vegetation has changed from historic conditions.

Livestock

Short-term loss in vegetation function and quality from treatments would have an impact on livestock productivity. Herbicide treatments have the potential to cause injury or death to livestock. Although some livestock could be displaced from public lands, forage could be found elsewhere, although possibly at a higher cost. As rangelands improved, their ability to support livestock populations at or near current levels should also improve.

Wild Horses and Burros

Short-term loss in vegetation function and quality from treatments would have an irreversible impact on wild horse and burro productivity, and potentially, survivorship. Wild horses and burros would be removed from rangelands to reduce their impacts to rangeland health and to speed up the process of rangeland restoration. These animals would be placed into adoption and would provide value to their owners, but their "place" in the wild would be lost. As rangelands improved, their ability to support populations of wild horses and burros near current levels would also improve.

Paleontological and Cultural Resources

Paleontological Resources

Because paleontological resources are nonrenewable, any impacts would render the resource disturbance irreversible and the integrity of the resource irretrievable.

Cultural Resources and Traditional Lifeway Values

Cultural resources are nonrenewable, so any impacts would be irreversible, and the integrity of the affected resource would be irretrievable. If near surface cultural resources were encountered, as during disking or chaining, such resources could be damaged or destroyed. The loss of such cultural resource information would be irreversible and irretrievable. Archaeological excavation to recover scientific data under terms of an appropriate data recovery plan could result in the partial or total destruction of the site, although the recovered data would effectively mitigate for this destruction. Any investigations of cultural resources made during inventories or investigations required prior to vegetation treatments would enhance knowledge of the history and early inhabitants of the region and serve to effectively mitigate further potential effects of activities in the area. Overall, such finds could help fill gaps in our knowledge of the history and early inhabitants of the area.

Vegetation treatment activities would impact plants and animals of traditional importance to Native peoples. However, these effects should be short-term and reversible as native plant communities would recover and habitat for fish and game species would improve.

Visual Resources

There would be no irreversible or irretrievable commitment of visual resources. Although there would be short-term impacts to visual resources from vegetation treatments, these impacts would not be irretrievable and could be reversed if restoration treatments were successful.

Wilderness and Special Areas

There would be no irreversible or irretrievable commitment of resources. Although there would be short-term impacts to wilderness and special area resources from vegetation treatments, these impacts would not be irretrievable and could be reversed if restoration treatments were successful.

Recreation

There would be no irreversible or irretrievable commitment of recreation resources. Although there would be short-term impacts to recreation resources from vegetation treatments, these impacts would not be irretrievable and could be reversed if restoration treatments were successful.

Social and Economic Values

Vegetation treatments would involve a substantial commitment by the BLM in terms of labor and financial resources. An estimated $1.1 billion would be needed to treat 6 million acres annually using the treatment and acreage assumptions outlined in Chapter 2. Several thousand jobs would be created to support treatment and restoration activities. Once the financial resources were used, they could not be retrieved. Treatments that result in the closure of recreation or grazing areas could have an irretrievable impact on the income of those involved in these industries.

Human Health and Safety

Serious injury or death to humans caused by vegetation treatments could be irreversible and irretrievable. However, risk of death or serious injury is very unlikely, based on incidence of injury (very low) and death (none) associated with BLM vegetation treatments during the past decade. It is likely that humans would experience minor discomfort from fire and herbicide treatments, but these effects would be short term and reversible.

CHAPTER 5

CONSULTATION AND COORDINATION

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CHAPTER 5

CONSULTATION AND COORDINATION

Preview of this Section

This section summarizes the public involvement and scoping process conducted for the preparation of the Draft PEIS and PER. Summaries of agency and Government-to-Government consultation is provided. The individual preparers, with their areas of expertise and/or responsibility, are also listed.

Public Involvement

Federal Register Notices and Newspaper Advertisements

The BLM published a Federal Register Notice of Intent to Plan (Notice) on October 12, 2001. The BLM also released a press release concurrent with the Notice. The Notice asked the public to help the BLM identify issues and resources relevant to vegetation treatment activities on lands administered by the BLM in 17 western states, including Alaska. The Notice stated that public comments on the proposal would be accepted from October 12 through November 11, 2001. A second Federal Register Notice was published on January 2, 2002, notifying the public of the location of public scoping meetings, and extending the public comment period until March 29, 2002. A third Federal Register Notice was published on January 22, 2002, notifying the public of changes to the meeting schedule.

All affected states issued public notices of the scoping period, which were placed in newspapers in or near locations where public meetings were held. In addition, information on the location of scoping meetings was provided by electronic mail in early December 2001, and again in early January 2002, to all members of the public that had placed their names on the electronic mailing list for the project before the date of the announcements.

Scoping Meetings

Eighteen public scoping meetings were held in 12 western states, including Alaska, during early 2002. Meeting locations were: Salt Lake City, Utah (January 8), Rock Springs, Wyoming (January 10), Socorro, New Mexico (January 14), Phoenix, Arizona (January 16), St. George, Utah (January 22), Grand Junction, Colorado (January 24), Miles City, Montana (January 29), Worland, Wyoming (January 31), Alturas, California (February 5), Helena, Montana (February 11), Boise, Idaho (February 13), Twin Falls, Idaho (February 14), Reno, Nevada (February 19), Elko, Nevada (February 21), Bakersfield, California (February 26), Spokane, Washington (February 28), Portland, Oregon (March 4), and Anchorage, Alaska (March 6). In addition, a meeting was held in Washington, D.C. (March 12). The scoping meetings were conducted in an open-house style. Informational displays were provided at the meeting, and handouts describing the project, the NEPA process, and issues and alternatives were given to the public. A formal presentation provided the public with additional information on program goals and objectives. This presentation was followed by a question and answer session.

The BLM received 1,034 requests to be placed on the project mailing list from individuals, organizations, and government agencies, and 381 written comment letters or facsimiles on the proposal. In addition, the public provided comments on the project at the public scoping meetings; over 2,800 catalogued individual comments (written and oral) were given during public scoping. In many cases, multiple respondents submitted the same comment. A *Scoping Comment Summary Report for the Vegetation Treatments Programmatic EIS* (ENSR 2002) was prepared that summarized the issues and alternatives identified during scoping. This document was made available to the public in July 2002.

Newsletters

The BLM prepared three newsletters during preparation of the Draft PEIS. These newsletters were made available to those individuals that provided their names and addresses to the BLM during scoping, and to BLM state offices and local field offices for distribution to visitors.

The first newsletter was issued in July 2002 and discussed the outcome of the scoping meetings, development of the initial project alternatives, coordination with affected tribes and fish and wildlife agencies, and treatment acreage determinations.

A second newsletter was issued in January 2003. It summarized activities on the risk assessments and development of the alternatives. It discussed the process the BLM was undertaking to determine future vegetation treatment acres. Other studies being conducted in support of the PEIS and PER, including preparation of a Biological Assessment and a cultural resource and Native American resource use report, were also discussed in the newsletter.

A third newsletter was issued in March 2005. This newsletter discussed the Draft PEIS/PER schedule, and noted that the PEIS will now focus on herbicide treatments, while a PER will be prepared to discuss other treatment methods. The newsletter also provided information of the alternatives that are evaluated in the Draft PEIS.

Agency Coordination and Consultation

Endangered Species Act Section 7 Consultation

The BLM initiated informal consultation with the USFWS and NOAA Fisheries (Services) in November 2001. The BLM met with the Services on November 16, 2001, to discuss the ESA Section 7 consultation process and to identify key contacts within the agencies. A preliminary draft consultation agreement was submitted to the Services in June 2002. The BLM and Services met in Denver, Colorado, on November 6-7, 2002, to discuss the risk assessment protocols and BA. The BLM met with the Services on February 28, 2003, to further discuss issues related to the development of the risk assessments and preparation of the Biological Assessment. A revised draft consultation agreement was submitted to the Services in April 2004 (see Appendix F).

The BLM prepared a formal initiation package that included: 1) a description of the program, species proposed for listing, listed species, critical habitats that may be affected by the program; and 2) a Biological Assessment that evaluated the likely impacts to listed species and critical habitats from the proposed action and SOPs to minimize impacts to listed species. In addition, the BLM coordinated with the NOAA Fisheries on Essential Fish Habitat as required under the Magnuson-Stevens Fishery Management Act. This package was submitted to the Services concurrently with release of the Draft PEIS. Consultations with the Services pursuant to the ESA and Magnuson-Stevens Fishery Management Act are ongoing and will be completed by the time of signing of the Record of Decision.

Risk Assessment Coordination

The BLM convened a group of scientists from the USEPA, USFWS, NOAA Fisheries, BLM, and its contractor, ENSR International, to work cooperatively to develop protocols for conducting HHRAs and ERAs that would meet agency guidelines and scientific and public scrutiny. Weekly conference calls were held among the participants beginning in May 2002, and continuing through November 2002. A meeting was held in Boise on September 12-13, 2002, and in Denver, Colorado, on November 5-6, 2002, to discuss the risk assessment protocols. Conference calls were held intermittently from November 2002 through July 2003 to resolve remaining issues related to the protocols. Conference calls were also held among agency participants during preparation of the risk assessments. The final HHRA and ERA protocols were finalized and submitted to the Services and USEPA in August 2003.

Cultural and Historic Resource Consultation

The BLM consulted with State Historic Preservation Officers as part of Section 106 consultation under the National Historic Preservation Act to determine how proposed industrial activities could impact cultural resources listed on or eligible for inclusion in the National Register of Historic Places. Formal consultations with State Historic Preservation Officers also may be required during implementation of individual projects. Consultations with State Historic Preservation Officers are ongoing and will be completed by the time of the signing of the Record of Decision.

Government-to-government Consultation

Federally-recognized tribes have a unique legal and political relationship with the government of the United States, as defined by the U.S. Constitution, treaties, statutes, court decisions, and executive orders. These definitive authorities also serve as the basis for the federal government's obligation to acknowledge the status of federally-recognized tribes.

The BLM consults with federally-recognized tribes, consistent with the Presidential Executive Memorandum dated April 29, 1994, on Government-to-Government Relations with Native American Tribal Governments; and Executive Order 13175 dated November 6, 2000, on Consultation and Coordination with Indian Tribal Governments. The BLM formally consults with federally-recognized tribes before taking action or undertaking activities that will have a substantial, direct effect on federally-recognized tribes, or their assets, rights, services, or programs. To this end, formal Government-to-Government consultation with federally-recognized traditional governments was initiated by written correspondence in July 2002 (see Appendix F).

The letter sent to all of the tribal governments described the proposed action. The tribes were provided with information on the project and were asked to provide the BLM with any concerns they might have about any of the proposed vegetation treatments and their impacts on subsistence, religious, and ceremonial purposes and traditional cultural properties.

The BLM invited the tribes to call if they had questions or wanted to set up individual meetings with the BLM. The letter also invited the tribal councils to attend the scoping meeting scheduled for their community.

List of Preparers of the Programmatic EIS

The following specialists (and company/agency and area of specialty) that participated in the development of the PEIS are listed below. Agencies included the BLM, USEPA, USFWS, and NOAA Fisheries Subcontractors that provided assistance to the BLM during preparation of the Draft PEIS/PER included ENSR International (ENSR); Historical Research Associates (HRA); Planera, Inc. (Planera); and Paleo Consultants.

TABLE 5-1
List of Preparers of the Programmatic EIS/ER

Contributor	Areas of Specialty	Years of Experience	Highest Degree/Education
Bureau of Land Management			
Scott Abdon	Recreation and Visitor Services Management	36	B.S., Forest and Recreation Management
Fran Ackley	Wild Horses and Burros	21	B.S., Range and Forest Management
Brian Amme	Co-Project Manager and NEPA Specialist	22	B.A., Cultural Anthropology
Scott Archer	Air Resources	28	B.S., Chemistry and Environmental Science
Miles Brown	Rangeland Management, Invasive Species, and Natural Resource Planning	25	B.S., Rangeland Management
Lisa Bryant	Soils and Invasive Species	16	M.S., Soil Science
Wendy Bullock	Spatial Data Analysis and Geographic Information System	27	B.S., Civil Engineering
Thomas Burke	Archaeology and Cultural Resources Management	31	Ph.D., Anthropology
Tim Burton	Fisheries Biology, Hydrology, and Aquatic Ecology	29	M.S., Watershed Science
Bill Carey	Hydrology, Water Quality, and Sediment Transport	30	M.S., Geophysics
Christina Caswell	Economics	13	B.B.A., Marketing, Economics, and International Business
Erik Christiansen	Fire and Fuels Management	27	M.S., Forest Protection, Silviculture, and Forestry
Jerry Cordova	Native American and Alaska Native Issues and Tribal Liaison Coordinator	32	B.S., Political Science and Native American Studies
Brad Cownover	Visual Resource Management and Landscape Architecture	10	B.S., Landscape Architecture
Cliff Faning	Soil	32	B.S., Soil Science
Scott Feldhausen	Fish and Fish Habitat, and Threatened, Endangered, and Sensitive Species Consultation	17	B.S., Fisheries
Karl Ford	Human Health, Ecological Risk Assessment, and Toxicology	32	Ph.D., Toxicology
Carl Gossard	Fire Management and Smoke Management	26	B.S., Natural Resource Management
Jeannette Griese	Forestry	16	B.S., Resource Management
Ruth Gronquist	Noxious Weeds and Invasive Species, Alaska State Weed Coordinator, and Wildlife Biology	23	B.S., Biology
Bill Grossi	Wildlife Habitat and Species of Concern	27	B.S., Wildlife Ecology
Theresa Hanley	Cultural Resources and Planning	15	M.A., Anthropology
Dave Harmon	Wilderness and Forestry	30	M.S., Forest Management
Rob Hellie	National Landscape Conservation System	32	B.S., Outdoor Recreation
Patricia Hester	Paleontology	20	M.S., Geology

TABLE 5-1 (Cont.)
List of Preparers of the Programmatic EIS/ER

Contributor	Areas of Specialty	Years of Experience	Highest Degree/Education
Barbara Hill	Wildlife Resources and Threatened, Endangered, and Sensitive Species	27	M.S., Wildlife Biology
Mike "Sherm" Karl	Plant Ecology and Livestock Grazing Management	24	Ph.D., Rangeland Ecology
Lee Koss	Hydrology and Riparian Restoration	35	B.S., Water Resource Management, Civil and Engineering, and Biology
Richard Lee	Herbicide Use and Management	21	Ph.D., Weed Science
Bonnie Lippitt	Recreation, Interpretation, and Tourism	22	B.S., Recreation Administration
Elroy Masters	Recreation, Fish and Wildlife Management, and Land Use Planning	14	B.A., Biology
Rosemary Mazaika	Water Resources, Wetlands, and Riparian Areas	16	M.S., Wildlife Ecology and Management M.A., Public Policy and Administration
Erin McConnell	Weed Management, Plant Science, and Recreation	12	B.S., Forestry and Recreation
Henry McNeel	Integrated Weed Management	47	M.S., Plant Science
Melanie Miller	Fire Ecology and Plant Ecology	31	M.S., Forestry
Joseph Moreau	Fish Resources	24	M.S., Natural Resources and Fish Biology
Dan Muller	Natural Resource and Watershed Management	28	B.S., Watershed Science
Robert Ohrn	Forestry	30	B.S., Forestry
Doug Powell	Rangeland Management and Livestock Grazing	25	B.S., Natural Resources
Gina Ramos	Co-Project Manager and Weed Management, Invasive Species, Pesticide Use, Range Management, and Economics	24	B.S., Range Science M.B.A., Business Administration
Roger Rosentreter	Botany, Plant Ecology, Weed Control, and Plant Species of Concern	27	Ph.D., Botany
Paul Schlobohm	Smoke Management and Fire	20	M.S., Environmental and Natural Resource Science
Carol Spurrier	Native Plant Communities and Species of Concern	26	M.S., Biology
Paul Summers	Groundwater Hydrology and Water Resources	36	B.S., Geology and Water Resources
John Styduhar	Realty and Rights-of-ways	35	B.S., Forest Science
Peter Teensma	Fire Ecology, Fire Management, and Air Quality Management	27	Ph.D., Geography
Rick Tholen	Forestry, Forest Health, and Landscape Ecology	28	M.S., Forest Management
Joan Trent	Social Environment and Social Impact Assessment	27	M.S., Environmental Science and Social Science
Sharon Wilson	Public Relations	43	B.A., Journalism
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TABLE 5-1 (Cont.)
List of Preparers of the Programmatic EIS/ER

Contributor	Areas of Specialty	Years of Experience	Highest Degree/Education
Margaret Wolf	Outdoor Recreation	28	M.S., Public Administration
William Ypsilantis	Soils	28	M.S., Forest Soils
Environmental Protection Agency			
Sid Abel	Environmental Chemistry and Modeling	30	M.S., Science
Tom Bailey	Fishery Biology and Aquatic Toxicology	26	Ph.D., Zoology
Angel Chiri	Entomology and Integrated Pest Management	25	Ph.D., Entomology
Pat Cimino	Pesticide Regulation, Plant Pathology, and Weed Science	29	M.S., Plant Pathology
Roxolana Dashuba	Air Quality Modeling and Environmental Fate	4	M.S., Chemistry
Mike Davy	Phytotoxicity and Ecological Risk Assessment	29	B.S., Agronomy
Michelle Embry	Ecotoxicology and Molecular Toxicology	7	Ph.D., Toxicology
William Erickson	Wildlife Biologist and Ecological Risk Assessment	30	Ph.D., Ecology
Jeff Evans	Toxicology and Pesticide Exposure	30	B.S., Agronomy
Brian Kiernan	Forest and Plant Ecology	7	M.S., Plant Ecology
Arty Williams	Endangered Species Act Implementation and Pesticide Registrations	26	B.S., Wildlife Biology
U.S. Fish and Wildlife Service			
Maria Boroja	Forest Management, Environmental Contaminants, and Fish and Wildlife Biology	16	B.S., Wildlife Management
Michael Horton	Endangered Species Coordinator	15	M.S., Wildlife Management
Jim Serfis	Endangered Species and Environmental Assessments	21	M.S., Environmental Studies
Ken Seeley	Ecological Risk Assessment and Environmental Toxicology	15	Ph.D., Marine Science
National Oceanic and Atmospheric Administration Fisheries Service			
Rachel Friedman	Endangered Species, Pesticide Ecosystem Effects, Contaminated Sediments, and Water Biotic Effects	25	M.S., Forest Ecology
Kelly Foster	Endangered Species Act Section 7 Consultation and Marine Biology	14	M.S., Biological Oceanography
ENSR International			
Jon Alstad	Rangeland Management	26	M.S., Range Science
Kimberly Anderson	Botany, Species of Concern, and Editor	7	M.S., Botany
Christine Archer	Ecological Risk Assessment	9	B.S., Zoology
Robert Berry	Hydrogeologist and Water Quality	29	Ph.D., Geology and Geochemistry
Lisa Bradley	Human Health Risk Assessment	22	Ph.D., Toxicology
Amanda Canning	Fish and Other Aquatic Organisms	4	B.S., Environmental Science
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TABLE 5-1 (Cont.)
List of Preparers of the Programmatic EIS/ER

Contributor	Areas of Specialty	Years of Experience	Highest Degree/Education
Rollin Daggett	Fish and Other Aquatic Organisms	30	M.S., Freshwater and Marine Biology
Gail Dethloff	Ecological Risk Assessment	11	Ph.D., Toxicology
Doree DuFresne	Ecological Risk Assessment	18	B.S., Biology and Microbiology
Kristie Dunkin	Soil, Wetlands, and Water Resources	16	Ph.D., Soil Science
Steve Ellsworth	Wildlife and Wetland Ecology	22	M.S., Wildlife Management
Ara Erickson	Forest Ecology	3	M.S., Forest Ecology
Cameron Fisher	Fish, Other Aquatic Organisms, and Geographic Information System	10	M.S., Marine Science and Fisheries Ecology
Barry Flaming	Soil Resources and Geographic Information System	3	M.S., Forest Ecology
Lucy Fraiser	Human Health Risk Assessment	17	Ph.D., Toxicology
Marcus Garcia	Human Health Risk Assessment	12	B.S., Toxicology
Robert Gensemer	Aquatic Toxicology and Ecological Risk Assessment	21	Ph.D., Biology
Mark Gerath	Ecological Risk Assessment	20	M.S., Environmental Engineering
Melisa Holman	Rangeland and Invasive Species	4	M.S., Forest and Rangeland Ecology
Alissa Long	Wetland and Aquatic Resources	8	B.S., Ecology, Evolution, and Conservation Biology
Amanda MacNutt	Air Quality	4	B.S., Meteorology
Ken Mongar	Graphics	16	A.T.A., Tele-data Communications
Rami Naddy	Ecological Risk Assessment	16	Ph.D., Environmental Toxicology
Kathleen Nolan	Human Health Risk Assessment	15	M.S., Public Health
Robert Paine	Air Quality	30	M.S., Meteorology
Merlyn Paulson	Visual Resources	29	M.L.S, Landscape Architecture, Geographic Information System
Stuart Paulus	Project Manager, NEPA Specialist, and Wildlife Ecology	25	Ph.D., Wildlife Ecology
David Pillard	Ecological Risk Assessment	24	Ph.D., Ecology
Devan Richardson	Wild Horses and Burros, Livestock	6	M.S., Range Management
Vanessa Stevens	Plant and Soil Sciences	5	M.S., Plant and Soil Science
Kelly Sullivan	Human Health Risk	10	M.S., Civil and Environmental Engineering and Environmental Health
Frank Vertucci	Ecological Risk Assessment	27	Ph.D., Ecology and Evolutionary Biology
Kristine Wandland	Ecological Risk Assessment	10	M.S., Natural Resources and Terrestrial Ecology
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Ann Emmons	History	14	M.A., History
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Rebecca Hanna	Paleontology	17	M.S., Earth Science

TABLE 5-1 (Cont.)
List of Preparers of the Programmatic EIS/ER

Contributor	Areas of Specialty	Years of Experience	Highest Degree/Education
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CHAPTER 6

REFERENCES

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REFERENCES

Adams, L., W. Collins, B. Dale, and K. Joly. 2000. Assessing Wildlife Fire Impacts on Winter Habitat Use and Distribution of Caribou within Alaska's Boreal Forest Ecosystem. U.S. Geological Survey and Alaska Department of Fish and Game. Juneau, Alaska.

Adovasio, J.M. 1986. Prehistoric Basketry. Pages 194-205 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, General ed.). Smithsonian Institution. Washington, D.C.

Agee, J. 1993. Fire Ecology of Pacific Northwest Forests. Island Press. Washington, D.C.

Agyagos, J., A. Telles, and R. Fletcher. 2001. Biological Assessment and Evaluation: Wildland Urban Interface Fuel Treatment. U.S. Department of Agriculture Forest Service, Southwestern Region. Albuquerque, New Mexico.

Aikens, M.C. 1983. The Far West. Pages 203-241 *in* Ancient North Americans (J.D. Jennings, ed.). W.H. Freeman and Company. New York, New York.

________, and D.B. Madsen. 1986. Prehistory of the Eastern Area. Pages 149-160 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Aldridge, D.W., B.S. Payne, and A.C. Miller. 1987. The Effects of Intermittent Exposure to Suspended Solids and Turbulence on Three Species of Freshwater Mussels. Environmental Pollution 45:17-28.

Allen, E.B., and N.E. West. 1993. Nontarget Effects of the Herbicide Tebuthiuron on Mycorrhizal Fungi in Sagebrush Semidesert. Mycorrhiza 3:75-78.

Allen, M.F. 1991. Ecology of Mycorrhizae. Cambridge University Press. Cambridge, United Kingdom.

Alley, W.M., T.E. Reilly, and O.L. Franke. 1999. Sustainability of Ground-water Resources. U.S. Geological Survey Circular 1186. Available at: http://water.usgs.gov/pubs/circ/circ1186/index.html.

Aly, O. M., and S. D. Faust. 1964. Studies on the Fate of 2,4-D and Ester Derivatives in Natural Surface Waters. Agricultural Food Chemistry 12:541-546.

Amaranthus, M., H. Jubas, and D. Arthur. 1989. Stream Shading, Summer Streamflow, and Maximum Water Temperatures Following Intense Wildfires in Headwater Streams. General Technical Report PSW-109: 75-78. U.S. Department of Agriculture Forest Service, Pacific Southwest Research Station. Albany, California.

American Cyanamid. 1986. Arsenal Herbicide: Technical Report. American Cyanamid Agricultural Division. Madison, New Jersey.

Ames, K.M., D.E. Dumond, J.R. Galm, and R. Minor. 1998. Prehistory of the Southern Plateau. Pages 73-80 *in* Plateau (D.E. Walker, Jr., ed.). Handbook of North American Indians, Volume 12 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

________, and H.D.G. Maschner. 1999. Peoples of the Northwest Coast: Their Archeology and Prehistory. Thames and Hudson Ltd. London, England.

Andersen, S.M., P.B. Hertz, T. Holst, R. Bossi, and C.S. Jacobsen. 2001. Mineralisation Studies of C-14-labelled Metsulfuron-methyl, Tribenuron-methyl, Chlorsulfuron and Thifensulfuron-methyl in One Danish Soil and Groundwater Sediment Profile. Chemosphere 45:775-782.

Anderson, D.C., K.T. Harper, and S.R. Rushforth. 1982. Recovery of Cryptogamic Soil Crusts from Grazing on Utah Winter Ranges. Journal of Range Management 35(3):355-359.

Anderson, D.D. 1984. Prehistory of North Alaska. Pages 80-93 *in* Arctic (D. Damas, ed.). Handbook of North American Indians, Volume 5 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Anderson, R. 1988. Montane Hardwood-conifer. Pages 70-71 *in* A Guide to Wildlife Habitats to California (K.E. Mayer and W.F. Laudenslayer, Jr., eds.). California Department of Forestry and Fire Protection. Sacramento, California.

Anderson, L. 2001. Terrestrial Wildlife and Habitat. Chapter 7 *in* Fire Effects Guide. National Wildfire Coordinating Group, National Interagency Fire Center. Boise, Idaho. Available at: http://fire.r9.fws.gov/ifcc/monitor/EFGuide/index.htm.

Anderson, W.P. 1983. Weed Science: Principles. 2nd Edition. West Group, Eagan, Minnesota.

Andreev, V. N. 1954. The Growth of Forage Lichens and the Methods for Their Regulation. Geobotanika 9:11-74.

Aquatic Ecosystem Restoration Foundation. 2004. Aquatic Plant Management: Best Management Practices Handbook in Support of Fish and Wildlife Habitat. Volume 3M CMC 2-13-4. Aquatic Ecosystem Restoration Foundation, Lansing, Michigan.

Archer, S. 1995. Tree-grass Dynamics in a Prosopis-thornscrub Savanna Parkland: Reconstructing the Past and Predicting the Future. Ecoscience 2:83-99.

Arend, J.L. 1950. Influence of Fire and Soil on Distribution of Redcedar in the Ozarks. Journal of Forestry 48:129-130.

Arno, S.F. 1988. Fire Ecology and its Management Implications in Ponderosa Pine Forests. Pages 13-140 *in* Ponderosa Pine—the Species and Its Management: Symposium Proceedings (D.M. Baumgartner and J.E. Lotan, eds.). September 29–October 1, 1987, Spokane, Washington. Washington State University Cooperative Extension. Pullman, Washington.

________. 2000. Fire in Western Forest Ecosystems. Pages 97-120 *in* Wildland Fire in Ecosystems: Effects of Fire on Flora (Brown, J.K. and J.K. Smith, eds.). General Technical Report RMRS-GTR-42-Volume 2. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Ogden, Utah.

Austin, A.P., G.E. Harris, and W.P. Lucey. 1991. Impact of an Organophosphate Herbicide (Glyphosate) on Periphyton Communities Developed in Experimental Streams. Bulletin of Environmental Contamination and Toxicology 41:29-35.

Back, G.N., B.L. Perryman, and J.K. McAdoo. 2002. Application of Sage Grouse Guidelines to Sage Grouse Habitats in Nevada. Paper Presented at the Restoration and Management of Sagebrush/grass Communities. Workshop, Elko, Nevada.

Badejo, M.A., and T.A. Adejuyigbe. 1994. Influence of Hexazinone on Soil Microarthropods in Nigeria. Fresenius Environmental Bulletin 3:263-268.

Bahre, C.J. 1985. Wildfire in Southeastern Arizona Between 1859 and 1890. Desert Plants 7(4):190-194.

Bailey, R.G. 1997. Map: Ecoregions of North America (Revised). (Scale: 1:15,000,000). U.S. Department of Agriculture Forest Service in Cooperation with the Nature Conservancy and the U.S. Geological Survey. Washington, D.C.

________. 2002. Ecoregions. Pages 235-245 *in* The Physical Geography of North America (A.R. Orme, ed.). Oxford University Press. Oxford, England.

Barbash, J. E., G. P. Thelin, D. W. Kolpin, and R. J. Gilliom. 1999. Distribution of Major Herbicides in Ground Water of the United States. Water-resources Investigations Report 98-4245.

Barker, C., K. Drottar, and H. Krueger. 1998. Toxicity of AC263,222 During the Early Life-stages of the Flathead Minnow (*Pimephales promelas*): Lab Project Number 2CO 98-134; 954-98-134; 130A-120. Unpublished Study by Wildlife International, Ltd. OPPTS 850.1440. MRID No. 44728202.

Barrows, D.P. 1900. The Ethnobotany of the Cahuilla Indians of Southern California. Ph.D. Dissertation, University of Chicago. Chicago, Illinois.

Basso, K.H. 1983. Western Apache. Pages 462-488 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Battaglin, W.A., E.T. Furlong, M.R. Burkhardt, and C.J. Peter. 2000. Occurrence of Sulfonylurea, Sulfonamide, Imidazolinone, and Other Herbicides in Rivers, Reservoirs and Ground Water in the Midwestern United States, 1998. Science of the Total Environment 248:123-133.

________, ________, and ________. 2001. Concentration of Selected Sulfonylurea, Sulfonamide, and Imidazolinone Herbicides, Other Pesticides, and Nutrients in 71 Streams, 5 Reservoir Outflows, and 25 Wells in the Midwestern United States, 1998. Water-resources Investigations Report 00–4225. USGS. Denver, Colorado.

Bean, L.J., and K.S. Sabel. 1972. Cahuilla Indian Knowledge and Usage of Plants. Malki Museum Press. Banning, California.

Beaver, D.L. 1976. Avian Populations in Herbicide Treated Brush Fields. Auk 93:543-553.

Beck, K.G. 1999. Biennial Thistles. Pages 145-165 *in* Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petroff, eds). Oregon State University Press. Corvallis, Oregon.

Behnke, R.J. 1992. Native Trout of Western North America. American Fisheries Society Monograph Number 6. Washington, D.C.

Belnap, J. 1994. Potential Role of Cryptobiotic Soil Crust in Semiarid Rangelands. Pages 179-185 *in* Proceedings—Ecology and Management of Annual Rangelands. (S.B. Monsen and S.G. Kitchen, eds.). General Technical Report INT-GTR-313. U.S. Department of Agriculture Forest Service, Intermountain Research Station. Ogden, Utah.

________. 1995. Surface Disturbances: Their Role in Accelerating Desertification. Environmental Monitoring and Assessment 37:39-57.

________, R. Rosentreter, S. Leonard, J.H. Kaltenecker, J. Williams, and D. Eldridge. 2001. Biological Soil Crusts: Ecology and Management. USDI BLM and U.S. Geological Survey Technical Reference 1730-2. Washington, D.C.

________. 2005. Personal Communication with K. Dunkin, ENSR, on Effects of Herbicides on Biological Soil Crusts. U.S. Biological Resources Division, Canyonlands Research Station. Moab, Utah.

________, and J.S. Gardner. 1993. Soil Microstructure of the Colorado Plateau: The Role of the Cyanobacterium *Microcoleus vaginatus*. Great Basin Naturalist 53:40-47.

________, and D.A. Gillette. 1998. Vulnerability of Desert Soil Surfaces to Wind Erosion: Impacts of Soil Texture and Disturbance. Journal of Arid Environments 39:133-142.

________, and S. L. Phillips. 2001. Soil Biota in an Ungrazed Grassland: Response to Annual Grass (*Bromus Tectorum*) Invasion. Ecological Applications 11:1261-1275.

________, R. Rosentreter, S. Leonard, J.H. Kaltenecker, J. Williams, and D. Eldridge. 2001. Biological Soil Crusts: Ecology and Management. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center. Report Technical Reference 1730-2. Denver, Colorado.

Belsky, A.J., and J.L. Gelbard. 2000. Livestock Grazing and Weed Invasions in the Arid West. Oregon Natural Desert Association. Bend, Oregon.

Bender, G.L. (ed.). 1982. Reference Handbook on the Deserts of North America. Greenwood Press. Westport, Connecticut.

Bendix, J. 2002. Pre-european Fire in California Chaparral, *in* Fire, Native Peoples, and the Natural Landscape (T.R. Vale, ed.). Island Press. Washington, D.C.

Beran, D.D., R.E. Gaussoin, and R.A. Masters. 1999. Native Wildflower Establishment with Imidazolinone Herbicides. Hortscience 34(2):283-286.

Berg, N.H., D. Azuma, and A. Carlson. 2002. Effects of Wildfire on In-channel Woody Debris in the Eastern Sierra Nevada, California. General Technical Report PSW-GTR-181. U.S. Department of Agriculture Forest Service, Pacific Southwest Research Station. Albany, California.

Berrill, M., S. Bertram, and B. Pauli. 1997. Effects of Pesticides on Amphibian Embryos and Larvae. Pages 233-245 *in* Amphibians in Decline: Canadian Studies of A Global Problem (D.M. Greed, ed.). Society for the Study of Amphibians and Reptiles.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream Temperature and Aquatic Habitat: Fisheries and Forestry Interactions. Pages 191-232 *in* Streamside Management: Forestry and Fishery Interactions. University of Washington, Institute of Forest Resources Contribution 57. Seattle, Washington.

Bevans, H.E., M.S. Lico, and S.J. Lawrence. 1998. Water Quality in the Las Vegas Valley Area and the Carson and Truckee River Basins, Nevada and California, 1992-96. U.S. Geological Survey Circular 1170. Available at: http://water.usgs.gov/pubs/circ1170.

Beyers, J.L., and W.O. Wirtz, II. 1997. Vegetative Characteristics of Coastal Sage Scrub Sites Used by California Gnatcatchers: Implications for Management in a Fire-prone Ecosystem. Pages 81-96 *in* Fire Effects on Rare and Endangered Species and Habitats (J.M. Greenlee, ed.). International Association of Wildland Fire. Fairfield, Washington.

Biological Resources Research Center. 2001. Threatened and Endangered Animals of the Great Basin. University of Nevada. Reno, Nevada. Available at: http://www.brrc.unr.edu.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Bethesda, Maryland.

Blaisdell, J.P. and R.C. Holmgren. 1984. Managing Intermountain Rangelands—Salt Desert Shrub Ranges. U.S. Department of Agriculture Forest Service General Technical Report INT-163. Intermountain Research Station. Ogden, Utah.

Blank, R.R., J.A. Young, and F.L. Allen. 1995. The Soil Beneath Shrubs Before and After Wildfire: Implications for Revegetation. Pages 173-176 *in* Proceedings: Wildland Shrub and Arid Land Restoration Symposium. April 1995. General Technical Report GTR-315. U.S. Department of Agriculture Forest Service, Intermountain Forest and Range Experiment Station. Ogden, Utah.

Bleak, A.T., N.C. Frischknecht, A.D. Plummer, and R. E. Eckert, Jr. 1965. Problems in Artificial and Natural Revegetation of the Arid Shadscale Vegetation Zone of Utah and Nevada. Journal of Range Management 18:59-65.

Blumler, M.A. 1992. Some Myths About California Grasslands and Grazers. Fremontia 20:22-27.

Bodine, J.J. 1979. Taos Pueblo. Pages 255-267 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Boertje, R.R., and C.L. Garner. 1998. Factors Limiting the Fortymile Caribou Herd. Federal Aid Final Report Study 3.38. Alaska Department of Fish and Game. Fairbanks, Alaska.

Bogan M.A., C.D. Allen, E.H. Muldavin, S.P. Platania, J.N. Stuart, G.H. Farley, P. Mehlhop, and J. Belnap. 2003. Southwest *in* Status and Trends of the Nation's Biological Resources. Available at: http://biology.usgs.gov/s+t/SNT/index.htm.

Bohn C.C., and J.C. Buckhouse. 1985. Coliforms as an Indicator of Water Quality in Wildland Streams. Journal of Soil and Water Conservation 40:95-97.

Bolen, E.G. 1998. Ecology of North America. John Wiley and Sons, Inc. New York, New York.

Bonneville Power Administration (BPA). 2000. Transmission System Vegetation Management Program Final Environmental Impact Statement. Portland, Oregon.

Boreson, K. 1998. Rock Art. Pages 611-619 *in* Plateau (D.E. Walker, ed.). Handbook of North American Indians, Volume 12 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Borjesson, E., L. Torstensson, and J. Stenstrom. 2004. The Fate of Imazapyr in a Swedish Railway Embankment. Pest Management Science 60:544-549.

Bossard, C.C., J.M. Randal, and M.C. Hoshovsky (eds.). 2000. Invasive Plants of California's Wildlands. University of California Press. Berkeley, California.

Bottrell, D.G. 1979. Integrated Pest Management. Council of Environmental Quality. Washington, D.C.

Boucard, T.K., R.D. Bardgett, K.C. Jones, and K.T. Semple. 2005. Influence of Plants on the Chemical Extractability and Biodegradability of 2,4-dichlorophenol in Soil. Environmental Pollution 133:53-62.

Boutin, C., N. Elmegaard, and C. Kjaer. 2004. Toxicity Testing of Fifteen Non-crop Plant Species with Six Herbicides in a Greenhouse Experiment: Implications for Risk Assessment. Ecotoxicology 13(4):349-369.

Bovey, R.W. 2001. Woody Plants and Woody Plant Management. Marcel Dekker, Inc. New York, New York.

Bowser, P.R., W.W. Falls, J. Van Zandt, N. Collier, and J.D. Phillips. 1983. Methemoglobinemia in Channel Catfish: Methods of Prevention. Progressive Fish Culturist 45:154-158.

Brabets, T.P., B. Wang, and R.H. Meade. 2000. Environmental and Hydrologic Overview of the Yukon River Basin, Alaska and Canada. U.S. Geological Survey Water-resources Investigations Report 99-4204. Washington, D.C.

Brady, N.C., and R.R. Weil. 1999. The Nature and Properties of Soils (12[th] Edition). Prentice-Hall, Inc. Upper Saddle River, New Jersey.

Braun, C.E. 1980. Alpine Bird Communities in Western North Implications for Management and Research. Pages 280-291 *in* Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds (R.M. DeGraaf and N.G. Tilghman, eds.). U.S. Department of Agriculture Forest Service General Technical Report INT-86.

________, T. Britt, and R.O. Wallestad. 1977. Guidelines for the Maintenance of Sage Grouse Habitats. Wildlife Society Bulletin 5:99-106.

British Crop Protection Council and The Royal Society of Chemistry. 1994. The Pesticide Manual - Incorporating the Agrochemicals Handbook. 10[th] Edition. British Crop Protection Council and Royal Society of Chemistry. Surrey and Cambridge, United Kingdom.

Brotherson, J.D., S.R. Rushforth, and J.R. Johansen. 1983. Effects of Long-term Grazing on Cryptogam Crust Cover in Navajo National Monument, Arizona. Journal of Range Management 36:579-581.

Brown, D.E. (ed.). 1982. Desert Plants. Volume 4 of Biotic Communities of the American Southwest – United States and Mexico. University of Arizona, for the Boyce Thompson Southwestern Arboretum. Tucson, Arizona.

Brown, D.N., and L. Irwin. 2001. Ponca, Pages 416-431 *in* Plains (R.J. DeMallie, ed.). Handbook of North American Indians, Volume 13 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Brown, J.C., R.A. Evans, and J.A. Young. 1985. Effects of Sagebrush Control Methods and Seeding on Runoff and Erosion. Journal of Range Management 38:195-199.

Brown, J.K., and J.K. Smith (eds.). 2000a. Wildland Fire in Ecosystems: Effects of Fire on Fauna. General Technical Report RMRS-GTR-42, Volume 1. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Ogden, Utah.

Brown, L. 1985. Grasslands: The Audubon Society Nature Guides. Alfred A. Knopf. New York, New York.

Buckhouse, J.C., and G.F. Gifford. 1976. Grazing and Debris Burning on Pinyon-juniper Sites – Some Chemical Water Quality Implications. Journal of Range Management 29(4):299-301.

Buffington, L.C., and C.H. Herbel. 1965. Vegetation Changes on a Semidesert Grassland Range from 1858 to 1963. Ecological Monographs 35:139-164.

Bugg, R.L. 1994. Earthworm Update. Sustainable Agriculture Technical Reviews 6(3):3. Sustainable Agriculture Research and Education Program, University of California.

Burkhardt, J.W., and E.W. Tisdale. 1969. Natural and Successional Status of Western Juniper Vegetation in Idaho. Journal of Range Management 22:264-270.

Busse, M.D., G.O. Fiddler, and A.W. Ratcliff. 2004. Ectomycorrhizal Formation in Herbicide-treated Soils of Differing Clay and Organic Matter Content. Water Air and Soil Pollution 152:23-34.

Butler, B.R. 1986. Prehistory of the Snake and Salmon River Area. Pages 127-134 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W. C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Butler, V.L., and R.F. Schalk. 1986. Holocene Salmonid Resources of the Upper Columbia. Institute for Environmental Studies, Office of Public Archaeology, University of Washington. Seattle, Washington.

Cable, D.R. 1975. Range Management in the Chaparral Type and its Ecological Basis: the Status of Our Knowledge. Research Paper RM-155. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Fort Collins, Colorado.

Calabrese, E.J., and M.W. Dorsey. 1984. Healthy Living in an Unhealthy World. Simon and Schuster. New York, New York.

California Environmental Protection Agency (CalEPA). 1996. Memorandum from T. Formoli (California EPA, Department of Pesticide Regulation, Worker Health and Safety Branch) to M. Mason (California EPA, Department of Pesticide Regulation, Pesticide Regulation Branch).

Call, D.J., L.T. Brooke, R.J. Kent, M.L. Knuth, S.H. Poirier, J.M. Huot, and A.R. Lima. 1987. Bromacil and Diuron Herbicides: Toxicity, Uptake, and Elimination in Freshwater Fish. Archives of Environmental Contamination and Toxicology 16:607-613.

Callaway, D., J. Janetski, and O.C. Stewart. 1986. Ute. Pages 336-367 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Campbell, S.E. 1979. Soil Stabilization by a Prokaryotic Desert Crust: Implications for Precambrian Land Biota. Origins of Life 9:335-348.

Cannon, M.E., and G.A. Nielsen. 1984. Estimating Production of Range Vegetation from Easily Measured Soil Characteristics. Journal of the Soil Science Society of America 48:1393-1397.

Carlson, C.A., and E.M. Carlson. 1982. Review of Selected Literature on the Upper Colorado River System and its Fishes. Pages 1-8 *in* Fishes of the Upper Colorado River System: Present and Future (W.H. Miller, H.M. Tyus, and C.A. Calrson, eds.). Western Division, American Fisheries Society.

Carrick, S. 1992. Copper River Highway Environmental Impact Studies: Hydrologic Aspects. State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys. Fairbanks, Alaska.

Cassell, M. 1998. The Rio Grande. The Green Line Volume 9, Number 4. Colorado Riparian Association. Available at: http://www.coloradoriparian.org/GreenLine/V09-4/RioGrande.html.

Cavalier, T.C., T.L. Lavy, and J.D. Mattice. 1991. Persistence of Selected Pesticides in Groundwater Samples. Ground Water 29:225-231.

Centers for Disease Control and Prevention (CDC). 2001. Web-based Injury Statistics Query and Reporting System (WISQARS) [Online]. National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Washington, D.C. Available at: www.cdc.gov/ncipc/wisqars.

_______**. 2005.** Worker Health Chartbook 2004. Chapter 1. National Institute for Occupation Safety and Health. Hyattsville, Maryland. Available at: http://www2a.cdc.gov/niosh-Chartbook/ch1/ch1-3.asp.

Chamberlain, J., R. Bush, and A.L. Hammett. 1998. Non-timber Forest Products – The Other Forest Products. Forest Products Journal 48:10-19.

Chatters, J.C. 1998. Environment. Pages 29-48 *in* Plateau (D. Walker, ed.). Handbook of North American Indians, Volume 12 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

_______**, and D.L. Pokotylo. 1998.** Prehistory: Introduction. Pages 73-80 *in* Plateau (D.E. Walker, Jr., ed.). Handbook of North American Indians, Volume 12 (W.C. Sturtevant, general ed.) Smithsonian Institution. Washington, D.C.

Chaudhry, G.R., and L. Cortez. 1988. Degradation of Bromacil by a *Pseudomonas* Species. Applied and Environmental Microbiology 54:2203-2207.

Chiou, C.T., and D.E. Kile. 2000. Contaminant Sorption by Soil and Bed Sediment. Is There a Difference? Fact Sheet-087-00. U.S. Department of the Interior U.S. Geological Survey. Washington, D.C.

Chorley, R.J. (ed.). 1969. Introduction to Physical Hydrology. London, England.

Chu, M.M., and D. Kamely. 1988. Environmental Cancer and Biotechnology. Biotechnology, Volume 6.

Clark, G.M., T.R. Maret, M.G. Rupert, M.A. Maupin, W.H. Low, and D.S. Ott. 1998. Water Quality in the Upper Snake River Basin, Idaho and Wyoming, 1992-95. U.S. Geological Survey Circular 1160. Available at: http://water.usgs.gov/pubs/circ/circ1160.

Clarke, S.E., and S.A. Bryce (eds.). 1997. Hierarchical Subdivisions of the Columbia Plateau and Blue Mountains Ecoregions, Oregon and Washington. General Technical Report PNW-GTR-395. U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Clary, W.P. 1971. Effects of Utah Juniper Removal on Herbage Yields from Springerville Soils. Journal of Range Management 24:373-378.

Clelow, C.W., Jr. 1978. Prehistoric Rock Art. Pages 619-625 *in* California (R.F. Heizer, ed.). Handbook of North American Indians, Volume 8 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Clinnick, P.F. 1984. A Summary Review of the Effects of Fire on the Soil Environment. Soil Conservation Authority. Kew, Victoria, Australia.

Cluff, G.J., J.A. Young, and R.A. Evans. 1983. Edaphic Factors Influencing the Control of Wyoming Big Sagebrush and Seedling Establishment of Crested Wheatgrass. Journal of Range Management 36(6):786-792.

Coffin, P., and W. Cowan. 1995. Lahontan Cutthroat Trout (*Oncorhynchus clarki henshawi*) Recovery Plan. U.S. Fish and Wildlife Service, Region 1. Portland, Oregon.

Cole, E.D., W.C. McComb, M. Newton, C.J. Chambers, and J.P. Leeming. 1997. Response of Amphibians to Clearcutting, Burning, and Glyphosate Application in the Oregon Coast Range. Journal of Wildlife Management 61:656-664.

Cole, G.A. 1981. Habitats of North American Desert Fishes. Pages 477-492 *in* Fishes in North American Deserts (Naiman, R.J., and D.L. Soltz, eds.). Wiley-Interscience Publication. New York, New York.

Colorado Natural Areas Program. 2000. Creating an Integrated Weed Management Plan: A Handbook for Owners and Managers of Lands with Natural Values. Colorado Natural Areas Program, Colorado State Parks, Colorado Department of Natural Resources; and Division of Plant Industry, Colorado Department of Agriculture. Denver, Colorado.

Conetah, F.A. 1982. Uintah-Ouray Tribe *in* A History of the Northern Ute People (K.L. MacKay and F.A. O'Neil, eds.). Salt Lake City, Utah.

Cooperrider, A.Y., R.J. Boyd, and H.R. Stuart (eds.). 1986. Inventory and Monitoring of Wildlife Habitats. U.S. Bureau of Reclamation. Washington, D.C.

Cox, J.R., H.L. Morton, T.N. Johnson, Jr., G.L. Jordan, S.C. Martin, and L.C. Fleo. 1982. Vegetation Restoration in the Chihuahuan and Sonoran Deserts of North America. ARM-W-28. U.S. Department of Agriculture Resource Service. Washington, D.C.

Cronquist, A., A.H. Holmgren, N.H. Holmgren, and J.L. Reveal. 1972. Intermountain Flora. Vascular Plants of the Intermountain West, U.S.A, Volume 1. Hafner Publishing Company, Inc. New York, New York.

Deacon, J.E., and C.D. Williams. 1991. Ash Meadows and the Legacy of the Devils Hole Pupfish. Pages 69-87 *in* Battle Against Extinction: Native Fish Management in the American West (Minckley, W. L. and J.E. Deacon, eds.). University of Arizona Press. Tucson, Arizona.

DeBano, L.F. 1981. Water Repellent Soils. General Technical Report PSW-46. U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experiment Station. Berkeley, California.

________. 1989. Effects of Fire on Chaparral Soils in Arizona and California and Postfire Management Implications *in* Proceedings of the Symposium on Fire and Watershed Management (N.H. Berg, Technical Coordinator). October 26-28, 1988, Sacramento, California. General Technical Report PSW-109. U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experiment Station. Berkeley, California.

DeByle, N.V., and R.P. Winokur. 1985. Aspen: Ecology and Management in the Western United States. U.S. Department of Agriculture Forest Service General Technical Report RM-119. Rocky Mountain Research Station. Fort Collins, Colorado.

Dennehy, K.F., D.W. Litke, C.M. Tate, S.L. Qi, P.B. McMahon, B.W. Bruce, R.A. Kimbrough, and J.S. Heiny. 1998. Water Quality in the South Platte River Basin, Colorado, Nebraska, and Wyoming, 1992-95. U.S. Geological Survey Circular 1167. Available at: http://water.usgs.gov/pubs/circ1167.

Dennis, N. 1989. The Effects of Fire on Watersheds: A Summary *in* Proceedings of the Symposium on Fire and Watershed Management, October 26-28, 1988 (N.H. Berg, technical coordinator). Sacramento, California. General Technical Report PSW-109. U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experiment Station. Berkeley, California.

Devesa, S.S., D.G. Grauman, W.J. Blot, G. Pennello, R.N. Hoover, and J.F. Franmeni Jr. 1999. Atlas of Cancer Mortality in the United States, 1950-1994. National Institute of Health Publication No. 99-4564. U.S. Government Printing Office. Washington D.C. Available at: http://www.dceg.cancer.gov/egi-bin/atlas.

Dexter, A.G. 1993. Herbicide Spray Drift. North Dakota State University Extension Service Fact Sheet A-657 (revised). Available at: http://www.ext.nodak.edu/extpubs/plantsci/weeds/a657w.htm.

Diaz, G., C. Carrillo, and M. Honrubia. 2003. Differential Responses of Ectomycorrhizal Fungi to Pesticides in Pure Culture. Cryptogamie Mycologie 24:199-211.

Dickerson, M.C. 1969. The Frog Book: North American Toads and Frogs. New York, New York.

Dick-Peddie, W.A., and J.P. Hubbard. 1977. Classification of Riparian Vegetation. Importance, Preservation, and Management of Riparian Vegetation: A Symposium. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. General Technical Report RM-43. Fort Collins, Colorado.

Dixon, E.J. 1999. Bones, Boats, and Bison: Archaeology and the First Colonization of Western North America. University of New Mexico Press. Albuquerque, New Mexico.

Dodson, J.J., and C.I. Mayfield. 1979. The Dynamics and Behavioral Toxicity of Aqua-Kleen (2,4-D Butoxyethanol Ester) as Revealed by the Modification of Rheotropism in Rainbow Trout. Transactions of the American Fisheries Society 108(6):632-640.

Doerr, T.B., and F.S. Guthery. 1983. Effects of Tebuthiuron on Lesser Prairie-chicken Habitat and Foods. Journal of Wildlife Management 47:1138-1142.

Domagalski, J.L., D.L. Knifong, P.D. Dileanis, L.R. Brown, J.T. May, V. Connor, and C.N. Alpers. 2000. Water Quality in the Sacramento River Basin, California, 1994–98. U.S. Geological Survey Circular 1215. Available at: http://water.usgs.gov/pubs/circ1215.

Donaldson, D., T. Kiely, and A. Grube. 2004. 2000-2001 Pesticide Industry Sales and Usage. U.S. Environmental Protection Agency Pesticide's Program. Washington, D.C. Available at: http://www.epa.gov/oppbead1/pestsales/01pestsales/.

Dormaar, J.F., and W.D. Willms. 1998. Effect of Forty-four Years of Grazing on Fescue Grassland Soils. Journal of Range Management 51:122-126.

Douglas, M. E., and P. C. Marsh. 1996. Population Estimates/Population Movements of *Gila cypha*, An Endangered Cyprinid Fish in the Grand Canyon Region of Arizona. Copeia 1996:15-28.

________, P.C. Marsh, and W.L. Minckley. 1994. Indigenous Fishes of Western North America and the Hypothesis of Competitive Displacement: *Meda fulgida* (Cryprinidae). Copeia 1994:9-19.

Dow AgroSciences. 1998. Clopyralid: A North American Technical Profile. Dow AgroSciences LLC, 9330 Zionsville Road. Indianapolis, Indiana.

Dow Chemicals. 1980. Summary of Fish and Wildlife Data. Summary of Studies 099724-B through 099724-G. Unpublished Study Received November 12, 1980 Under 464-563; CDL:099724-A. MRID Number 00059968.

Downing, W.L. (ed.). 1980. Proceedings, National Conference on Urban Erosion and Sediment Control: Institutions and Technology. U.S. Environmental Protection Agency, EPA Report 905/9-80-002. Washington, D.C.

Driver, H.E., and W.C. Massey. 1957. Comparative Studies of North American Indians. Transactions of the American Philosophical Society 47(2). Philadelphia, Pennsylvania.

Dubrovsky, N.M., C.R. Kratzer, L.R. Brown, J.M. Gronberg, and K.R. Burow. 1998. Water Quality in the San Joaquin-Tulare Basins, California, 1992-95. U.S. Geological Survey Circular 1159. Available at: http://water.usgs.gov/pubs/circ1159.

Duchesne, L.C. and B.C. Hawkes. 2000. Fire in Northern Ecosystems. Pages 35-51 *in* Wildland Fire in Ecosystems: Effects of Fire on Flora (Brown, J.K. and J.K. Smith, eds.). General Technical Report RMRS-GTR-42-Volume 2. U.S. Department of Agriculture Forest Service Rocky Mountain Research Station. Ogden, Utah.

Duffy, W.G., C.R. Berry, and K.D. Keenlyne. 1996. Biology of the Pallid Sturgeon with an Annotated Bibliography Through 1994. South Dakota Cooperative Research Unit Technical Bulletin Number 5. South Dakota State University. Brookings, South Dakota.

Dumond, D.E. 1987. The Eskimos and Aleuts. Thames and Hudson, Ltd. London, United Kingdom.

Duncan, C.L., and J.K. Clark (eds.). 2005. Invasive Plants of Range and Wildlands and Their Environmental, Economic, and Social Impacts. Weed Science Society of America, Lawrence, Kansas.

Dunham, J. 1998. Bringing Back the Lahontan Cutthroat Trout: Restoring Habitat for Fish and People. Trout Magazine (Spring). Trout Unlimited.

Eckert, R.E., Jr., M.K. Wood, W.H. Blackburn, and F.F. Peterson. 1979. Impacts of Off-road Vehicles on Infiltration and Sediment Production of Two Desert Soils. Journal of Range Management 32:394-397.

Edison Electric Institute. 2002. Letter Dated March 29, 2002 from R. M. Loughery, Director of Environmental Activities, to B. Amme, NEPA Manager, BLM. Reno, Nevada. Washington, D.C.

Edwards, W.M., G.B. Triplett, Jr., and R.M. Kramer. 1980. A Watershed Study of Glyphosate Transport in Runoff. Journal of Environmental Quality 9:661-665.

Egan, H.R. 1917. Pioneering the West, 1846-1878: Major Howard Egan's Diary. Howard R. Egan Estate. Richmond, Utah.

Eijsackers, H., and J. Van Der Drift. 1976. Effects on the Soil Fauna. Pages 149-174 *In* Herbicides Physiology, Biochemistry, and Ecology. Academic Press, London.

Eisler, R. 1991. Cyanide Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. USDI Fish and Wildlife Service. Washington, D.C.

Eldridge, D.J. 1996. Distribution and Floristics of Terricolous Lichens in Soil Crusts in Arid and Semi-arid New South Wales, Australia. Australian Journal of Botany 44:581-599.

________, and R.S.B. Greene. 1994. Microbiotic Soil Crusts: A Review of Their Roles in Soil and Ecological Processes in the Rangelands of Australia. Australian Journal of Soil Research 32: 389-415.

Elston, R.G. 1986. Prehistory of the Western Area. Pages 135-148 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11. (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Energy Information Administration. 2001. U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2001 Annual Report. Available at: http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/current/pdf/cover.pdf.

________. 2003. U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2002 Annual Report. Available at: http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/current/pdf/cover.pdf.

Engle, D.M., J.F. Stritzke, and P.L. Claypool. 1987. Herbage Standing Crop Around Easter Redcedar Trees. Journal of Range Management 40:237-239.

________, T.G. Bidwell, J. F. Stritzke, and D. Rollins. 1990. Atrazine and Burning in Tallgrass Prairie Infested with Prairie Threeawn. Journal of Range Management 43:424-427.

English Nature. 2003. The Herbicide Handbook: Guidance on the Use of Herbicides on Nature Conservation Sites. Nature Contract No. EIT 31-04-003. Wetherby, West Yorkshire, United Kingdom.

ENSR. 2001. The Effects of Herbicides on Plants Used for Subsistence by Native Americans on Yakima Training Center, Washington. Prepared for the Department of the Army, Fort Lewis, Washington. Redmond, Washington.

________. 2002. Scoping Comment Summary Report for the Vegetation Treatments Programmatic Environmental Impact Statement. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Redmond, Washington.

________. 2003. Air Quality Policies Summary Report for the Vegetation Treatments Programmatic EIS. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

________. 2004. Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005a.** Annual Emissions Inventory for BLM Treatment Alternatives. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005b.** Vegetation Treatments Programmatic EIS – Bromacil Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005c.** Vegetation Treatments Programmatic EIS – Chlorsulfuron Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005d.** Vegetation Treatments Programmatic EIS – Diflufenzopyr Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005e.** Vegetation Treatments Programmatic EIS – Diquat Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005f.** Vegetation Treatments Programmatic EIS – Diuron Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005g.** Vegetation Treatments Programmatic EIS – Fluridone Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005h.** Vegetation Treatments Programmatic EIS – Imazapic Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005i.** Vegetation Treatments Programmatic EIS – Overdrive® Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005j.** Vegetation Treatments Programmatic EIS – Sulfometuron methyl Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005k.** Vegetation Treatments Programmatic EIS – Tebuthiuron Ecological Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005l.** Vegetation Treatments Programmatic EIS Human Health Risk Assessment Final Report. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

_______. **2005m.** Air Quality Modeling for BLM Vegetation Treatment Methods. Prepared for the U.S. Department of the Interior Bureau of Land Management, Nevada State Office. Reno, Nevada. Westford, Massachusetts.

Environmental Laboratory. 1987. Corps of Engineers Wetland Delineation Manual. Technical Report Y-87-1, U.S. Army Engineers Waterways Experimental Station. Vicksburg, Mississippi.

Eschholz, W.E., F.A. Servello, B. Griffith, K.S. Raymond, and W.B. Krohn. 1996. Winter Use of Glyphosate-treated Clearcuts by Moose in Maine. Journal of Wildlife Management 60(4):764-769.

Estok, D., B. Freedman, and D. Boyle. 1989. Effects of the Herbicides 2,4-D, Glyphosate, Hexazinone, and Triclopyr on the Growth of Three Species of Ectomycorrhizal Fungi. Bulletin of Environmental Contamination and Toxicology 42:835-839.

Evans, R.A., R.E. Eckert, and J.A. Young. 1975. The Role of Herbicides in Management of Pinyon-juniper Woodlands. Pages 83-89 *in* The Pinyon-juniper Ecosystem: A Symposium (G.F. Gifford and F.E. Busby, eds.). Utah State University, Logan.

Evans, R.D., and J.R. Ehleringer. 1993. A Break in the Nitrogen Cycle in Aridlands? Evidence from ^{15}N isotope of Soils. Oecologia 94:314-317.

________, and J. Belnap. 1999. Long-term Consequences of Disturbance on Nitrogen-cycling in an Arid Grassland. Ecology 80:150-160.

Extension Toxicology Network (Extoxnet). 1993. Pesticide Information Profiles. A Pesticide Information Project of Cooperative Extension Offices of Cornell University, Oregon State University, the University of Idaho, the University of California at Davis, and the Institute for Environmental Toxicology, Michigan State University. Available at: http://extoxnet.orst.edu/.

________. 1996a. Glyphosate. Pesticide Information Profiles. Extension Toxicology Network. Available at: http://extoxnet.orst.edu/pips/glyphosa.htm.

________. 1996b. Metsulfuron Methyl. Pesticide Information Profiles. Extension Toxicology Network. Available at: http://extoxnet.orst.edu/pips/metsulfu.htm.

________. 1996c. Picloram Pesticide Information Profile. Extension Toxicology Network: A Pesticide Information Project of Cooperative Extension Offices of Cornell University, Michigan State University, Oregon State University, and University of California at Davis. Revised June, 1996. Available at: http://ace.orst.edu/cgi-bin/mfs/01/pips/picloram.htm.

________. 1996d. Sulfometuron Methyl. Pesticide Information Profiles. Extension Toxicology Network. Available at: http://extoxnet.orst.edu/pips/sulfomet.htm.

________. 1996e. Atrazine. Pesticide Information Profiles. Extension Toxicology Network. Available at: http://extoxnet.orst.edu/pips/atrazine.htm.

Fagerston, K.A., H.P. Tietjen, and K. LaVoie. 1977. Effect of Range Treatment with 2,4-D on Prairie Dog Diet. Journal of Range Management 30:57-60.

Fanning, D.S., and C.B. Fanning. 1989. Soil: Morphology, Genesis, and Classification. John Wiley and Sons. New York, New York.

Federal Geographic Data Commission. 1997. Vegetation Subcommittee National Vegetation Classification Standard. Reston, Virginia. Available at: http://www.fgdc.gov/standards/documents/standards/vegetation/vegclass.pdf.

Federal Register. 1994. Endangered and Threatened Wildlife and Plants; Final Rule to List the Rio Grande Silvery Minnow as an Endangered Species. Department of the Interior, Fish and Wildlife Service, Volume 59, Number 138. Washington D.C.

________. 2000. Wilderness Management. Department of the Interior Bureau of Land Management 43 CFR Parts 6300 and 8560. Final Rule. Washington, D.C.

________. 2002. Volume 67, Number 1, Page 102. Wednesday, January 2, 2002.

Feldmeth, C.R. 1981. The Evolution of Thermal Tolerance in Desert Pupfish (Genus *Cyprinodon*). Pages 357-384 *in* Fishes in North American Deserts (Naiman, R.J. and D.L. Soltz, eds.). Wiley-Interscience Publication. New York, New York.

Feng, J.C., D.G. Thompson, and P. E. Reynolds. 1990. Fate of Glyphosate in a Canadian Forest Watershed: 1. Aquatic Residues and Off-target Deposit Assessment. Journal of Agricultural Food Chemistry 38:1110- 1118.

Ferrell, M.A., and T.D. Whitson. 1999. Plateau (Imazapic) for Leafy Spurge Control in Wyoming. *In* Proceedings: 20th Anniversary Leafy Spurge Symposium. Medora, North Dakota. June 29, 1999. Available at: www.team.ars.usda.gov/symposium/1999/index.html.

Field, J.A., R.L. Reed, T.E. Sawyer, S.M. Griffith, and P.J. Wigington, Jr. 2003. Diuron Occurrence and Distribution in Soil and Surface and Ground Water Associated with Grass Seed Production. Journal of Environmental Quality 32:171-179.

Fire Regime Condition Class. 2004. Interagency Handbook Reference Conditions. Available at: http://www.frcc.gov/docs/PNVG/West/JUST1_Description.pdf.

Fletcher, J.S., J.E. Nellessen, and T.G. Pfleeger. 1994. Literature Review and Evaluation of the EPA Food-chain (Kenaga) Nomogram, and Instrument for Estimating Pesticide Residue on Plants. Environmental Toxicology and Chemistry 13(9):1383-1391.

________, T.G. Pfleeger, H.C. Ratsch, and R. Hays. 1996. Potential Impact of Low Levels of Chlorsulfuron and Other Herbicides on Growth and Yield of Nontarget Plants. Environmental Toxicology and Chemistry 15:1189-1196.

Folmar, L.C., H.O. Sanders, and A.M. Julin. 1979. Toxicity of the Herbicide Glyphosate and Several of Its Formulations to Fish and Aquatic Invertebrates. Archives of Environmental Contamination and Toxicology 8:269-278.

Forest Ecosystem Management Assessment Team. 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of Commerce, and U.S. Environmental Protection Agency. Washington, D.C.

Foster, R.K., and R.B. McKercher. 1973. Laboratory Incubation Studies of Chlorophenoxyacetic Acids in Chernozemic Soils. Soil Biology and Biochemistry 5.

Fowler, C.S. 1986. Subsistence. Pages 64-97 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Fowler, E. 2005. The Deer of DeSoto National Wildlife Refuge. Nebraskaland Magazine. Nebraska Game and Parks Commission.. Available at: http://www.ngpc.state.ne.us/nebland/articles/hunting/ desoto.asp.

Franklin, J.F. 1988. Pacific Northwest Forests. Pages 103-130 *in* North American Terrestrial Vegetation (M.G., Barbour, and W.D. Billings, eds.). Cambridge University Press. New York, New York.

________, and C.T. Dyrness. 1988. Natural Vegetation of Oregon and Washington. Oregon State University Press. Corvallis, Oregon.

Frenzel, S.A., R.B. Swanson, T.L. Huntzinger, J.K. Stamer, P.J. Emmons, and R.B. Zelt. 1998. Water Quality in the Central Nebraska Basins, Nebraska, 1992-95. U.S. Geological Survey Circular 1163. Available at: http://water.usgs.gov/pubs/circ1163.

Fresquez, T., C. Scheck, and B. Hopkins. 2002. Biological Assessment for the Glenwood Spring Field Office Fire Management Plan. U.S. Department of the Interior Bureau of Land Management. Glenwood Springs, Colorado.

Frison, G.C. 2001. Hunting and Gathering Tradition: Northwestern and Central Plains. Pages 131-145 *in* Plains (R.J. Demailie. ed.). Handbook of North American Indians, Volume 13 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Fuerst, E.P., T.M. Sterling, M.A. Norman, T.S. Prather, G.P. Irzyk, Y. Wu, N.K. Lownds, and R.H. Callihan. 1996. Physiological Characterization of Picloram Resistance in Yellow Starthistle. Pesticide Biochemistry and Physiology 56:149-161.

Gadkari, D. 1988. Effect of Some Photosynthetic Inhibiting Herbicides on Growth and Nitrogenase Activity of a New Isolate of Cyanobacteria *Nostoc* G3. Journal of Basic Microbiology 28:419-426.

Gaikowski, M.P., S.J. Hamilton, K.J. Buhl, S.F. McDonald, and C. Summers. 1996a. Acute Toxicity of Three Fire-retardant and Two Fire-suppressant Foam Formulations to the Early Life Stages of Rainbow Trout (*Oncorynchus mykiss*). Environmental Toxicology and Chemistry 15:1365-1374.

________, **S.J. Hamilton, K.J. Buhl, S.F. McDonald, and C. Summers. 1996b.** Acute Toxicity of Firefighting Chemical Formulations to Four Life Stages of Fathead Minnow. Ecotoxicology and Environmental Safety 34:252-263.

Garbarino, M.S., and R.F. Sasso. 1994. Native American Heritage. Waveland Press, Inc. Prospect Heights, Illinois.

Gardener, M.B. 1981. Effects of Turbidity on Feeding Rates and Selectivity of Bluegills. Transactions of the American Fisheries Society 110:446-450.

Garrison, G.A., A.J. Bjugstad, D.A. Duncan, M.E. Lewis, and D.R. Smith. 1977. Vegetation and Environmental Features of Forest and Range Ecosystems. Agriculture Handbook No. 475. U.S. Department of Agriculture Forest Service. Washington, D.C.

Gautier D.L., G.L. Dolton, and E.D. Attanasi. 1998. 1995 National Oil and Gas Assessment and Onshore Federal Lands. U.S. Geological Survey Open-file Report 95-75-N. Denver, Colorado.

Gay, D.L., D.M. Engle, E.R. Allen, and J.F. Stritzke. 1997. Nitrogen and Biomass Dynamics Following Brush Control in the Cross Timbers. Journal of Range Management 50:55-61.

Gebhardt, K., S. Leonard, G. Staidl, and D. Prichard. 1990. Riparian Area Management: Riparian and Wetland Classification and Review. USDI, BLM /YA/PT-91/002+1737. Denver, Colorado.

General Accounting Office. 1999. Western National Forests: A Cohesive Strategy is Needed to Address Catastrophic Wildland Fire Threats. April 1999. GAO/RCED-99-65. Available at: www.gao.org.

George, M.R. 1996. Creating Awareness of Clean Water Issues Among Private Landowners. Pages 96-100 *in* Sustaining Rangeland Ecosystems (W.D. Edge and S.L. Olson-Edge, eds.). Oregon State University Extension Service, Special Report 953. Corvallis, Oregon.

________, **R.E., Larson, N.K. McDougald, K.W. Tate, J.D. Gerlach Jr., and K.O. Fulgham. 2002.** Influence of Grazing on Channel Morphology of Intermittent Streams. Journal of Range Management 55:551-557.

Germano, D.J. 1978. Response of Selected Wildlife to Mesquite Removal in Desert Grassland. M.S. Thesis, University of Arizona, Tucson.

Giacomazzi, S., and N. Cochet. 2004. Environmental Impact of Diuron Transformation: A Review. Chemosphere 56:1021-1032.

Gifford, G.F., and R.H. Hawkins. 1978. Hydrologic Impact of Grazing on Infiltration: A Critical Review. Water Resources Research 14:305-313.

________, **G. Williams, and G.B. Coltharp. 1970.** Infiltration and Erosion Studies in Pinyon-juniper Conversion Sites in Southern Utah. Journal of Range Management 23:402-406.

Gilbraith, D.M., M.J. Schwalbach, and C.R. Berry. 1998. Preliminary Report on the Status of the Pallid Sturgeon, *Scaphirhychus albus*, a Candidate Endangered Species. Cooperative Fish and Wildlife Research Unit, South Dakota State University. Brookings, South Dakota.

Gimsing, A.L., O.K. Borggaard, and M. Bang. 2004. Influence of Soil Composition on Adsorption of Glyphosate and Phosphate by Contrasting Danish Surface Soils. European Journal of Soil Science 55:183-191.

Glenn-Lewin, D.C. 1977. Species Diversity in North American Temperate Forests. Vegetation 33:153-162.

Goldsborough, L.G., and D.J. Brown. 1993. Dissipation of Glyphosate and Aminomethylphosphonic Acid in Water and Sediments of Boreal Forest Ponds. Environmental Toxicology and Chemistry 12:1139-1147.

Gore, J.A. 1985. Mechanisms of Colonization and Habitat Enhancement for Benthic Macroinvertebrates in Restored River Channels. Pages 81-102 *in* The Restoration of Rivers and Streams: Theories and Experience (J.A. Gore, ed.). Butterworth Publishers. Boston, Massachusetts.

Gottfried, G.J., T.W. Swetnam, C.D. Allen, J.L. Betancourt, and Chung-MacCoubrey. 1995. Pinyon-juniper Woodlands. Pages 95-132 *in* Ecology, Diversity, and Sustainability of the Middle Rio Grande Basin. General Technical Report RM-268. U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Grande, M., S. Andersen, and D. Berge. 1994. Effects of Pesticide on Fish: Experimental and Field Studies. Norwegian Journal of Agricultural Sciences 13:195-209.

Grant, N., E. Prusinkiewicz, and R. Makowski. 1990. Effect of Selected Pesticides on Survival of *Colletotrichum gloeosporioides* F. Sp. Malvae, a Bioherbicide for Round-leaved Mallow (Malva Pusilla). Weed Technology 4:701–715.

Green, D.M., and J.B. Kauffman. 1995. Succession and Livestock Grazing in a Northeastern Oregon Riparian Ecosystem. Journal of Range Management 48:307-313.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An Ecosystem Perspective of Riparian Zones. Bioscience 41:540-551.

Griffith, J.S., and T.R. Tiersch. 1989. Ecology of Fishes in Redfield Canyon, Arizona, with Emphasis on *Gila robusta intermedia.* Southwestern Naturalist 34:131-164.

Gruell, G.E. 1983. Fire and Vegetative Trends in the Northern Rockies: Interpretations from 1871-1982 Photographs. General Technical Report INT-158. U.S. Department of Agriculture Forest Service Intermountain Research Station. Ogden, Utah.

Gunnerson, J.H. 2001. Plains Village Tradition: Western Periphery. Pages 234-244 *in* Plains (R.J. DeMallie, ed.). Handbook of North American Indians, Volume 13 (W.C. Sturtevant, ed.). Smithsonian Institution. Washington, D.C.

Guynn, D.C., Jr., S.T. Guynn, T.B. Wigley, and D.A. Miler. 2004. Herbicides and Forest Biodiversity—What Do We Know and Where Do We Go From Here? Wildlife Society Bulletin 32:1085-1092.

Hall, J.D., and R.L. Lantz. 1969. Effects of Logging on the Habitat of Coho Salmon and Cutthroat Trout in Coastal Streams. Pages 335-375 *in* Symposium on Salmon and Trout in Streams (T.G. Northcote, ed.). H.R. MacMillian Lectures in Fisheries, University of British Columbia. Vancouver, British Columbia, Canada.

Hall M.J., and M.F. Owings. 2000. Hospitalizations for Injury: United States, 1996. Advance Data from Vital and Health Statistics No. 318. National Center for Health Statistics. Hyattsville, Maryland.

Hamelink, J.L., D.R. Buckler, F.L. Mayer, D.U. Palawski, and H.O. Sanders. 1986. Toxicity of Fluridone to Aquatic Invertebrates and Fish. Environmental Toxicity and Chemistry 5:87-94.

Hamilton, J.G. 1997. Changing Perceptions of Pre-european Grasslands in California. Madrono 44:311-333.

Han, J.C. 1979. Stability of [C14] Fosamine Ammonium in Water and Soils. Journal of Agricultural Food Chemistry 27:564-571.

Hance, R. J. 1976. Adsorption of Glyphosate by Soils. Pesticide Science 7:363-366.

Hann, W.J., J.L. Jones, M.G. Karl, P.F. Hessburg, R.E. Keane, D.G. Long, J.P. Menakis, C.H. McNicoll, S.G. Leonard, R.A. Gravenmier, and B.G. Smith. 1997. Landscape Dynamics of the Basin. Chapter 3 *in* An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins: Volume 2. (T.M. Quigley and S.J. Arbelbide, tech. eds.). General Technical Report PNW-GTR-405. U.S. Department of Agriculture Forest Service Pacific Northwest Research Station. Portland, Oregon.

________**, M. Beighley, P. Teensma, T. Sexton, and M. Hilbruner. 2002.** A Cohesive Strategy for Protecting People and Sustaining Natural Resources: Predicting Outcomes for Program Options. Presented at Fire, Fuel Treatments, and Ecological Restoration Conference. Fort Collins, Colorado. Available at: http://www.frcc.gov/AssocPubs.html.

Hardy, C.C., R.O. Ottmar, J.L. Peterson, J.E. Core, and P. Seamon. 2001. Smoke Management Guide for Prescribed and Wildland Fire, 2001 Edition. National Wildfire Coordination Group. Boise, Idaho.

Harniss, R.O., and R.B. Murray. 1973. Thirty Years of Vegetal Change Following Burning of Sagebrush-grass Range. Journal of Range Management 26:322-325.

Harper, B.L., B. Flett, S. Harris, C. Abeyta, and F. Kirschner. 2002. The Spokane Tribe's Multipathway Subsistence Exposure Scenario and Screening Level RME. Risk Analysis 22(3):513-526.

Harper K., and J. Belnap. 2001. The Influence of Biological Soil Crusts on Mineral Uptake by Associated Vascular Plants. Journal of Arid Environments 47(3):347-357.

Harris, S.G., and B.L. Harper. 1997. A Native American Exposure Scenario. Risk Analysis 17(6):789-795.

Harrison, I., R.U. Leader, J.J.W Higgo, and G.M. Williams. 1998. A Study of the Degradation of Phenoxy Acid Herbicides at Different Sites in a Limestone Aquifer. Chemosphere. 36:1211-1232.

Hassan, S., F. Bigler, and H. Bogenschutz. 1994. Results of the Sixth Joint Pesticide Testing Programme of the Iobc/Wprs-Working Group "Pesticides and Beneficial Organisms." Entomophaga 39:107–119.

Hayward, S.F. 2005. Index of Leading Environmental Indicators. Pacific Research Institute. San Francisco, California.

Hebert, M. 2001. Strategic Plan for Noxious and Invasive Plants Management in Alaska. University of Alaska. Fairbanks, Alaska.

Hein, L. 2002. Checklist for the Potential Costs of Land Degradation and the Benefits of Mitigation Measures. Prepared for The International Centre for Environmental Assessment Foundation for Sustainable Development and The International Centre for Integrative Studies. Available at: http://www.icis.unimaas.nl/medaction/downs/Deliverable_12.pdf.

Hendee, J.C., and C.P. Dawson. 2002. Wilderness Management Stewardship and Protection of Resources and Values. Third Edition. Fulcrum Publishing. Golden, Colorado.

Hershler, R., and D.W. Sada. 1987. Springsnails (Gastropoda: Hydrobiidae) of Ash Meadows, Amargosa Basin, California-Nevada. Proceedings of the Biological Society of Washington 100:776-843.

________, and W.L. Pratt. 1990. A New *Pyrgulopsis* (Gastropoda: Hydrobiidae) from Southeastern California, With a Model for Historical Development of the Death Valley Hydrographic System. Proceedings of the Biological Society of Washington 103:279-299.

Hesse, L.W., J.C. Schmulbach, J.M. Carr, K.D. Keenlyne, D.G. Unkenholz, J.S. Robinson, and G.E. Mestl. 1989. Missouri River Resources in Relation to Past, Present, and Future Stresses. Pages 352-371 *in* Proceedings of the International Large River Symposium (D.P. Dodge, ed.). Canadian Special Publications in Fisheries and Aquatic Science 106. Department of Fisheries and Oceans, Ottawa. Ontario, Canada

Hickman, M.V., C.G. Messersmith, and R.G. Lynn. 1990. Picloram Release from Leafy Spurge Roots. Journal of Range Management 43:442-445.

Hildebrand, L.D., D.S. Sullivan, and T.P. Sullivan. 1980. Effects of Roundup Herbicide on Populations of *Daphnia magna* in a Forest Pond. Bulletin of Environmental Contamination and Toxicology 25:353-357.

Hofman, V., and E. Solseng. 2001. Reducing Spray Drift. North Dakota State University Extension Service, Agricultural and Biosystems Engineering. Fargo, North Dakota.

Hole, F.D., and G.A. Nielsen. 1970. Some Processesof Soil Genesis under Prairie. Pages 28-34 *in* Symposium on Prairie and Prairie Restoration. Special Publication No. 3. Knox College Field Station, Galesburg, Illinois.

Holecheck, J.L., R.D. Pieper, and C.H. Herbel. 1989. Range Maintenance Principles and Practices. Prentice-Hall, Englewood Cliffs, New Jersey.

________, ________, and ________. 1995. Range Management: Principles and Practices. Second Edition. Prentice Hall. Englewood Cliffs, New Jersey.

Howard, G.L., S.R. Johnson, and S.L. Ponce. 1983. Cattle Grazing Impact on Surface Water Quality in a Colorado Front Range Stream. Journal of Soil and Water Conservation: 124-128.

Howard, P. (ed). 1991. Handbook of Physical Properties of Organic Chemicals. CRC Lewis Publishers. Boca Raton, Florida.

Howard, R.P., and M.L. Wolfe. 1976. Range Improvement Practices and Ferruginous Hawks. Journal of Range Management 29:33-37.

Huber, A., S. Goodrich, and K. Anderson. 1999. Diversity with Successional Status in the Pinyon-juniper/mountain Mahogany/Bluebunch Wheatgrass Community Type Near Dutch John, Utah. *In* Proceedings: Ecology and Management of Pinyon-juniper Communities Within the Interior West (S.B. Monsen and R. Stevens, compilers.). September 15-18, 1997, Provo, Utah. Proceedings RMRS-P-9. U.S. Department of Agriculture Forest Service Rocky Mountain Research Station. Ogden, Utah.

Hubert, W.A., R.P. Lanka, T.A. Wesche, and F. Stabler. 1985. Grazing Management Influences on Two Brook Trout Streams in Wyoming. Pages 290-294 *in* Riparian Ecosystems and Their Management – Reconciling Conflicting Uses (R.R. Johnson, ed.). General Technical Report RM-120. U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Hudson, B., J. Augsburger, M. Hillis, and P. Boehne. 2000. Draft Biological Assessment for the Interior Columbia River Basin Ecosystem Management Project Final Environmental Impact Statement. U.S. Department of the Interior Bureau of Land Management and U.S. Department of Agriculture Forest Service. Washington, D.C.

Humphrey, R.R. 1974. Fire in the Deserts and Desert Grasslands of North America. Pages 365-400 *in* Fire and Ecosystems (T.T. Kozlowski and C.E. Ahlgren, eds.). Academic Press. New York, New York.

Hunn, E.S. 1990. Nch'i-Wana: The Big River. University of Washington Press. Seattle, Washington.

________, and D.H. French. 1998. Western Columbia River Sahaptins. Pages 378-394 *in* Plateau (D.E. Walker, Jr., ed.). Handbook of the North American Indian, Volume 12 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Hunter, Jr., M.L. 1990. Wildlife, Forests, and Forestry. Principles of Managing Forests for Biological Diversity. Regents/Prentice Hall. Englewood Cliffs, New Jersey.

Information Ventures, Inc. 1995a. Asulam. Prepared for the U.S. Department of Agriculture Forest Service. Philadelphia, Pennsylvania. Available at: http://infoventures.com/ehlth/pesticide/asulam.html.

________. 1995b. Atrazine. Prepared for the U.S. Department of Agriculture Forest Service. Philadelphia, Pennsylvania. Available at: http://infoventures.com/ehlth/pesticide/atrazine.html.

________. 1995c. Mefluidide. Prepared for the U.S. Department of Agriculture Forest Service. Philadelphia, Pennsylvania. Available at: http://www.fluoridealert.org/pesticides/mefluidide.fact.sheet.usda.html.

________. 1995d. Simazine. Prepared for the U.S. Department of Agriculture Forest Service. Philadelphia, Pennsylvania. Available at: http://infoventures.com/ehlth/pesticide/simazine.html.

Irwin-Williams, C. 1979. Post-Pleistocene Archeology, 7000-2000 B.C. Pages 22-30 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Ismail, B., and L. Wong. 1994. Effects of Herbicides on Cellulolytic Activity in Peat Soil. Microbios. 78:117-123.

________, and B.A. Azlizan. 2002. Persistence and Bioactivity of Metsulfuron-methyl in Three Soils. Journal Of Environmental Science and Health Part B-Pesticides Food Contaminants and Agricultural Wastes 37:345-353.

________, K. Yapp, and O. Omar. 1998. Effects of Metsulfuron-methyl on Amylase, Urease, and Protease Activities in Two Soils. Australian Journal Of Soil Research 36:449-456.

Jacobs, B.F., and R.G. Gatewood. 1999. Restoration Studies in Degraded Pinyon-juniper Woodlands of North-central New Mexico. *In* Proceedings: Ecology and Management of Pinyon-juniper Communities within the Interior West (S.B. Monsen and R. Stevens, compilers). September 15-18, 1997, Provo, Utah. Proceedings RMRS-P-9. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Ogden, Utah.

Jacobs, J.S., M.F. Carpinelli, and R.L. Sheley. 1999. Revegetating Noxious Weed-infested Rangeland. Page 133-141 *in* Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petroff, eds.). Oregon State University Press. Corvallis, Oregon.

James, T.K., P.T. Holland, A. Rahman, and Y.R. Lu. 1999. Degradation of the Sulfonylurea Herbicides Chlorsulfuron and Triasulfuron in a High-organic-matter Volcanic Soil. Weed Research 39:137-147.

Janetski, J.C. 1991. The Ute of Utah Lake. University of Utah Anthropological Papers Number 116. Salt Lake City, Utah.

Jenny, H. 1980. The Soil Resource: Origins and Behavior. Ecological Studies, Volume 37. Springer-Verlag. New York, New York.

Jensen, M., I. Goodman, K. Brewer, T. Frost, G. Ford, and J. Nesser. 1997. Biophysical Environments of the Basin. Pages 99-320 *in* An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins (T.M. Quigley and S.J. Arbelbide, tech. eds.). General Technical Report PNW-GTR-405. U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Johansen, J.R. and W.R. Rayburn. 1989. Effects of Range Fire on Soil Cryptogamic Crusts. Pages 107-109 *in* Prescribed Fire in the Intermountain Region. Forest Site Preparation and Range Improvement. Symposium Proceedings (D.M. Baumgartner, D.W. Breuer, B.A. Zamora, L.F. Neuenschwander, and R.H. Wakimoto, eds.). ©Washington State University. Pullman, Washington.

Johnsen, T. N., Jr. 1980. Picloram in Water and Soil from a Semiarid Pinyon-juniper Watershed. Journal of Environmental Quality 9:601-605.

Johnson, W.G., T.L. Lavy, and E.E. Gbur. 1995. Persistence of Triclopyr and 2,4-D in Flooded and Non-flooded Soils. Journal of Environmental Quality 24:493-497.

Joly, K.B., W. Dale, W.B. Collins, and L.G. Adams. 2002. Evaluating the Impacts of Wildland Fires on Caribou in Interior Alaska. Arctic Research of the United States 16:63–67.

Jones, K.B. 1986. Deserts. Pages 123-145 *in* Inventory and Monitoring of Wildlife Habitat (A.Y. Cooperrider, R.J. Boyd, and H.R. Stuart, eds.). U.S. Department of the Interior Bureau of Land Management Service Center. Denver, Colorado.

Jordan, G.L. 1981. Range Seeding and Brush Management on Arizona Rangelands. T81121. University of Arizona Agricultural Experiment Station. Tucson, Arizona.

Jorgensen, J. 1980. Western Indians: Comparative Environments, Languages, and Cultures of 172 Western American Indian Tribes. W.H. Freeman and Company. San Francisco, California.

Joseph, T.W., J.A. Sinning, R.J. Behnke, and P.B. Holden. 1977. An Evaluation of the Status, Life History, and Habitat Requirements of Endangered and Threatened Fishes of the Upper Colorado River System (FWS/OBS-77/62). U.S. Fish and Wildlife Service. Fort Collins, Colorado.

Kaeding, L.R., B.D. Burdick, P.A., Schrader, and W.R. Noonan. 1986. Recent Capture of a Bonytail (*Gila elegans*) and Observations on this Nearly Extinct Cyprinid from the Colorado River. Copeia 1986:1021-1023.

Kaniewska-Prus, M. 1975. The Effect of 2,4-D-Na Herbicide on Oxygen Consumption and Survival *Simocephalus vetulus* (Cladocera). Polar Achieves of Hydrobiology 22(4):593-599.

Karthikeyan, R., L.C. Davis, L.E. Erickson, K. Al-Khatib, P.A. Kulakow, P.L. Barnes, S.L. Hutchinson, and A.A. Nurzhanova. 2003. Studies on Responses of Non-target Plants to Pesticides: A Review. Hazardous Substance Research Center, Kansas State University. Manhattan, Kansas.

Kauffman, J.B., W.C. Krueger, and V. Varva. 1983. Effects of Late Season Cattle Grazing on Riparian Plant Communities. Journal of Range Management 36(6):685-691.

________, R.L. Beschta, N. Otting, and D. Lytjen. 1997. An Ecological Perspective on Riparian and Stream Restoration in the Western United States. Fisheries 22:12-24.

Kehoe, A.B. 1992. North American Indians: A Comprehensive Account (2nd Edition). Prentice Hall. Englewood, New Jersey.

Kelly, I.T. 1964. Southern Paiute Ethnography. Glen Canyon Series 21, University of Utah Anthropological Paper 69. Salt Lake City, Utah.

________. 1976. Southern Paiute Ethnography. Pages 11-223 *in* Paiute Indians II (D.A. Horr, ed.). Garland Publishing Inc. New York, New York.

________, and C.S. Fowler. 1986. Southern Paiute. Pages 368-397 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Kelsey, R.G., and D.J. Bedunah. 1989. Ecological Significance of Alleopathy for Centaura Species in the Northwestern United States. Knapweed Symposium Proceedings, Land and Soil Science Department and Extension Service. Montana State University Bulletin 45:10-31.

Kennard, E.A. 1979. Hopi Economy and Subsistence. Pages 554-563 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Kennedy, D., and R.T. Bouchard. 1998. Northern Okanogan, Lakes, and Colville. Pages 238-252 *in* Plateau (D.E. Walker, Jr., ed.). Handbook of the North American Indian, Volume 12 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Khera, S., and P.S. Mariella. 1983. Yavapai. Pages 38-54 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Kie, J.G. 1988. Annual Grasslands. Pages 120-121 *in* A Guild to Wildlife Habitats of California (K.E. Mayer and W.F. Laudenslayer, eds.). California Department of Forestry and Fire Protection. Sacramento, California.

Kirby, D.R., R.G. Lym, J.J. Sterling, and C.H. Sieg. 2003. Observation: Leafy Spurge Control in Western Prairie Fringed Orchid Habitat. Journal of Range Management 56(5):466-473.

Kleijn, D., and G.I.J. Snoeijing. 1997. Field Boundary Vegetation and the Effects of Agrochemical Drift: Botanical Change Caused by Low Levels of Herbicide and Fertilizer. Journal of Applied Ecology 34:1413-1425.

Knoepp, J.D., and W.T. Swank. 1993. Site Preparation Burning to Improve Southern Appalachian Pine-hardwood Stands: Nitrogen Responses in Soil, Soil Water, and Streams. Canadian Journal of Forest Resources 23:2263-2270.

Komarek, E. V. 1969. Fire and Man in the Southwest. Pages 3-22 *in* Proceedings of the Symposium on Fire Ecology and the Control and Use of Fire in Wild Land Management. Journal of Arizona Academy of Sciences. Tucson, Arizona.

Konikoff, M. 1975. Toxicity of Nitrite to Channel Catfish. Progressive Fish-Culturist 37:96-98.

Kookana, R. S., and L. A. G. Aylmore. 1993. Retention and Release of Diquat and Paraquat Herbicides in Soils. Australian Journal Of Soil Research 31:97-109.

Koskinen, W.C., J.C. Anhalt, O. Sakaliene, P.J. Rice, T.B. Moorman, and E.L. Arthur. 2003. Sorption-desorption of "Aged" Sulfonylaminocarbonyltriazolinone Herbicide Metabolites in Soil. Journal of Agricultural and Food Chemistry 51:3604-3608.

Koterba, M. T., W. S. L. Banks, and R. J. Shedlock. 1993. Pesticides in Shallow Groundwater in the Delmarva Peninsula. Journal of Environmental Quality. 22:500-518.

Kreamer, G. 1996. Early Life-stage Toxicity of DPX-T6376-141 (Metsulfuron-methyl) to Rainbow Trout (*Oncorhynchus mykiss*). Lab Project Number HLR 182-96 10352:182-196. Unpublished Study Prepared by DuPont Haskell Lab for Toxicity and Industrial Medicine. MRID Number 44122801.

Kroeber, A.L. 1976. Handbook of the Indians of California. Dover Publications, New York. Originally Published in 1925 as Bureau of Ethnology Bulletin 78. Smithsonian Institution. Washington, D.C.

Krueger, J.P., R.G. Butz, and D.J. Cork. 1991. Aerobic and Anaerobic Soil Metabolism of Dicamba. Journal of Agricultural and Food Chemistry 39:995-999.

Krzyszowska, A., R. Allen, and G. Vance. 1994. Assessment of the Fate of Two Herbicides in a Wyoming Rangeland Soil: Column Studies. Journal of Environmental Quality 23:1051-1058.

Kufeld, R.C. 1977. Improving Gambel Oak Ranges for Elk and Mule Deer by Spraying with 2,4,5-TP. Journal of Range Management 30:53-57.

Kuhlmann, B., B. Kaczmarczyk, and U. Schottler. 1995. Behavior of Phenoxyacetic Acids During Underground Passage with Different Redox Zones. International Journal Of Environmental Analytical Chemistry 58:199-205.

Lacey, J.R., C.B. Marlow, and J.R. Lane. 1989. Influence of Spotted Knapweed (*Centaurea macuolosa*) on Surface Runoff and Sediment Yield. Weed Technology 3:627-631.

Lajeunesse, S. 1999. Dalmatian and Yellow Toadflax. Pages 202-216 in Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petrolff, eds.). Oregon State University Press Corvallis, Oregon.

Lajeunesse, S., R.L. Sheley, C. Duncan, and R. Lym. 1999. Leafy Spurge. Pages 249-260 *in* Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petrolff, eds.). Oregon State University Press. Corvallis, Oregon.

Lantis, M. 1984. Aleut. Pages 161-184 *in* Arctic (D. Damas, ed.). Handbook of North American Indians, Volume 5 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

LaPrade, J.C. 1992. Fate of Pesticides in Soil and Water. Alabama Cooperative Extension System, Community Resource Development, Auburn University Document Number ANR-737. Auburn, Alabama. Available at: http://www.aces.edu/department/crd/publications/ANR-737.html.

Larsen, L., and J. Aamand. 2001. Degradation of Herbicides in Two Sandy Aquifers under Different Redox Conditions. Chemosphere 44:231-236.

Larson, S.J., P.D. Capel, and M.S. Majewski. 1997. Pesticides in Surface Water: Distribution, Trends, and Governing Factors. Series 3: Pesticides in the Hydrologic System. Ann Arbor Press. Chelsea, Michigan.

Laudenslayer, W.F., Jr., and J.R. Boggs. 1988. Desert Scrub. Pages 114-115 *in* A Guide to Wildlife Habitats of California (K.E. Mayer and W.F. Laudenslayer, Jr., eds.). California Department of Forestry and Fire Protection. Sacramento, California.

Lautenschlager, R.A., T.P. Sullivan, and R.G. Wagner. 1995. Using Herbicides for Wildlife Management in Northern Ecosystems. Pages 152-154 *in* Proceedings for Second International Conference on Forest Vegetation Management (R.E. Gaskin and J.A. Zabkiewicz, eds.). New Zealand Forest Research Institute, Bulletin No. 192, Rotorua, New Zealand.

LeJeune, K.D. and T.R. Seastedt. 2001. *Centaurea* Species: The Forb that Won the West. Conservation Biology 15(6):1568-1574.

Lent, P.C. 1986. Tundra. Pages 149-167 *in* Inventory and Monitoring of Wildlife Habitat (A.Y. Cooperrider, R.J. Boyd, and H.R. Stuart, eds.). U.S. Department of the Interior Bureau of Land Management Service Center. Denver, Colorado.

Leopold, A. 1924. Grass, Brush, Timber, and Fire in Southern Arizona. Journal of Forestry 22:1-10.

Leopold, L.B. 1951. Vegetation of Southwestern Watersheds in the Nineteenth Century. Geographical Reviews 41:295-316.

Levings, G.W., D.F. Healy, S.F. Richey, and L.F. Carter. 1998. Water Quality in the Rio Grande Valley, Colorado, New Mexico, and Texas, 1992-95. U.S. Geological Survey Circular 1162. Available at: http://water.usgs.gov/pubs/circ1162.

Levy, R. 1978. Eastern Miwok. Pages 398-413 *in* California (R.F. Heizer, ed.). Handbook of the North American Indians, Volume 8 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Lewis, H.T. 1973. Patterns of Indian Burning in California: Ecology and Ethnohistory. Ballena Press Anthropological Papers 1:1-101. Ramona, California.

Lewis, W.M., and D.P. Morris. 1986. Toxicity of Nitrite to Fish: A Review. Transactions of the American Fisheries Society 115:183-195.

Liljeblad, S., and C.S. Fowler. 1986. Owens Valley Paiute. Pages 412-434 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Loeb, E.M. 1926. Pomo Folkways. University of California Publications in American Archaeology and Ethnology 19(2):149-405. Berkeley, California.

Loomis, D., D.B. Richardson, J.F. Bena, and A.J. Bailer. 2004. Deindustrialization and the Long-term Decline in Fatal Occupation Injuries. Occupational and Environmental Medicine 61:616-621. Available at: http://oem.bmjjournals.com/cgi/content/full/61/7/616.

Louda, S.M., D. Kendall, J. Conner, and D. Simberloff. 1997. Ecological Effects of an Insect Introduced for the Biological Control of Weeds. Science 277:1088-1090.

Lym, R.G., and J.A. Nelson. 2000. Biological Control of Leafy Spurge (*Euphorbia esula*) with *Aphthona* spp. Along Railroad Right-of-ways. Weed Technology 14:642-646.

Lyman, R.L. 1991. Prehistory of the Oregon Coast: The Effects of Excavation Strategies and Assemblage Size on Archeological Inquiry. Academic Press. San Diego, California.

Lyman, W., W. Reehl, and D. Rosenblatt. 1990. Handbook of Chemical Estimation Methods. American Chemical Society, Washington D.C.

Lyon, L.J., J.K. Brown, M.H. Huff, and J.K. Smith. 2000a. Introduction. Pages 1-8 *in* Wildland Fire in Ecosystems (J.K. Smith, ed.). USDA Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-42, Volume 1. Fort Collins, Colorado.

________, E. S.Telfer, and D.S. Schreiner. 2000b. Direct Effects of Fire and Animal Responses. Pages 1723 *in* Wildland Fire in Ecosystems (J.K. Smith, ed.). USDA Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-42, Volume 1. Fort Collins, Colorado.

Mackay, D., S. Wan-Ying, and M. Kuo-ching. 1997. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Volume III. Pesticides. Lewis Publishers. Chelsea, Michigan.

MacMahon, J.A. 1988. Warm Deserts. Pages 231-264 *in* North American Terrestrial Vegetation (M.G. Barbour and W.D. Billings, eds.). Cambridge University Press. New York, New York.

Maddux, H.R., L.A. Fitzpatrick, and W.R. Noonan. 1993. Colorado River Endangered Fishes Critical Habitat, Draft Biological Document. U.S. Fish and Wildlife Services. Salt Lake City, Utah.

Mahler, R.L., H.W. Homan, and G.P. Carpenter. 1998. Pesticides and Their Movement in Soil and Water. Quality Water for Idaho Current Information Series No. 865. University of Idaho College of Agriculture Cooperative Extension System Agricultural Experiment Station. Moscow, Idaho.

Maikawa, E., and K.A. Kershaw. 1976. Studies on Lichen-dominated Systems. XIX. The Postfire Recovery Sequence of Black Spruce-lichen Woodland in the Abitau Lake Region, N. W.T. Canadian Journal of Botany 54:2679-2687.

Malik, J., G. Barry, and G. Kishore. 1989. A Mini-review of the Herbicide Glyphosate. BioFActors 2:17-25.

Malik, M., and D. Drennan. 1990. Bioavailability and Dissipation of Fluridone under Controlled Conditions. Journal of Environmental Science and Health B25:447-472.

Mallipudi, N.M., S.J. Stout, A.R. daCunha, and A. Lee. 1991. Photolysis of Imazapyr (Ac 243997) Herbicide in Aqueous Media. Journal of Agricultural Food Chemistry 39:412-417.

Mangels, G. 1991. Behavior of the Imidazolinone Herbicides in the Aquatic Environment. *In* The Imidazolinone Herbicides (D. L. Shaner and S. L. O'Connor, eds.). CRC Press. Boca Raton, Florida.

Manning, C. 1989. Chronic Effect of AC 243,997 to the Water Flea (*Daphnia magna*) in a 21-day Flow-through Exposure, Final Report. Laboratory Report Number 87384-0500-21300, AC 243,997/DM Protocol 020F. MRID Number 41315805. Unpublished Report.

Marcuson, P.E. 1977. The Effect of Cattle Grazing on Brown Trout in Rock Creek, Montana. Montana Department of Fish and Game, Special Report, Project F-20-R-21, 11-a. Helena, Montana.

Markle, D.M., and R.G. Lym. 2001. Leafy Spurge (*Euphorbia esula*) Control and Herbage Production with Imazapic. Weed Technology 15(3):474-480.

Marriott, B.B. 1997. Practical Guide to Environmental Impact Assessment. McGraw-Hill. New York, New York.

Martens, D.A., and J.M. Bremner. 1993. Influence of Herbicides on Transformations of Urea Nitrogen in Soil. Journal Of Environmental Science And Health Part B-pesticides Food Contaminants And Agricultural Wastes 28:377-395.

Martin, S.C., and H.L. Morton. 1993. Mesquite Control Increases Grass Density and Reduces Soil Loss in Southern Arizona. Journal of Range Management 46(2):170-175.

Masters, R.A., D.B. Beran, and R.E. Gaussoin. 2001. Restoring Tallgrass Prairie Species Mixtures on Leafy Spurge-infested Rangeland. Journal of Range Management 54(4):362-369.

Maxwell, J.A. 1978. America's Fascinating Indian Heritage. Reader's Digest Association, Inc. New York, New York.

Mayack, D.T., P.B. Bush, D.G. Neary, and J.E. Douglass. 1982. Impact of Hexazinone on Invertebrates after Application to Forested Watersheds. Archives of Environmental Contamination and Toxicology 11:209-217.

Mayes, M. 1990. Dow Chemical USA Phase 3 Summary of MRID 00151958. The Acute and Chronic Toxicity of Triclopyr [(3,5,6-Trichloro-2-Pyridiny)loxy) Acetic Acid] Triethylamine Salt Solution to the Fathead Minnow (*Pimephales promelas*). Project ID: ES-582. Dow Chemical. Colorado.

________, D.C. Dill, K.M. Bodner, and C.G. Mendoza. 1984. Triclopyr Triethylamine Salt Toxicity to Life Stages of the Fathead Minnow Pimpephales-promelas. Bulletin of Environmental Contamination and Toxicology 33(3):339-347.

Mayeux, H. S., Jr., C. W. Richardson, R. W. Bovey, E. Burnett, M. G. Merkle, and R. E. Meyer. 1984. Dissipation of Picloram in Storm Runoff. Journal of Environmental Quality 13:44-49.

McAllister, K.R. 1995. Washington State Recovery Plan for the Pygmy Rabbit. Washington Department of Fish and Wildlife. Olympia, Washington.

McCartney, A.P. 1984. Prehistory of the Aleutian Region. Pages 119-135 *in* Arctic (D. Damas, ed.). Handbook of North American Indians, Volume 5 (W.C. Sturtevant, general ed). Smithsonian Institution, Washington, D.C.

McClellan, C., and G. Deniston. 1981. Environment and Culture in the Cordillera. Pages 372-386 *in* Sub-arctic (J. Helm, ed.). Handbook of North American Indians, Volume 6 (W.C. Sturtevant, general ed.). Smithsonian Institution, Washington, D.C.

McCormick, D.P. 1975. Effect of Mesquite Control on Small Game Populations. M.S. Thesis, University of Arizona. Tucson, Arizona.

McDonald, P.M. 1988. Montane Hardwood. Pages 72-73 *in* A Guild to Wildlife Habitats of California (K.E. Mayer and W.F. Laudenslayer, eds.). California Department of Forestry and Fire Protection. Sacramento, California.

McDonald, S.F., S.J. Hamilton, K.J. Buhl, and J.F. Heisinger. 1996. Acute Toxicity of Fire Control Chemicals to *Daphnia magna* (Straus) and *Selenastrum capricornutum* (Printz). Ecotoxicology and Environmental Safety 33:62-72.

________, ________, ________, and ________. 1997. Acute Toxicity of Fire-retardant and Foam-suppressant Chemicals to *Hyalella azteca* (Saussure). Environmental Toxicology and Chemistry 16:1370-1376.

McGinty, A., F.E. Smeins, and L.B. Merrill. 1983. Influence of Spring Burning on Cattle Diets and Performance on Edwards Plateau. Journal of Range Management 36(2):175-178.

McGuire, T.R. 1983. Walapai. Pages 25-37 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

McMullin, C., and R. Thomas. 2000. Phase II Herbicide Analysis – Environmental Impact Statement. Prepared for the U.S. Department of the Interior Bureau of Land Management by Intercet Ltd. McLean, Virginia.

McNabb, D.H., and F.J. Swanson. 1990. Effects of Fire on Soil Erosion. Pages 159-176 *in* Natural and Prescribed Fire in Pacific Northwest Forests (J.D. Walstad, S.R. Radosevich, and D.V. Sandberg, eds.). Oregon State University Press. Corvallis, Oregon.

McNabb, K. 1997. Environmental Safety of Forestry Herbicides. Alabama Cooperative Extension System ANR-846. Available at: http://www.aces.edu/pubs/docs/A/ANR-0846/.

Meehan, W.R. (ed.). 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. American Fisheries Society Special Publication 19. Bethesda, Maryland.

________, and T.C. Bjornn. 1991. Salmonid Distribution and Life Histories. American Fisheries Society Special Publication 19:47-82. Bethesda, Maryland.

Mehringer, P.J., Jr. 1986. Prehistoric Environments. Pages 31-50 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Metting, F.B. 1990. Soil Algae. Pages 355-368 *in* The Rhizosphere (J. M. Lynch, ed.). Wiley Interscience, London, England.

Michael, J.L. 2000. Pesticides. Pages 139-149 *in* Drinking Water from Forests and Grasslands: A Synthesis of the Scientific Literature (G.E. Dissmeyer, ed.). General Technical Report SRS-039. U.S. Department of Agriculture Forest Service, Southern Research Station. Asheville, North Carolina.

________, D. G. Neary, and M. J. M. Wells. 1989. Picloram Movement in Soil Solution and Streamflow from a Coastal Plain Forest. Journal of Environmental Quality 18:89-95.

________, E. C. Webber, D. R. Bayne, J. B. Fischer, H. L. Gibbs, and W. C. Seesock. 1999. Hexazinone Dissipation in Forest Ecosystems and Impacts on Aquatic Communities. Canadian Journal of Forest Research 29:1170-1181.

Miller, J. 1998. Middle Columbia River Salishans. Pages 253-270 *in* Plateau (D.E. Walker, Jr., ed.). Handbook of the North American Indians, Volume 12 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Miller, J.H., R.S. Boyd, and M.B. Edwards. 1999. Floristic Diversity, Stand Structure, and Composition 11 years after Herbicide Site Preparation. Canadian Journal of Forest Research 29:1073-1083.

Miller, J.J., B. D. Hill, C. Chang, and C. W. Lindwall. 1995. Residue Detections in Soil and Shallow Groundwater after Long-term Herbicide Applications in Southern Alberta. Canadian Journal Of Soil Science 75:349-356.

Miller, K.V., and J.H. Miller. 2004. Forestry Herbicide Influences on Biodiversity and Wildlife Habitat in Southern Forests. Wildlife Society Bulletin 32(4):1049-1060.

Miller, W.H., H.M. Tyus, and C.A. Carlson (eds). 1982. Fishes of the Upper Colorado River System: Present and Future. American Fisheries Society, Western Division. Bethesda, Maryland.

Mills, M.J. 1994. Harvest, Catch, and Participation in Alaska Sport Fisheries during 1993. Alaska Department of Fish and Game Fishery Data Series 94-28. Anchorage, Alaska.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department. Phoenix, Arizona.

_______, and J.E. Deacon (eds). 1991. Battle against Extinction: Native Fish Management in the American West. University of Arizona Press. Tucson, Arizona.

Minino, A.M., E. Arias, K.D. Kochanek, S.L. Murphy, and B.L. Smith. 2002. Deaths: Final Data for 2000. National Vital Statistics Reports Volume 50, Number 15. September 16, 2002. Centers for Disease Control, Division of Vital Statistics, Washington, D.C.

Minshall, G.W., C.T. Robinson, and D.E. Lawrence. 1997. Postfire Response to Lotic Ecosystems in Yellowstone National Park, USA. Canadian Journal of Fisheries and Aquatic Sciences 54:2509-2525.

_______, J.T. Brock, and J.D. Varley. 1989. Wildfires and Yellowstone Stream Ecosystem. BioScience 39:707-715.

Moapa Memories. 2002. Available at: http://www.xeri.com/Moapa/moapa-afidavits.html.

Montana Department of Environmental Quality. 2002. Montana Modeling Guideline for Air Quality Permits. Available at: http://www.deq.state.mt.us/AirQuality/modeling/MTmodelingGuidelines.

Montgomery, J.H., editor. 1997. Illustrated Handbook of Physical-chemical Properties and Environmental Fate for Organic Chemicals. Volume V, Pesticide Chemicals. Lewis Publishers, Boca Raton, Florida.

Moratto, M.J. 1984. California Archaeology. Academic Press, Inc. Orlando, Florida.

Morton, H.L., and A. Melgoza 1991. Vegetation Changes Following Brush Control in Creosotebush Communities. Journal of Range Management 44:133-139.

Moseley, J.C., S.C. Bunting, and M.E. Manoukian. 1999. Cheatgrass. *In* Biology and Management of Rangeland Weeds (R.L. Sheley and J. K. Petroff, eds.). Oregon State University Press. Corvallis, Oregon.

Moss, J.L. 1978. Toxicity of Selected Chemicals to the Fairy Shrimp, *Streptocephalus seali*, Under Laboratory and Field Conditions. The Progressive Fish-Culturist 40(4):158-160.

Mostafa, F. I. Y., and C. S. Helling. 2003. Isolation and 16s DNA Characterization of Soil Microorganisms from Tropical Soils Capable of Utilizing the Herbicides Hexazinone and Tebuthiuron. Journal Of Environmental Science And Health Part B-pesticides Food Contaminants And Agricultural Wastes 38:783-797.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press. Berkeley, California.

Mueggler, W.F., and W.L. Stewart. 1980. Grassland and Shrubland Habitat Types of Western Montana. General Technical Report INT-66. U.S. Department of Agriculture Forest Service Intermountain Research Station. Ogden, Utah.

Mueller-Warrant, G., and S.M. Griffith. 2005. High Yield Grass Seed Production and Water Quality Handbook. Oregon Seed Council. Salem, Oregon. Available at: http://forages.oregonstate.edu/organizations/seed/osc/ brochures/water-quality.

Muhn, J., and H.R. Stewart. 1988. Opportunity and Challenge: The Story of the BLM. USDI BLM. U.S. Government Printing Office. Washington, D.C.

Muir, D.C.G.L., N.P. Grift, A.P. Blouw, and W.L. Lockhart. 1980. Persistence of Fluridone in Small Ponds. Journal of Environmental Quality 9(1):151-156.

Munn, L.C., G.A. Nielsen, and W.F. Mueggler. 1978. Relationships of Soils to Mountain and Foothill Range Habitat Types and Production in Western Montana. Journal of the Soil Science Society of America 42:135-139.

Murphy, R.F., and Y. Murphy. 1986. Northern Shoshone and Bannock. Pages 284-307 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Naiman, R.J. 1981. An Ecosystem Overview: Desert Fishes and Their Habitats. Pages 493-531 *in* Fishes in North American Deserts (R.J. Naiman and D.L. Soltz, eds.). Wiley-Interscience Publication. New York, New York.

Naqvi, S.M., and R.H. Hawkins. 1989. Responses and LC50 Values for Selected Microcrustaceans Exposed to Spartan, Malathion, Sonar, Weedtrine-D, and Oust Pesticides. Bulletin of Environmental Contamination and Toxicology 43:386-393.

Nash, L. 1993. Water Quality and Health. Pages 25-39 *in* Water in Crisis: A Guide to the World's Fresh Water Resources (P.H. Gleick, ed.). Oxford University Press. New York, New York.

National Academy of Science (NAS). 1968. Principles of Plant and Animal Pest Control, Volume 2: Weed Control. Washington, D.C.

________**. 1983.** Risk Assessment in the Federal Government: Managing the Process. National Academy Press. Washington, D.C.

National Center for Health Statistics. 2004. Vital Statistics. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Hyattsville, Maryland. Available at: http://www.cdc.gov/nchs/.

National Institute for Occupational Safety and Health (NIOSH). 1997. NIOSH Facts. Work-related Musculoskeletal Disorders. Available at: http://www.cdc.gov/niosh/muskdsfs.html.

________**. 2001.** Traumatic Occupational Injuries. Available at: http://www.cdc.gov/niosh/injury/trauma.html.

________**. 2002.** Occupational Cancer. Available at: http://www.cdc.gov/niosh/occancer.html.

National Interagency Fire Center. 2005. Wildland Fire Statistics. Boise, Idaho. Available at: http://www.nifc.gov/stats/wildlandfirestats.html.

National Invasive Species Council. 2001. Management Plan for Meeting the Invasive Species Challenge. Washington, D.C.

National Library of Medicine. 2002. Hazardous Substances Data Bank. A Toxicology Data file on the National Library of Medicines Toxicology Data Network (TOXNET). Available at: http://toxnet.nlm.nih.gov.

________**. 2003.** Database Prepared by the U.S. National Library of Medicine, Office of Health and Human Services, National Institute of Health. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?hsdbb.htm.

National Network of Forest Practitioners. 2005. Nontimber Forest Products (NTFP) Fact Sheet. Available at: http://www.ntfp.org/definition.html.

National Registry of Historic Places. No year. Available at: http://www.cr.nps.gov/nr/.

National Resources Conservation Service. 2000. National Resources Inventory Summary Report. Tables 10 and 11. Washington, D.C. Available at: http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/.

National Wildfire Coordinating Group (NWCG). 2001. Fire Effects Guide. (NFES 2394). Fire Use Working Team, National Interagency Fire Center. Boise, Idaho. Available at: http://fire.r9.fws.gov/ifcc/monitor/FEG.pdf.

National Wildlife Federation and Natural Resources Defense Council. 2001. Conservation Management of America's Public Lands: An Assessment and Recommendations for Progress 25 Years after FLPMA. National Wildlife Federation. Washington, D.C.

NatureServe Explorer. 2001. An Online Encyclopedia of Life. Version 1.6. Arlington, Virginia. Available at: http://www.natureserve.org/explorer.

Neary, D.G., and J.L. Michael. 1996. Herbicides. Protecting Long-term Sustainability and Water Quality in Forest Ecosystems. New Zealand Journal of Forestry Science 26:241-264.

________, J.W. Taylor Jr., and P.B. Bush. 1984. Fate of Hexazinone in Forest Watersheds. U.S. Department of Agriculture Forest Service. Forest Pest Management Technology Update. Washington D.C.

________, P. B. Bush, and J. L. Michael. 1993. Fate, Dissipation and Environmental-effects of Pesticides in Southern Forests - a Review of a Decade of Research Progress. Environmental Toxicology and Chemistry 12:411-428.

________, C.C. Klopatek, L.F. DeBano, and P.F. Ffolliott. 1999. Fire Effects on Belowground Sustainability: A Review and Synthesis. Forest Ecology and Management 122:51-71.

Nelson, C.M. 1990. Prehistory of the Puget Sound Region. Pages 481-484 *in* Northwest Coast (W. Suttles, ed.). Handbook of North American Indians, Volume 7 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Newmaster, S.G., F.W. Bell, and D.H. Vitt. 1999. The Effects of Glyphosate and Triclopyr on Common Bryophytes in Northwestern Ontario. Canadian Journal of Forest Research 29:1101-1011.

Newton, M., F. Roberts, A. Allen, B. Kelpsas, D. White, and P. Boyd. 1990. Deposition and Dissipation of Three Herbicides in Foliage, Litter, and Soil of Brushfields of Southwest Oregon. Journal of Agricultural Food Chemistry 38:574-583.

Nevada Commission for the Preservation of Wild Horses. 1999. A Plan of Goals, Strategies, and Recommendations for the Preservation and Protection of Wild Horses on Federal Lands in the State of Nevada. Carson City, Nevada.

Nomura, N.S., and H.W. Hilton. 1977. The Adsorption and Degradation of Glyphosate in Five Hawaiian Sugarcane Soils. Weed Research 17:113-121.

Norris, K.S. 1953. The Ecology of the Desert Iguana, *Dipsosaurus dorsalis*. Ecology 34:265-287.

Norris, L.A., H.W. Lorz, and S.V. Gregory. 1991. Forest Chemicals. American Fisheries Society Special Publication 19:207-296. Bethesda, Maryland.

Norton, J.B., T.A. Monaco, J.M. Norton, D.A. Johnson, and T.A. Jones. 2004. Cheatgrass Invasion Alters Soil Morphology and Organic Matter Dynamics in Big Sagebrush—Steppe Rangelands. *In* Seed and Soil Dynamics in Shrubland Ecosystems: Proceedings; 2002, August 12-16 (A. L. Hild, N. L. Shaw, S. E. Meyer, D. T. Booth, and E. D. McArthur, eds.). U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Laramie, Wyoming.

Obrigawitch, T.T., G. Cook, and J. Wetherington. 1998. Assessment of Effects on Non-target Plants from Sulfonylurea Herbicides Using Field Approaches. Pesticide Science 52:199-217.

Office of Management and Budget (OMB). 2005. Program Assessment Rating Tool Direct Federal Programs. Washington, D.C. Available at: http://www.whitehouse.gov/omb/budget/fy2006/pma/interior.pdf.

Oh, K.H., and O.H. Tuovinen. 1991. Bacterial Degradation of Phenoxy Herbicide Mixtures 2,4-D and Mcpp. Bulletin of Environmental Contamination and Toxicology 47:222-229.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common-sense Pest Control, Least-toxic Solutions for Your Home, Garden, Pets and Community. The Taunton Press. Newton, Connecticut.

Olson, B.E. 1999. Grazing and Weeds. Pages 85-97 *in* Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petroff, eds.). Oregon State University Press. Corvallis, Oregon.

________, and R.T. Wallander. 1997. Biomass and Carbohydrates of Spotted Knapweed and Idaho Fescue After Repeated Grazing. Journal of Range Management 50:409-412.

________, and R.T. Wallander. 1998. Effect of Sheep Grazing on a Leafy Spurge-infested Idaho Fescue Community. Journal of Range Management 51(2):247-252.

Olson, R., J. Hansen, T. Whitson, and K. Johnson. 1994. Tebuthiuron to Enhance Rangeland Diversity. Rangelands 16:197-201.

Opler, M.E. 1983. Mescarlero Apache. Pages 419-439 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

O'Rourke, J.T., and R.R. Ogden. 1969. Vegetative Response Following Pinyon-juniper Control in Arizona. Journal of Range Management 22(6):416-417.

Ott, R. 2000. Factors Affecting Stream Bank and River Bank Stability, with an Emphasis on Vegetation Influences. Prepared for the Region III Forest Practices Riparian Management Committee. Tanana Chiefs Conference, Inc. Forestry Program. Fairbanks, Alaska.

Page, L.M., and B.M. Burr. 1991. The Peterson Field Guide Series: A Field Guide to Freshwater Fishes. Houghton Mifflin Publishers. Boston, Massachusetts.

Paige, C., and S.A. Ritter. 1999. Birds in a Sagebrush Sea: Managing Sagebrush Habitats for Bird Communities. Partners in Flight Western Working Group. Boise, Idaho.

Partners for Fish and Wildlife. 2002. Available at: http://partners.fws.gov/pdfs/WY-needs.pdf.

Pastor, P.N., D.M. Makuc, C. Reuben, and H. Xia. 2002. Chartbook on Trends in the Health of Americans. Health, United States, 2002. National Center for Health Statistics. Hyattsville, Maryland.

Patterson, R.L. 1952. The Sage Grouse in Wyoming. Sage Books. Denver, Colorado.

Paul E.A., H.A. Simonin, J. Symula, and R.W. Bauer. 1994. The Toxicity of Diquat, Endothall, and Fluridone to the Early Life Stages of Fish. Journal of Freshwater Ecology 9:229-239.

Paulin, K.M., J.J. Cook, and S.R. Dewey. 1999. Pinyon-juniper Woodlands as Sources of Avian Diversity. Pages 240-243 *in* Proceedings: Ecology and Management of Pinyon-juniper Communities within the Interior West. U.S. Department of Agriculture Forest Service Proceedings RMPRS-P-9. Rocky Mountain Research Station. Ogden, Utah.

Paveglio, F.L. 1996. Use of Rodeo and X-77 Spreader to Control Smooth Cordgrass (*Spartina alterniflora*) in a Southwestern Washington Estuary: Environmental Fate. Environmental Toxicology and Chemistry 15:961- 968.

Pavel, E. W., A. R. Lopez, D. F. Berry, E. P. Smith, R. B. Reneau, and S. Mostaghimi. 1999. Anaerobic Degradation of Dicamba and Metribuzin in Riparian Wetland Soils. Water Research 33:87-94.

Payne, N.F., and F. Copes. 1986. Wildlife and Fisheries Habitat Improvement Handbook. U.S. Department of Agriculture Forest Service. U. S. Government Printing Office, Washington, D.C.

________, **and F.C. Bryant. 1998.** Wildlife Habitat Management of Forestlands, Rangelands, and Farmlands. Krieger Publishing Company. Malabar, Florida.

Paysen, T.E., R.J. Ansley, J.K. Brown, G.J. Gottfried, S.M. Haase, M.G. Harrington, M.G. Narog, S.S. Sackett, and R.C. Wilson. 2000. Fire in Western Shrubland, Woodland, and Grassland Ecosystems. Pages 121-160 *in* Wildland Fire in Ecosystems: Effects of Fire on Flora (J.K. Brown and J.K. Smith, eds.). General Technical Report RMRS-GTR-42, Volume 2. U.S. Department of Agriculture Forest Service Rocky Mountain Research Station. Ogden, Utah.

Pekar, S. 2002. Susceptibility of the Spider Theridion Impressum to 17 Pesticides. Anzeiger fuer Schaedlingskunde 75:51–55.

Perryman, B.L., R.E. Wilson, and W.I. Morrill. 2003. Eastern Nevada Landscape Coalition Position. Rangelands 25:30-34.

Perschbaucher, P., G.M. Ludwig, and R. Edzigie. 2004. Effects of Propanil, Diuron, and Atrazine Drift on Sunshine Bass Pond Plankton and Water Quality. University of Arkansas-Pine Bluff Aquaculture Field Day.

Pesticide Management Educator Program. 2001. 2,4-DP (dichlorprop) Herbicide Profile 9/88. Cornell University. Ithaca, New York. Available at: http://pmep.cce.cornell.edu.

Peterjohn, W.T., and W.H. Schlesinger. 1990. Nitrogen Loss from Deserts in the Southwestern United States. Biogeochem 10:67-79.

Peterson, H., C. Boutin, P. Martin, K. Freemark, N. Ruecker, and M. Moody. 1994. Aquatic Phytotoxicity of 23 Pesticides Applied at Expected Environmental Concentrations. Aquatic Toxicology 28:275-292.

Petit, V., R. Cabridenc, R.P.J. Swannell, and R.S. Sokhi. 1995. Review of Strategies for Modeling the Environmental Fate of Pesticides Discharged into Riverine Systems. Environmental International 21(2):167-176.

Petty, D.G., J.G. Skogerboe, K.D. Getsinger, D.R. Foster, B.A. Houtman, J.F. Fairchild, and L.W. Anderson. 2001. The Aquatic Fate of Triclopyr in Whole-pond Treatments. Pest Management Science 57:764-775.

________, **K.D. Getsinger, and K.B. Woodburn. 2003.** A Review of the Aquatic Environmental Fate of Triclopyr and Its Major Metabolites. Journal of Aquatic Plant Management 41:69-75.

Pfleeger, T.G., A. Fong, R. Hayes, H. Ratsch, and C. Wickliff. 1996. Field Evaluation of the EPA (Kenaga) Nomogram, a Method for Estimating Wildlife Exposure to Pesticide Residues on Plants. Environmental Toxicology and Chemistry 15(4):535-543.

Pianka, E.R. 1966. Convexity, Desert Lizards, and Spatial Heterogeneity. Ecology 47:1055-1059.

Pickle, L.W., M. Mungiole, G.K. Jones, and A.A. White. 1996. Atlas of United States Mortality. National Center for Health Statistics. (PHS) 97-1015. Hyattsville, Maryland. Available at: http://www.cdc.gov/nchs/products/pubs/pubd/other/atlas.

Pierson, K. 1990. Effects of IN A3674-207 on the Embryos and Larvae of Fathead Minnows (Pimephales promelas): Lab Project Number HLR 656-89: MR-8705-001. Unpublished Study Prepared by E.I. du Pont De Nemours and Company, Inc.

Pitelka. F.A. 1979. An Avi-faunal Review for the Barrow Region and North Slope of Arctic Alaska. Arctic and Alpine Research 6:161-184.

Platania, S.P. 2003. Perils Facing the Gila Trout in the Status and Trends of the Nation's Biological Resources. Available at: http://biology.usgs.gov/s+t/SNT/index.htm.

________, **and K.R. Bestgen. 1988.** An Interim Report on the Fishes of the Lower San Juan River, New Mexico, 1987. New Mexico Department of Game and Fish. Santa Fe, New Mexico.

Platts, W.S. 1981. Impairment, Protection, and Rehabilitation of Pacific Salmonid Habitats on Sheep and Cattle Ranges. Pages 82-92 *in* Proceedings, Symposium on Propagation, Enhancement, and Rehabilitation of Anadromous Salmonid Populations and Habitat in the Pacific Northwest (T.J. Hasler, ed.). California Cooperative Fishery Research Unit, Humbolt State University. Arcata, California.

________, and R.L. Nelson. 1985. Impacts to Rest-rotation Grazing on Stream Banks in Forested Watersheds in Idaho. North American Journal of Fisheries Management 5:547-556.

Plog, F. 1979. Prehistory: Western Anasazi. Pages 108-130 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Plumb, T.R. 1980. Response of Oaks to Fire. Pages 202-215 *in* Proceedings, Symposium on the Ecology, Management, and Utilization of California Oaks (T.R. Plumb, technical coordinator). General Technical Report PSW-44. U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experiment Station. Berkeley, California.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegarrd, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime: A Paradigm for River Conservation and Restoration. BioScience 47:769-784.

Pramer, D., and R. Bartha. 1980. How Pesticides Affect the Soil. Ecologist 10:83-86.

Prichard, D., F. Berg, S. Leonard, W. Hagenbuck, M. Manning, R. Krapf, C. Noble, R. Leinard, and J. Staats. 2003. Riparian Area Management: A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lentic Areas. TR 1737-16, U.S. Department of the Interior Bureau of Land Management, BLM/RS/ST-99/001+1737+REV03. Denver, Colorado.

Purdue Pesticide Programs. 2001. Pesticide Impact Assessment Program. Purdue University Pesticide Program. Document Number PPP-35., Purdue Cooperative Extension Service, West Lafayette, Indiana. Available at: http://www.btny.purdue.edu/PPP/.

Que Hee, S.S., and R.G. Sutherland. 1981. The Phenoxyalkanoic Herbicides, Volume I: Chemistry, Analysis, and Environmental Pollution. CRC Press, Inc. Boca Raton, Florida.

Rahman, A., T.K. James, and P. Sanders. 1993. Leaching and Movement of Imazapyr in Different Soil Types. Proceedings of the Forty Sixth New Zealand Plant Protection Conference, Christchurch. New Zealand. 1:115-119.

Rauzi, F., and C.L. Hanson. 1966. Water intake and runoff as affected by intensity of grazing. Journal of Range Management 19:351-356.

Rees, N.E., P.C. Quimby Jr., G.L. Piper, C.E. Turner, N.R. Spencer, and L.V. Knutson (eds.). 1995. Biological Control of Rangeland Weeds in the Northwestern United States. U.S. Department of Agriculture Agricultural Research Service Range Weeds and Cereals Research Unit, Montana State University. Bozeman, Montana.

________, ________, ________, E.M. Coombs, C.E. Turner, N.R. Spencer, and L.V. Knutson (eds.). 1996. The Biological Control of Weeds in the West. Western Society of Weed Science. Bozeman, Montana.

Reinert, K. H. 1989. Environmental Behavior of Aquatic Herbicides in Sediments. In Reactions and Movements of Organic Chemicals in Soils. Soil Science Society of American and American Society of Agronomy. Madison, Wisconsin.

Retzinger, E.J., Jr., and C. Mallory-Smith. 1997. Classification of Herbicides by Site of Action for Weed Resistance Management Strategies. Weed Technology 11:384-393.

Reynolds, H.G., and J.W. Bohning. 1956. Effects of Burning on a Desert Grass-shrub Range in Southern Arizona. Ecology 37:769-777.

Rhodes, R.C. 1980. Studies with 14C-labeled Hexazinone in Water and Bluegill Sunfish. Journal of Agricultural and Food Chemistry 28:306-310.

Rice, P.M., J.C. Toney, and D.J. Bedunah. 1997. Plant Community Diversity and Growth Form Responses to Herbicide Applications for Control of *Centaurea maculosa.* Journal of Applied Ecology 34:1397–1412.

Richardson, C.R., E. Burnett, and R.W. Bovey. 1979. Hydrologic Effects of Brush Control on Texas Rangelands. Transactions of the American Society of Agriculture and Engineering 22:315-319.

Richter, D., C.W. Ralston, and W.R. Harms. 1982. Prescribed Fire: Effects on Water Quality and Forest Nutrient Cycling. Science 215:661-663.

Rinne, J.N. 1995. The Effects of Introduced Fishes on Native Fishes: Arizona, Southwestern United States. Pages 149-159 *in* Protection of Aquatic Biodiversity, Proceedings of the World Fisheries Congress, Theme 3. Science Publishers, Inc. Lebanon, New Hampshire.

________. **1996.** Short-term Effects of Wildfire on Fishes and Aquatic Macroinvertebrates in the Southwestern United States. North American Journal of Fish Management 16:653-658.

________. **2003.** Native and Introduced Fishes: Their Status, Threat, and Conservation. Pages 194-213 *in* Ecology, Hydrology, and Management of Riparian Areas in the Southwestern United States (P.F. Ffolliott, M.B. Baker, L.F. Debano, and D.G. Neary, eds.). Lewis Publishers. Boca Raton, Florida.

________**, and W.L. Minckley. 1991.** Native Fishes of Arid Lands: A Dwindling Resources of the Desert Southwest. General Technical Report RM-206. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

________**, and J.A. Stefferud. 1997.** Factors Contributing to Collapse Yet Maintenance of a Native Fish Community in the Desert Southwest (USA). *In* Developing and Sustaining World Fisheries Resources: The State of Science and Management (D.A. Hancock, D.C. Smith, A. Grant, and J.P. Beaumer, eds.). Second World Fish Congress. Brisbane, Australia.

Roath, L.R., and W.C. Krueger. 1982. Cattle Grazing and Influences on a Forested Range. Journal of Range Management 35:332-338.

Robinson, W.L., and E.G. Bolen. 1989. Wildlife Ecology and Management. MacMillan Publishing Company. New York, New York.

Robson, S.G., and E.R. Banta. 1995. Ground Water Atlas of the United States: Arizona, Colorado, New Mexico, Utah. HA 730-C. Available at: http://capp.water.usgs.gov/gwa/.

Rood, S., J.W. Aanenson, S.S. Mohler, P.D. McGavran, H.J. Moholer, and H.A. Grogan. 2002. Analysis of Exposure and Risks to the Public from Radionuclides and Chemicals Released by the Cerro Grande Fire at Los Alamos. Task 1.7: Final Report on Estimated Risks from Releases to Air. RAC Report No. 3-NMED-2002-FINAL (Rev. 1). Risk Assessment Corporation. Neeses, South Carolina.

Rose, B. 2001. BLM Assists Investigation of Effects of OUST Herbicide on Croplands. USDI, BLM, Idaho Office. Boise, Idaho. Available at: http://www.id.blm.gov/newsreleases/data/01articles/oust.htm.

Roshon, R.D., J.H. McCann, D.G. Thompson, and G.R. Stephenson. 1999. Effects of Seven Forestry Management Herbicides on *Myriophyllum sibiricum*, as Compared with Other Nontarget Aquatic Organisms. Canadian Journal of Forest Research 29:1158-1169.

Ross, R.E. 1998. Prehistory of the Oregon Coast. Pages 554-559 *in* Northwest Coast (W. Suttles, ed.). Handbook of North American Indians, Volume 7 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Rottenberry, J.T., and J.A. Wiens. 1980. Habitat Structure, Patchiness, and Avian Communities in North American Steppe Vegetation: A Multivariate Analysis. Ecology 61:1228-1250.

Roundy, B.A., and J.A. Young. 1985. Salt Deserts of the Great Basin. Pages 34-49 *in* Proceedings, Selected Papers Presented at the 38th Annual Meeting of the Society for Range Management. Denver, Colorado.

_______, W.H. Blackburn, and R.E. Eckert, Jr. 1978. Influence of Prescribed Burning on Infiltration and Sediment Production in the Pinyon-juniper Woodland. Nevada. Journal of Range Management 31(4):250-253.

Rovesti, L., and K. V. Deseo. 1990. Compatibility of Chemical Pesticides with the Entomopathogenic Nematodes: Steinernema Carpocapsae Weiser and Steinernema Feltiae Filipjev (Nematoda: Steinernematidae). Nematologica 36:237-245.

Rowe, J.S., J.L. Bergsteinsson, G.A. Padbury, and R. Hermesh. 1974. Fire Studies in the Mackenzie Valley. Indian and Northern Affairs Publication No. QS-1567-000-EE-A1. Arctic Land Use Research Program, Northern Economic Development Branch, Department of Indian Affairs and Northern Development. Ottawa, Canada.

Rueppel, M. L., B. B. Brightwell, J. Schaefer, and J. T. Marvel. 1977. Metabolism and Degradation of Glyphosate in Soil and Water. Journal of Agricultural and Food Chemistry 25:517-528.

Russo, R.C., C.E. Smith, and R.V. Thurston. 1974. Acute Toxicity of Nitrite to Rainbow Trout (*Salmo gairdenri*). Journal of the Fisheries Research Board of Canada 31:1653-1655.

Rutske, L.H. 1969. A Minnesota Guide to Forest Fame Habitat Improvement. Minnesota Department of Conservation Technical Bulletin 10.

Sage Grouse Conservation Planning Team. 2001. Nevada Sage Grouse Conservation Strategy. Office of the Governor. Carson City, Nevada.

Salih, M.S.A., F.K. Taha, and G.F. Payne. 1973. Water Repellency of Soils under Burned Sagebrush. Journal of Range Management 26(5):330-331.

Sandberg, D.V., C.C. Hardy, R.D. Ottmar, J.A.K. Snell, A.L. Acheson, J.L. Peterson, P. Seamon, P. Lahm, and D. Wade. 1999. National Strategic Plan: Modeling and Data Systems for Wildland Fire and Air Quality. USDA Forest Service Pacific Northwest Research Station. Portland, Oregon.

Sandmann, E., M.A. Loos, and L.P. v. Dyk. 1988. The Microbial Degradation of 2,4-Dichlorophenoxyacetic Acid in Soil. Reviews in Environmental Contamination and Toxicology 101.

Sarmah, A.K., and J. Sabadie. 2002. Hydrolysis of Sulfonylurea Herbicides in Soils and Aqueous Solutions: A Review. Journal Of Agricultural and Food Chemistry 50:6253-6265.

_______, R.S. Kookana, and A.M. Alston. 1998. Fate and Behaviour of Triasulfuron, Metsulfuron-methyl, and Chlorsulfuron in the Australian Soil Environment: A Review. Australian Journal Of Agricultural Research 49:775-790.

_______, _______, and _______. 1999. Degradation of Chlorsulfuron and Triasulfuron in Alkaline Soils under Laboratory Conditions. Weed Research 39:83-94.

Satterlund, D.R., and P.W. Adams. 1992. Wildland Watershed Management (2[nd] edition). John Wiley and Sons, Inc. New York, New York.

Scarnecchia, D., S. Everett, T. Welker, and F. Ryckman. 2002. Missouri River Fishes: Big Changes in the Big Muddy. North Dakota Outdoors (March).

Schaaf, M.D. 1994. Wildfire and Air Quality. Pages 82-88 *in* Proceedings of the Conference on Forest Health and Fire Danger in Inland Western Forests. Harmen Press. Spokane, Washington.

Schaafsma, P. 1980. Indian Rock Art of the Southwest. School of American Research, Southwest Indian Art Series. Santa Fe, New Mexico.

Schaefer, J.A., and W.O. Pruitt, Jr. 1991. Fire and Woodland Caribou in Southeastern Manitoba. Wildlife Monographs No. 116.

Schmidt, K.M., J.P. Menakis, C.C. Hardy, W.J. Hann, and D.L. Bunnell. 2002. Development of Coarse-scale Spatial Data for Wildland Fire and Fuel Management. General Technical Report RMRS-GTR-87. U.S. Department of Agriculture Forest Service Rocky Mountain Research Station. Fort Collins, Colorado.

Schroeder, A.H. 1979. Pueblos Abandoned in Historic times. Pages 236-254 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Schuster, H.H. 1998. Yakima and Neighboring Groups. Pages 308-335 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Schwartz, D.W. 1983. Havasupai. Pages 13-24 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Scifres, C.J., R.R. Hahn, J. Diaz-Colon, and M.G. Merkle. 1971. Picloram Persistence in Semiarid Rangeland Soils and Water. Weed Science 19:381-384.

Scurlock, D. 1998. From the Rio to the Sierra: An Environmental History of the Middle Rio Grande Basin. General Technical Report RMRS-GTR-5. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Fort Collins, Colorado.

Seaber, P.R., F.P. Kapinos, and G.L. Knapp. 1987. Hydrologic Unit Maps. U.S. Geological Survey Water-supply Paper 2294. Available at: http://water.usgs.gov/GIS/huc.html.

Segawa, R., A. Bradlye, P. Lee, D. Tran, J. White, J. Hsu, and K. Goh. 1997. Residues of Forestry Herbicides in Plants of Interest to Native Americans: Phase One – Development of Methodologies and Pilot Sampling. Environmental Hazards Program, California Environmental Protection Program. Sacramento, California.

Severson, K.E., and A.L. Medina. 1983. Deer and Elk Habitat Management in the Southwest. Journal of Range Management Monograph 2.

Shaw, L.J., and R.G. Burns. 1998. Biodegradation of 2,4-D in a Noncontaminated Grassland Soil Profile. Journal of Environmental Quality 27:1464-1471.

Sheehan, R., and W.M. Lewis. 1986. Influence of pH and Ammonia Salts on Ammonia Toxicity and Water Balance in Young Channel Catfish. Transactions of the American Fisheries Society 115:891-899.

Sheley, R.L., J.S. Jacobs, and M.L. Carpinelli. 1999. Spotted Knapweed. Pages 350-361 *in* Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petrolff, eds.). Oregon State University Press. Corvallis, Oregon.

________, L.L. Larson, and J.S. Jacobs. 1999. Yellow Starthisle. Pages 408-416 in Biology and Management of Noxious Rangeland Weeds (R.L. Sheley and J.K. Petrolff, eds.). Oregon State University Press, Corvallis.

Shelton, D.R., S. Khader, J.S. Karns, and B.M. Pogell. 1996. Metabolism of Twelve Herbicides by Streptomyces. Biodegradation 7:129-136.

Shimkin, D.B. 1986. Eastern Shoshone. Pages 308-335 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, ed.). Smithsonian Institution. Washington, D.C.

Shinn S.L., and D.C. Thill. 2002. The Response of Yellow Starthistle (*Centaurea solstitialis*), Annual Grasses, and Smooth Brome (*Bromus inermis*) to Imazapic and Picloram. Weed Technology 16(2):366-370.

Short, H.L., and C.Y. McCulloch. 1977. Managing Pinyon-juniper Ranges for Wildlife. General Technical Report RM-47. U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Sieg, C.H. 1991. Rocky Mountain Juniper Woodlands: Year-round Avian Habitat. Research Paper RM-296. U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Sigmon, C.F. 1979. Physiological Effects of 2,4-D and 2,4,5-T on Selected Aquatic Organisms. Report (22): 30. Water Resources Research Institute, Clemson University. Clemson, South Carolina.

Sims, P.L. 1988. Grasslands. Pages 265-286 *in* North American Terrestrial Vegetation (M.G. Barbour and W.D. Billings, eds.). Cambridge University Press. New York, New York.

Simsiman, G. V., and G. Chesters. 1976. Persistence of Diquat in Aquatic Environment. Water Research 10:105-112.

Skogerboe, J.G. 2003. Invasion of Eurasian Watermilfoil in Lakes of the Western Upper Peninsula, Michigan. Waterways Experiment Station U. S. Army Engineer Research and Development Center. Vicksburg, Mississippi.

Smith, A.E., and A.J. Aubin. 1994. Loss of Enhanced Biodegradation of 2,4-D and Mcpa in a Field Soil Following Cessation of Repeated Herbicide Applications. Bulletin of Environmental Contaminent Toxicology 53.

Smith, B.H. 1984. Avian Habitat Selection in a Mixed Creosotebush-grassland Community. M.S. Thesis, University of Arizona. Tucson, Arizona.

Smith, J.K. 2000. Wildland Fire in Ecosystems: Effects of Fire on Fauna. General Technical Report RMRS-GTR-42 Volume 1. USDA Forest Service Rocky Mountain Research Station. Fort Collins, Colorado.

Soil Quality Institute. 2001. Soil Quality – Introduction, Prepared by the Soil Quality Institute, National Soil Survey Center, Natural Resource Conservation Service, U.S. Department of Agriculture, and the National Tilth Laboratory, ARS, U.S. Department of Agriculture. Available at: http://www.soils.usda.gov/sqi/soil_quality/what_is/sqiinfo.html.

Spahr, N.E., L.E. Apodaca, J.R. Deacon, J.B. Bails, N.J. Bauch, C.M. Smith, and N. Driver. 2000. Water Quality in the Upper Colorado River Basin, Colorado, 1996-98. U.S. Geological Survey Circular 1214. Available at: http://water.usgs.gov/pubs/circ1214.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation, TR-4501-96-6057. Management Technology. Portland, Oregon.

Spencer, C.N., and F.R. Hauer. 1991. Phosphorous and Nitrogen Dynamics in Streams During Wildfire. Journal of North American Benthological Society 10:24-30.

Sprankle, P., W.F. Meggitt, and D. Penner. 1975. Rapid Inactivation of Glyphosate in the Soil. Weed Science 23:224-228.

Spray Drift Task Force (SDTF). 2002. A User's Guide for AgDRIFT® 2.0.05: A Tiered Approach for the Assessment of Spray Drift of Pesticides. Regulatory Version. C.D.I. Report No. 01-02. Macon, Missouri.

Spurlock, F., K. Burow, and N. Dubrovsky. 2000. Chlorofluorocarbon Dating of Herbicide-containing Well Waters in Fresno and Tulare Counties, California. Journal of Environmental Quality 29:474-483.

Standley, W.G., and N.S. Smith. 1988. Effects of Treating Creosotebush with Tebuthiuron on Rodents. Pages 422-424 *in* Symposium on the Management of Amphibians, Reptiles and Small Mammals in North America. Flagstaff, Arizona.

Starnes, W.C. 1995. Colorado River Basin Fishes *in* Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems (E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, eds.). U.S. Department of the Interior National Biological Service. Washington, D.C.

Steinman, A.D., and C.D. McIntire. 1990. Recovery of Lotic Periphyton Communities After Disturbance. Environmental Management 14:598-604.

Steward, J.H. 1939. Changes in Shoshonean Indian Culture. Scientific Monthly 49:524-537.

________. **1997.** Basin-Plateau Aboriginal Sociopolitical Groups. Reprint. University of Utah Press, Salt Lake City. Originally Printed in 1938, Smithsonian Institution Bureau of American Ethnology Bulletin 120, United States Government Printing Office. Washington, D.C.

Stinson, K. 2001. Prefire and Postfire Grazing Management. Pages 178-190 *in* National Wildfire Coordinating Group. Fire Effects Guide. Fire Use Working Team, National Interagency Fire Center. Boise, Idaho. Available at: http://fire.r9.fws.gov/ifcc/monitor/FEG.pdf.

Storrs, S.I., and J.M. Kiesecker. 2004. Survivorship Patterns of Larval Amphibians Exposed to Low Concentrations of Atrazine. Environmental Health Perspectives. Volume 112. Available at: http://ehp.niehs.nih.gov/members/2004/6821/6821.html.

Strek, H.J. 1998a. Fate of Chlorsulfuron in the Environment. 1. Laboratory Evaluations. Pesticide Science 53:29-51.

________. **1998b.** Fate of Chlorsulfuron in the Environment. 2. Field Evaluations. Pesticide Science 53:52-70.

Stuber, R.J. 1985. Trout Habitat, Abundance, and Fishing Opportunities in Fenced Versus Unfenced Riparian Habitat Along Sheep Creek, Colorado. Pages 310-314 *in* Riparian Ecosystems and their Management: Reconciling Conflicting Uses. (R.R. Johnson, C.D. Ziebell, D.R. Patton, eds.). General Technical Report RM-120. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Sturges, D.L. 1975. Hydrologic Relations on Undisturbed and Converted Big Sagebrush Lands: the Status of Our Knowledge. Research Paper RM-140. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. Fort Collins, Colorado.

________. **1977.** Soil Moisture Response to Spraying Big Sagebrush: A Seven-year Study and Literature Interpretation. Research Paper RM-188. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Sturtevant, W.C. (ed.). 1978-2001. Handbook of North American Indians. Smithsonian Institution. Washington, D.C.

Sullivan, T.P., C. Nowotny, and R.A. Lautenschlager. 1998. Silvicultural Use of Herbicide in Sub-boreal Spruce Forest: Implications for Small Mammal Population Dynamics. Journal of Wildlife Management 62(4):1196-1206.

Suttles, W. 1990. Environment. Pages 16-29 *in* Northwest Coast (W. Suttles, ed.). Handbook of North American Indians, Volume 7 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Suzuki, T., K. Yaguchi, S. Suzuki, and T. Suga. 2001. In Vitro Pesticide Degradation in Turfgrass Soil Incubated under Open and Sealed Conditions. Journal of Environmental Quality 30:18-23.

Swanston, D.N. 1991. Natural Processes. American Fisheries Society Special Publication 19:139-179.

Swetnam, T. 1990. Fire History and Climate in the Southwest United States. Pages 6-17 *in* Proceedings of Symposium: Effects of Fire Management of Southwestern Natural Resources. General Technical Report RM-191. U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Syracuse Environmental Research Associates, Inc. (SERA). 1997. Selected Commercial Formulations of Hexazinone – Human Health and Ecological Risk Assessment Final Draft. SERA TR 95-21-04-01b. March 4, 1997.

________. **1998.** 2,4 Dichlorophenoxyacetic Acid Formulations – Human Health and Ecological Risk Assessment Final Report. SERA TR 95-21-09-01d. Prepared for the U.S. Department of Agriculture Forest Service. Arlington, Virginia. Fayetteville, New York.

________. **1999.** Clopyralid (Transline) – Human Health and Ecological Risk Assessment Final Report. SERA TR 99-21-11/12-01c. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2001a.** Preparation of Environmental Documentation and Risk Assessments, SERA MD 2001-01a, Draft Dated July 2001. Syracuse Environmental Research Associates, Inc. Fayetteville, New York. Available at: www.sera-inc.com.

________. **2001b.** Imazapic [Plateau and Plateau DG] - Human Health and Ecological Risk Assessment Final Report. SERA TR00-21-28-01e. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2003a.** 2,4-D. Human Health and Ecological Risk Assessment Final Report. SERA TR 95-21-09-01d. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2003b.** Glyphosate – Human Health and Ecological Risk Assessment Final Report. SERA TR 02-43-09-04a. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2003c.** Picloram – Revised Human Health and Ecological Risk Assessment Final Report. SERA TR 03-43-16-01b. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2003d.** Triclopyr – Revised Human Health and Ecological Risk Assessment Final Report. SERA TR 02-43-13-03b. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2004a.** Chlorsulfuron – Human Health and Ecological Risk Assessment Final Report. SERA TR 04-43-18-01c. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2004b.** Clopyralid (Transline) – Human Health and Ecological Risk Assessment Final Report. SERA TR 04 43-17-03c. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2004c.** Dicamba – Human Health and Ecological Risk Assessment Final Report. SERA TR 04-43-17-05b. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2004d.** Imazapic Plateau and Plateau Dg – Human Health and Ecological Risk Assessment Final Report. SERA TR 04-43-17-04b. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2004e.** Imazapyr – Human Health and Ecological Risk Assessment Final Report. SERA TR 04-43-17-05b. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2004f.** Metsulfuron methyl – Human Health and Ecological Risk Assessment Peer Review Draft. SERA TR 04-43-17-01b. Prepared for the U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville, New York.

________. **2005a.** Herbicide Risk Assessment Locator: Herbicides and Surfactants Analyzed in the Invasive Plants EIS. Prepared for U.S. Department of Agriculture Forest Service, Arlington, Virginia. Fayetteville. New York. Available at: http://www.fs.fed.us/r6/invasiveplant-eis/Risk-Assessments/Herbicides-Analyzed-InvPlant-EIS.htm.

________. **2005b.** Risk Assessment Worksheets. Prepared for the U.S. Department of Agriculture Forest Service by Syracuse Environmental Research Associates, Inc., Fayetteville, New York.

Szaro, R.C. 1995. Biodiversity of Forest Ecosystems of Western North America. International Union of Forest Research Organizations. Tenth Congress "Caring for the Forest: Research in a Changing World" August 6-12, 1995. Tampere, Finland. IUFRO-95 Papers and Abstracts. Available at: http://www.metla.fi/iufro/iufro95abs/rsp7.htm.

Tatum, V.L. 2004. Toxicity, Transport, and Fate of Forest Herbicides. Wildlife Society Bulletin 32:1042-1048.

Temple, A.J., B.R. Murphy, and E.F. Cheslak. 1991. Effects of Tebuthiuron on Aquatic Productivity. Hydrobiologia 224:117-127.

Thomas, D.H., L.S.A. Pendleton, and S.C. Cappannari. 1986. Western Shoshone. Pages 262-283 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution, Washington, D.C.

Thompson, D.G., L.M. Macdonald, and B. Staznik. 1992. Persistence of Hexazinone and Metsulfuron-methyl in a Mixed-wood/Boreal Forest Lake. Journal of Agricultural and Food Chemistry 40:1444-1449.

________, D. P. Kreutzweiser, S. S. Capell, D. R. Thomas, B. Staznik, and T. Viinikka. 1995. Fate and Effects, of Triclopyr Ester in a First-order Forest Stream. Environmental Toxicology and Chemistry 14:1307-1317.

Thomas, J.W., E.D. Forsman, J.B. Lint, E. Meslow, B.R. Noon, and J. Verner. 1990. A Conservation Strategy for the Northern Spotted Owl. Report to the Interagency Scientific Community to Address the Conservation of the Northern Spotted Owl. U.S. Government Printing Office. Washington, D.C.

Tiller, V.E. 1983. Jicarilla Apache. Pages 440-461 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Tixier, C., M. Sancelme, S. Ait-Aissa, P. Widehem, F. Bonnemoy, A. Cuer, N. Truffaut, and H. Veschambre. 2002. Biotransformation of Phenylurea Herbicides by a Soil Bacterial Strain, *Arthrobacter* Sp. N2: Structure, Ecotoxicity and Fate of Diuron Metabolite with Soil Fungi. Chemosphere 46:519-526.

Tomlin, C. (ed.). 1994. The Agrochemicals Desk Reference. 2nd Edition. Lewis Publishers. Boca Raton, Florida.

Tranel, P.J., and T.R. Wright. 2002. Resistance of Weeds to ALS-inhibiting Herbicides: What Have We Learned? Weed Science 50(6):700-712.

Tromble, J.M. 1980. Infiltration Rates on Rootplowed Rangeland. Journal of Range Management 33(6):423-424.

Tu, C.M. 1994. Effects of Herbicides and Fumigants on Microbial Activities in Soil. Bulletin of Environmental Contaminent Toxicology 53:12-17.

Tu, M., C. Hurd, and J.M. Randall. 2001. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. Wildland Invasive Species Program. The Nature Conservancy. Available at: http://tncweeds.ucdavis.edu/handbook.html.

Turner, S.A. 1987. Post-application Movement of Sulfometuron Methyl from Treated Rights of Way Areas Via Wind Erosion. Proceedings Fourth Symposium on Environmental Concerns in Rights of Way Management. October 25-28, 1987. Indianapolis, Indiana.

University of Missouri Extension. 1997. Pesticides and the Environment. Columbia, Missouri. Available at: http://muextension.missouri.edu/explore/agguides/pests/g07520.htm.

Urness, P.J. 1979. Wildlife Habitat Manipulation in Sagebrush Ecosystems. Pages 164-178 in The Sagebrush Ecosystem: A Symposium. Utah State University, Logan.

U.S. Department of Agriculture (USDA). 1995. Pesticide Properties Database. U.S. Department of Agriculture Agricultural Research Service. Available at: http://www.arsusda.gov/acsl/services/ppdb/textfiles/METSULFURON_ME.

________, and U.S. Department of the Interior. 2001. Interagency Burned Areas Emergency Stabilization and Rehabilitation Handbook. Washington, D.C.

U.S. Department of Agriculture Forest Service (USDA Forest Service). 1988. Managing Competing and Unwanted Vegetation Final Environmental Impact Statement. Washington, D.C.

________. 1989. An Analysis of the Range Forage Situation in the United States: 1989-2040. Available at: http://www.fs.fed.us/pl/rpa/rge89.htm.

________. **1999.** Dicamba Herbicide Information Profile. Washington, D.C.

________. **2000a.** Picloram Herbicide Information Profile. Pacific Northwest Region. Report Available at: http://www.fs.fed.us/r6/nr/fid/pubsweb/piclo.pdf.

________. **2000b.** Protecting People and Sustaining Resources in Fire-adapted Ecosystems—A Cohesive Strategy. Available at: http://www.fs.fed.us/pub/fam/.

________. **2002.** Biological Assessment for the Implementation of the Preferred Alternatives for the Sierra Nevada Forest Plan Draft Environmental Impact Statement. U.S. Department of Agriculture Forest Service Pacific Southwest Region. Vallejo, California.

________. **2005.** Preventing and Managing Invasive Plants, Final Environmental Impact Statement. U.S. Department of Agriculture Forest Service Pacific Northwest Region. Available at: http://www.fs.fed.us/r6/invasiveplant-eis/.

________, **and U.S. Department of the Interior. 2000.** Managing the Impacts of Wildfires on Communities and the Environment. A Report to the President in Response to the Wildfires of 2000. September 8, 2000. http://www.fireplan.gov/president.cfm.

U.S. Department of Agriculture Forest Service and U.S. Department of the Interior Bureau of Land Management. 1997. Upper Columbia River Basin Draft Environmental Impact Statement Interior Columbia Basin Ecosystem Management Project. BLM-ID-PT-96-021. Washington, D.C.

________, **and** ________. **2000.** Interior Columbia Basin Supplemental Draft Environmental Impact Statement. Boise, Idaho.

U.S. Department of Agriculture National Agricultural Statistics Service. 2001. Washington, D.C. Available at: http://www.usda.gov/nass/.

U.S. Department of Agriculture Natural Resources Conservation Service. 1996. Soil Quality Indicators: Organic Matter. Soil Quality Information Sheet Series. Natural Resources Conservation Service National Soil Survey Center in Cooperation with the Natural Resources Conservation Service Soil Quality Institute, and the Agricultural Research Services National Soil Tilth Lab. Available Online with Updates at http://soils.usda.gov/sqi/sqiinfo.html.

U.S. Department of Commerce (USDOC) Bureau of the Census. 2004. Washington, D.C. Available at: http://www.census.gov/.

U.S. Department of Commerce Bureau of Economic Analysis. 2002. Regional Accounts Data. Washington, D.C. Available at: http://www.bea.gov.

U.S. Department of the Interior (USDI). 2001. Integrating Fire and Natural Resource Management – A Cohesive Strategy for Protecting People by Restoring Land Health. Draft Report. Washington, D.C.

U.S. Department of the Interior Bureau of Land Management (USDI BLM). 1980. Control of Salinity from Point Sources Yielding Groundwater Discharge and from Diffuse Surface Runoff in the Upper Colorado River Basin. BLM Service Center. Denver, Colorado.

________. **1984a.** Grazing Management. Manual Handbook Number H-4120-1. Washington, D.C.

________. **1984b.** Visual Resource Management. Manual Handbook Number 8400-1. Washington, D.C.

________. **1984c.** Visual Resource Management. Manual 8400. Washington, D.C.

________. **1985a.** Northwest Area Noxious Weed Control Program Final Environmental Impact Statement. BLM Oregon State Office. Portland, Oregon.

________. **1985b.** Renewable Resource Improvements and Treatments. Manual Number 1740. Washington, D.C.

________. **1986a.** Visual Resources Management Inventory. Manual 8410. Washington, D.C.

________. **1986b.** Visual Resources Inventory. Handbook H- 8410-1. Washington, D.C.

________. **1986c.** Visual Resources Inventory. Manual Handbook H-8431-1. Washington, D.C.

________. **1987a.** Supplemental Record of Decision Northwest Area Noxious Weed Control Program. Washington, D.C.

________. **1987b.** Supplement to the Northwest Area Noxious Weed Control Program Final Environmental Impact Statement. BLM Oregon State Office. Portland, Oregon.

________. **1987c.** Fire Planning, Manual Number 9211. Washington, D.C.

________. **1987d.** Renewable Resource Improvement and Treatment Guidelines and Procedures. Manual Handbook Number H-1740-1. Washington, D.C.

________. **1987e.** Salinity Control on BLM-administered Public Lands in the Colorado River Basin: A Report to Congress. BLM Service Center. Denver, Colorado.

________. **1988a.** California Vegetation Management Final Environmental Impact Statement. BLM California State Office. Sacramento, California.

________. **1988b.** Record of Decision, California Vegetation Management. BLM California State Office. Sacramento, California.

________. **1988c.** National Environmental Policy Act Handbook. BLM Handbook H-1790-1. Washington, D.C.

________. **1988d.** Prescribed Fire Management. Manual Number 9214. Washington, D.C.

________. **1988e.** Chemical Pest Control. BLM Handbook H-9011-1. Washington, D.C.

________. **1988f.** Management of Designated Wilderness Areas. BLM Manual Handbook H-8560-1. Washington, D.C.

________. **1989a.** Western Oregon – Management of Competing Vegetation Final Environmental Impact Statement. Washington, D.C.

________. **1989b.** Fencing. Manual Handbook Number H-1741-1. Washington, D.C.

________. **1990a.** National Range Handbook. Manual Handbook Number H-4410-1. Washington, D.C.

________. **1990b.** Water Developments. Manual Handbook Number H-1741-2. Washington, D.C.

________. **1991a.** Final Environmental Impact Statement Vegetation Treatment on BLM Lands in Thirteen Western States. BLM Wyoming State Office. Casper, Wyoming.

________. **1991b.** Record of Decision for Final Environmental Impact Statement Vegetation Treatment on BLM Lands in Thirteen Western States. BLM Wyoming State Office. Cheyenne, Wyoming.

________. **1991c.** Forest Management (Public Domain). Manual Number 5000-1. Washington, D.C.

________. **1992a.** Western Oregon Program-management of Competing Vegetation. Final Record of Decision. Portland, Oregon.

________. **1992b.** Integrated Weed Management. BLM Manual Section 9015. Washington, D.C.

________. **1993.** Management of Designated Wilderness Areas. Manual Number 8560. Washington, D.C.

________. **1994.** Rangeland Reform Draft Environmental Impact Statement. Washington, D.C.

________. **1995.** Interim Management Policy for Lands Under Wilderness Review. BLM Manual Handbook H-8550-1. Washington D.C.

________. **1996.** Partners Against Weeds: An Action Plan for the Bureau of Land Management. Washington, D.C.

________. **1997.** Public Land Statistics. Washington, D.C. Available at: http://www.blm.gov/.

________. **1998.** Wildfire Statistics. Office of Fire and Aviation Management. Boise, Idaho.

________. **1999.** Out of Ashes, An Opportunity. National Office of Fire and Aviation. Boise, Idaho.

________. **2000a.** Strategic Plan FY 2000-2005. Washington, D.C.

________. **2000b.** Public Rewards from Public Lands 2000 – Great Basin Restoration. Washington, D.C.

________. **2000c.** Public Rewards from Public Lands 2000 – Alaska. Washington, D.C.

________. **2000d.** The Great Basin: Healing the Land. Washington, D.C.

________. **2000e.** Annual Performance Plan 2001 and Annual Performance Report 1999. Washington, D.C.

________. **2000f.** Science Strategy. Washington, D.C.

________. **2000g.** Land Use Planning Handbook H-1601-1. Washington, D.C.

________. **2000h.** BLM Clean Water Action Plan (CWAP) Fact Sheet. Available at: http://www.blm.gov/nhp/what/cwap/cwapfact.html.

________. **2000i.** National Assessment Prototype. June 2000. Available at: http://www.blm.gov/nhp/200/nap/.

________. **2000j.** Nevada State Office Press Release Number 2001-03. Reno, Nevada.

________. **2000k.** Nevada State Office Press Release Number 2000-25. Reno, Nevada.

________. **2001a.** Wilderness Inventory and Study Procedures. BLM Manual Handbook H-6310-1. Washington, D.C.

________. **2001b.** Dawn of an American Legend. Prepared for Science and Children Magazine. National Science Teachers Association. Available at: http://www.blm.gov/education/00_resources/articles/wild_bunch/wildbunch1.html.

________. **2002a.** Public Land Statistics, 2001. Washington, D.C. Available at: http://www.blm.gov/natacq/pls01/.

________. **2002b.** Budget Justifications and Annual Performance Plan FY 2003, Annual Performance Report. Washington, D.C.

________. **2003.** Prescribed Fire Management. Manual Handbook Number H-9214-1. Washington, D.C.

________. **2004a.** Public Land Statistics Fiscal Year 2004. Washington, D.C.

________. **2004b.** Manual 620 Wildland Fire Management. Washington, D.C.

________. **2004c.** Proposed Revisions to Grazing Regulations for the Public Lands Final Environmental Impact Statement. Washington, D.C. Available at: www.blm.gov.

________. **2005a.** Vegetation Treatments on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Report. Reno, Nevada.

________. **2005b.** Draft Programmatic Biological Assessment for Vegetation Treatments on Bureau of Land Management Lands in 17 Western States. Reno, Nevada.

________. **2005c.** The United States Department of the Interior Bureau of Land Management Budget Justifications and Performance Information Fiscal Year 2006, and Annual Performance Report Fiscal Year 2005. Washington, D.C.

________. **2005d.** Public Land Statistics Fiscal Year 2004. Washington, D.C.

________. **2005e.** Northeast National Petroleum Reserve-Alaska Final Amended Integrated Activity Plan/Environmental Impact Statement. Document BLM/AK/PL-05/006+1610+930. Anchorage, Alaska.

________. **2005f.** Injury Breakout. All Injuries Report Breakout by Cause. Washington, D.C.

USDI BLM 2005f. Strategic Research Plan Wild Horse and Burro Management. Wild Horse and Burro Program. Washington, D.C. Available at: http://www.wildhorseandburro.blm.gov.

U.S. Department of the Interior, and U.S. Department of Agriculture. 2001a. Managing the Impacts of Wildland Fires on Communities and the Environment. The National Fire Plan. Available at: http://www.fireplan.gov.

_______, **and** _______. **2001b.** A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment. 10-year Comprehensive Strategy. August 2001. Available at: http://www.fireplan.gov/fire.report.1.pdf.

_______, **and** _______. **2002.** A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment. 10-year Comprehensive Strategy Implementation Plan. May 2002. Available at: http://www.fireplan.gov/10yrIPfinal.cfm.

_______, _______, **and U.S. Department of Energy. 2003.** Scientific Inventory of Onshore Federal Lands' Oil and Gas Resources and Reserves and the Extent and Nature of Restrictions or Impediments to the Development: The Paradox/San Juan, Uinta/Piceance, Greater Green River, and Powder River Basins, and the Montana Thrust Belt. Washington, D.C.

_______, **and U.S. Department of Agriculture Forest Service. 1994.** Rangeland Reform '94. Draft Environmental Impact Statement. U.S. Department of Interior. Washington, D.C.

U.S. Department of the Interior National Park Service. 2003. Invasive Exotic Plant Management Plan and Environmental Assessment Rocky Mountain National Park. Colorado.

U.S. Department of Labor Bureau of Labor Statistics. 2004. Census of Fatal Occupational Injuries, 2003 Summary. Washington, D.C. Available at: http://stats.bls.gov/news.release/cfoi.nr0.htm.

_______. **2005.** Local Area Unemployment Statistics, Regional Resources. Washington, D.C. Available at: http://www.bls.gov.

U.S. Environmental Protection Agency (USEPA). 1986. Pesticide Fact Sheet - fluridone. Fact Sheet 81. Office of Pesticide Programs. Washington, D.C.

_______. **1992.** Pesticide Environmental Fate One-liner Summaries: Sulfometuron methyl. USEPA. One-liner Summaries. Washington, D.C.

_______. **1994a.** Tebuthiuron Reregistration Eligibility Decision (Red). Special Review and Reregistration Division, Office of Pesticide Programs. Washington D.C.

_______. **1994b.** HED Doc. No. 013110. Bromacil. PC Code: 012301. 11/16/94.

_______. **1995a.** Compilation of Air Pollution Emission Factors, AP-42, Fifth Edition, Volume II: Mobile Sources, Appendix H Highway Mobile Source Emission Factor Tables. Supplemented through November 2000. Available at: http://www.epa.gov/otaq/ap42.htm.

_______. **1995b.** Re-registration Eligibility Decision (RED) Asulam. Prevention, Pesticides, and Toxic Substances. EPA 738-R-95-024. Washington, D.C.

_______. **1995c.** Re-registration Eligibility Decision (RED) Diquat Dibromide. Prevention, Pesticides, and Toxic Substances. EPA 738-R-95-016. Washington, D.C.

_______. **1995d.** Re-registration Eligibility Decision (RED) Fosamine Ammonium. Prevention, Pesticides, and Toxic Substances. EPA 738-F-95-005. Washington, D.C.

_______. **1996.** Pesticide Tolerance for Cadre. Final Rule Published in the Federal Register. 40 CFR Part 180.490. Docket number: PP 4F4390/R2215. March 20, 1996.

_______. **1997.** Exposure Factors Handbook, Volumes I, II, and III. EPA/600/P-95/002Fa, b, and c. Office of Research and Development, Washington, D.C.

_______. **1998a.** Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. Washington, D.C.

_______. **1998b.** Freedom of Information Act Request. Cited in: Aerial Herbicide Spraying: Poisoning the Maine (and New Hampshire) Woods. Available at: http://www.powerlink.net/fen/tmwfall99_05.html.

______. **1998c.** Framework for Assessing Non-occupational, Non-dietary (Residential) Exposure to Pesticides. Office of Pesticide Programs. Washington, D.C.

_______. **1998d.** Pesticide Handlers Exposure Database Version 1.1, Surrogate Exposure Table. August 1998.

_______. **1999a.** Pesticide Fact Sheet: Diflufenzopyr United States Environmental Protection Agency. Office of Prevention, Pesticides and Toxic Substances. Washington, D.C.

_______. **1999b.** Regional Haze Regulations: Final Rule. 40 CFR Part 51. Federal Register, Volume 64, Number 126, July 1, 1999. Washington, D.C. Available at: http://www.epa.gov/ttn/oarpg/t1/fr_notices/rhfedreg.pdf.

_______. **1999c.** Overall Watershed Characterization-National Maps. September 1999 Index of Watershed Indicators (IWI) Release. Washington, D.C. Available at: http://www.epa.gov/iwi/1999sept/catalog.html.

______. **1999d.** Guidance for Performing Aggregate Exposure and Risk Assessments. Office of Pesticide Programs, Environmental Protection Agency. October 29, 1999.

_______. **2000a.** Water Quality Conditions in the United States: A Profile from the 1998 National Water Quality Inventory Report to Congress. EPA-841-F-00-006. Office of Water (4503F). Washington, DC.

_______. **2000b**. Science Advisory Council For Exposure. Policy Number 3.1:Agricultural Transfer Coefficients. Office of Pesticide Programs. Health Effects Division. Washington, D.C.

_______. **2000c.** The Role of Use-related Information in Pesticide Risk Assessment and Risk Management. Office of Pestide Programs, USEPA. August 21, 2000. Available at: http://www.epa.gov/pesticides/trac/science/.

_______. **2001a.** Environmental Risk Assessment for the Reregistration of Diuron. Environmental Fate and Effects Division. Washington, D.C.

_______. **2001b.** Notice of Availability of National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution. EPA 841-B-01-001. Washington, D.C.

_______. **2001c.** Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual. Part E. Supplemental Guidance for Dermal Risk Assessment. Interim. Review Draft for Public Comment. EPA/540/R/99/005. OSWER 9285.7-02EP. Washington, D.C.

______. **2001d.** General Principles for Performing Aggregate Exposure and Risk Assessments. November 28, 2001.

_______. **2002a.** Air Data. Access to Air Pollution Data. Washington, D.C. Available at: http://www.epa.gov/air/data/index.html.

_______. **2002b.** Revised Human Health Risk Assessment – Atrazine. Health Effects Division, Reregistration Branch 3, Office of Pesticide Programs. Washington, D.C. Available at: http://www.epa.gov/oppsrrd1/reregistration/atrazine/hed_redchap_16apr02.PDF.

_______. **2003a.** Compilation of Air Pollution Emission Factors, AP-42, Fifth Edition, Volume I, Chapter 13 Miscellaneous Sources 13.2.2 Unpaved Roads. Available at: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf.

_______. **2003b.** USEPA Pesticide Ecotoxicity Database, Provided by Brian Montague. Office of Pesticide Programs. June 6, 2003.

_______. **2003c.** Atrazine Interim Re-registration Eligibility Decision (IRED). Case Number 0062. Washington, D.C.

_______. **2003d.** Reregistration Eligibility Decision (Red) for Diuron. United States Environmental Protection Agency. Office of Prevention, Pesticides and Toxic Substances. Washington D.C.

_______. **2003e.** Laws and Regulations, Clean Water Act. Washington, D.C. Available at: http://www.epa.gov/region5/water/cwa.htm.

________. **2003f.** White Paper on Potential Development Effects of Atrazine on Amphibians. Office of Prevention, Pesticides, and Toxic Substances Office of Pesticide Programs Environmental Fate and Effects Division. Washington, D.C. Available at: http://www.epa.gov/scipoly/sap/2003/june/finaljune2002telconfreport.pdf#search='atrazine%20and%20amphibians.

________. **2003g.** 40 Code of Federal Regulations. Section 156.62. Available at: www.epa.gov/pesticides/health/tox_categories.html.

________. **2003h.** 40 Code of Federal Regulations. Section 156.62. (7/1/03 edition). Available at: www.epa.gov/pesticides/health/tox_categories.html.

________. **2004.** Prevention of Significant Deterioration (PSD) Basic Information. Available at: http://www.epa.gov/nsr/psd.html. Updated June 30, 2004.

________. **2005.** National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data. Technology Transfer Network Clearinghouse for Inventories and Emissions Factors. Available at: http://www.epa.gov/ttn/chief/trends/index.html.

U.S. Environmental Protection Agency Office of Pesticide Programs (OPP). 1993. Re-registration Eligibility Decision (RED) for Glyphosate. EPA 738-R-93-014. Available at: http://www.epa.gov/oppsrrd1/REDs/factsheets/0178fact.pdf.

________. **1998.** Registration Eligibility Decision (RED) for Triclopyr. EPA 738-R-98-011. Available at: http://www.epa.gov/oppsrrd1/REDs/2710red.pdf.

U.S. Fish and Wildlife Service (USFWS). 1985. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Hutton Tui Chub and Foskett Speckled Dace. Federal Register 50:12302-12306.

________. **1990.** Determination of Endangered Status for the Pallid Sturgeon. Federal Register, Volume 55, Number 173. Washington D.C.

________. **1994a.** Desert Tortoise (Mojave Population) Recovery Plan. Portland, Oregon.

________. **1994b.** Mexican Long-nosed Bat (*Leptonycteris nivalis*) Recovery Plan. Albuquerque, New Mexico.

________. **1995a.** Lesser Long-nosed Bat Recovery Plan. Albuquerque, New Mexico.

________. **1995b.** Final Rule Determining Endangered Status for the Southwestern Willow Flycatcher. Federal Register 60(38): 10693-10715.

________. **1997.** Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for Three Wetland Species Found in Southern Arizona and Northern Sonora, Mexico. Federal Register 62(3):665-689.

________. **2000.** Determination of Threatened Status for the Northern Idaho Ground Squirrel. Federal Register 65(66):17779-17786.

________. **2001.** Interagency Burned Area Emergency Stabilization and Rehabilitation Handbook. Washington, D.C.

________. **2004.** National Wetland Inventory. Available at: http://wetlandsfws.er.usgs.gov/.

U.S. Geological Survey (USGS). 2000. Groundwater Atlas of the United States. HA 730-B-HA 730-N. Reston, Virginia. Available at: http://capp.water.usgs.gov/gwa/gwa.html.

________. **2002a.** Hydrologic regions data. Available at: http://water.usgs.gov/GIS/huc.html.

________. **2002b.** National Water Information System (NWIS) Database. Available at: http://waterdata.usgs.gov/nwis/.

________ **2002c.** National Water Quality Assessment (NAWQA) Program. Available at: http://water.usgs.gov/nawqa/.

________. **2003.** An Introduction to Biological Soil Crusts. Prepared by Canyonlands Research Station, Southwest Biological Science Center. Moab, Utah. Available at: http://www.soilcrust.org/crust101.htm.

________. **2004.** Southwest Biological Research Center, Canyonlands Research Station. Moab, Utah. Website Available at: http://www.soilcrust.org/crust101.htm.

Valdez, R.A., and G.H. Clemmer. 1982. Life History and Prospects for Recovery of the Humpback and Bonytail Chub. Pages 109-119 *in* Fishes of the Upper Colorado River System, Present and Future: Proceedings of a Symposium Presented at the Annual Meeting of the American Fisheries Society in Albuquerque, New Mexico, September 18, 1981 (W.H. Miller, H.M. Tyus, and C.A. Carlson, eds.). Western Division of the American Fisheries Society. Bethesda, Maryland.

Vallentine, J.F. 1989. Range Development and Improvement. 3rd Edition. Brigham Young University Press. Provo, Utah.

Vehik, S.C. 2001. Hunting and Gathering Tradition: Southern Plains. Pages 146-158 *in* Plains (R.J. Demailie, ed.). Handbook of North American Indians, Volume 13 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Vienneau, D.M., C.A. Sullivan, S.K. House, and G.W. Stratton. 2004. Effects of the Herbicide Hexazinone on Nutrient Cycling in a Low-pH Blueberry Soil. Environmental Toxicology 19:115-122.

Viereck, L.A. 1973. Wildfire in the Taiga of Alaska. Quaternary Research 3(3):465-495.

________**, and L.A. Schandelmeier. 1980.** Effects of Fire in Alaska and Adjacent Canada—A Literature Review. U.S. Department of Interior Bureau of Land Management Alaska Technical Report 6, BLM/AK/TR-80/06. USDI BLM. Anchorage, Alaska.

Voget, F.W. 2001. Crow. Pages 695-717 *in* Plains (R.J. DeMallie, ed.). Handbook of North American Indians, Volume 13 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Vogue, P.A., E.A. Kerle, and J.J. Jenkins. 1994. Oregon State University Extension Pesticide Properties Database. Corvallis, Oregon. Available at: http://npic.orst.edu/ppdmove.htm.

Voos, G., and P. Groffman. 1997a. Dissipation of 2,4-D and Dicamba in a Heterogeneous Landscape. Applied Soil Ecology. Agriculture, Ecosystems and Environment 5:181-187.

________**, and P. Groffman. 1997b**. Relationships between Microbial Biomass and Dissipation of 2,4-D and Dicamba in Soil. Biology and Fertility of Soils 24:106-110.

Waggoner, J.A., S.L. Dowhower, W.R. Teague, and J.F. Cadenhead. 2003. Herbicide Use and Labor for Hand Applied Control of Mesquite. Rangelands 25:19-23.

Wagner, R.G., M. Newton, E.C. Cole, J.H. Miller, and B.D. Shiver. 2004. The Role of Herbicides for Enhancing Forest Productivity and Conserving Land for Biodiversity in North America. Wildlife Society Bulletin 32:1028-1042.

Wagner, S.M., and J.D. LaPerriere. 1985. Effects of Placer Mining on the Invertebrate Communities of Interior Alaska Streams. Freshwater Invertebrate Biology 4:208-214.

Walker, J.W., S.L. Kronberg, S.L. Al-Rowaily, and N.E. West. 1994. Comparison of Sheep and Goat Preferences for Leafy Spurge. Journal of Range Management 47:429-434.

Wallace, W.J. 1978. Post-Pleistocene Archeology, 9000 to 2000 B.C. Pages 25-37 *in* California (R.F. Heizer, ed.). Handbook of North American Indians, Volume 8. (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Wallestad, R.O., J.G. Peterson, and R.L. Eng. 1975. Foods of Adult Sage Grouse in Central Montana. Journal of Wildlife Management 39:628–630.

Walleyes Unlimited. 2002. Available at http://www.walleyesubnlimited.com/adopt-fis/fishspecies.html.

Walter, J. 1984. Rangeland Revolutionary: An Interview with Allen Savory. Journal of Soil and Water Conservation 39:235-240.

Wambolt, C.L., and G.F. Payne. 1986. An 18-year Comparison of Control Methods for Wyoming Big Sagebrush in Southwestern Montana. Journal of Range Management 39(4):314-319.

Wan, M.T., R.G. Watts, and D.J. Moul. 1988. Evaluation of the Acute Toxicity of Juvenile Pacific Salmonids of Hexazinone and its Formulated Products: Pronone 10G; Velpar L; and Their Carriers. Bulletin of Environmental Contamination and Toxicology 41:609-616.

________, R.G. Watts, and D.J. Moul. 1990. Acute Toxicity to Juvenile Pacific Salmonids and Rainbow Trout of Butoxyethyl Esters of 2,4-D, 2,4-DP and Their Formulated Product: Weedone CB and its Carrier. Bulletin Environmental Contamination and Toxicology 45(4):604-11.

Wang, Y.S., J.H. Yen, Y.N. Hsieh, and Y.L. Chen. 1994. Dissipation of 2,4-D, Glyphosate, and Paraquat in River Water. Water Air and Soil Pollution 72:1-7.

Warren, C.N., and R.H. Crabtree. 1986. Prehistory of the Southwestern Area. Pages 183-193 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Washington Department of Ecology. 2002. Eurasian Watermilfoil Infested Lake Control Strategies. Eradication - Whole Lake Fluridone Treatment (Aquatic Herbicide). Available at: http://www.ecy.wa.gov/programs/wq/plants/management/fluridone_strategies.html.

________. 2004. Aquatic Plant Management: Aquatic Herbicides. Available at: http://www.ecy.wa.gov/programs/wq/plants/management/aqua028.html.

Washington Department of Ecology. 2005. Wetlands in Washington State. Volume I – A Synthesis of the Science. Chapter 7. Olympia, Washington.

Washington Department of Health. 2000. Fluridone (Sonar) Fact Sheet. Environmental Health Programs. Office of Environmental Health and Safety. Available at: http://www.doh.wa.gov/ehp/factsheets.htm.

Water in the West. 2002. Available at: http://waterinthewest.org/riverbasins/riogrande.htm.

Water Science and Technology Board and Board on Environmental Studies and Toxicology. 2002. Riparian Areas: Functions and Strategies for Management. National Academy Press. Washington, D.C. Available at: http://books.nap.edu/books/0309082951/html/1.html.

Weber, J., P. Shea, and S. Weed. 1986. Fluridone Retention and Release in Soils. Soil Science Society of America Journal 50:582-588.

Wedel, W.R. 1961. Prehistoric Man on the Great Plains. University of Oklahoma Press. Norman, Oklahoma.

________. 1983. The Prehistoric Plains. Pages 203-241 *in* Ancient North Americans (J.D. Jennings, ed.). W.H. Freeman and Company. New York, New York.

________, and G.C. Frison. 2001. Environment and Subsistence. Pages 44-60 *in* Plains (R.J. DeMallie, ed.). Handbook of North America Indians, Volume 13 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Weltz, M.A., and M.K. Wood. 1986. Short Duration Grazing in Central New Mexico: Effects on Infiltration Rates. Journal of Range Management 39:365-368.

Wentz, D.A., B.A. Bonn, K.D. Carpenter, S.R. Hinkle, M.L. Janet, F.A. Rinella, M.A. Uhrich, I.R. Waite, A. Laenen, and K.E. Bencala. 1998. Water Quality in the Willamette Basin, Oregon, 1991-95. U.S. Geological Survey Circular 1161. Available at: http://water.usgs.gov/pubs/circ1161.

West, N.E., and N. Van Pelt. 1987. Successional Patterns in Pinyon-juniper Woodlands. Pages 43-52 *in* Proceedings Pinyon-juniper Conference. General Technical Report INT-215. U.S. Department of Agriculture Forest Service Intermountain Research Station. Ogden, Utah.

Western Governors' Association. 1996. Grand Canyon Visibility Transport Commission: Recommendations for Improving Western Vistas to the U.S. Environmental Protection Agency. Available at: http://www.westgov.org/wga/publicat/epafin.htm.

Western Region Climate Center. 2002. Western U.S. Climate Historical Summaries. Available at: http://www.wrcc. dri.edu/ index.html.

Wheeler, M.A., M.J. Trlica, G.W. Frasier, and J.D. Reeder. 2002. Seasonal Grazing Affects Soil Physical Properties of a Montane Riparian Community. Journal of Range Management 55:49-56.

Whisenant, S.G. 1987. Selective Control of Mountain Big Sagebrush (*Artemesia tridentata* spp. Vaseyana) with Clopyralid. Weed Science 35:120-123.

Whitcomb, C.E. 1999. An Introduction to ALS-inhibiting Herbicides. Toxicology and Industrial Health 15(1-2):231-239.

White House. 2002. Healthy Forests: An Initiative for Wildfire Prevention and Stronger Communities. Available at: http://www.whitehouse.gov/infocus/healthyforests/index.html.

White R.G., and R.G. Bramblett. 1993. The Yellowstone River: Its Fish and Fisheries. Pages 396-414 *in* Proceedings of the Symposium on Restoration Planning for the Rivers of the Mississippi River Ecosystem (L.W. Hesse, C.B. Stalnaker, N.G. Benson, and J.R. Zuboy, eds.). Biological Report 19. U.S. Department of the Interior National Biological Survey. Washington, D.C.

Whitson, T.D. (ed.) 2001. Weeds of the West. The Western Society of Weed Science. Jackson, Wyoming.

Whittaker, R.H. 1975. Communities and Ecosystems. MacMillian Publishing Co. New York, New York.

Whittier, T.R., R.M. Hughes, and D.P. Larsen. 1988. Correspondence between Ecoregions and Spatial Patterns in Stream Ecosystems in Oregon. Canadian Journal of Fisheries and Aquatic Sciences 45:1264-1278.

Wicklow-Howard, M.C. 1994. Mycorrhizal Ecology of Shrub-steppe Habitat. Pages 207-210 *in* Proceedings—Ecology and Management of Annual Rangelands (S.B. Monsen and S.G. Kitchen, eds.). General Technical Report GTR-INT-313. U.S. Department of Agriculture Forest Service, Intermountain Research Station. Ogden, Utah.

Widehem, P., S. Ait-Aissa, C. Tixier, M. Sancelme, H. Veschambre, and N. Truffaut. 2002. Isolation, Characterization and Diuron Transformation Capacities of a Bacterial Strain Arthrobacter Sp. N2. Chemosphere 46:527-534.

Wiens, J.A., and M.I. Dyer. 1975. Rangeland Avifaunas: Their Composition, Energetics, and Role in the Ecosystem. Pages 146-182 *in* Proceedings of the Symposium on Management of Forests and Range Habitats for Nongame Birds (D.R. Smith, ed.). General Technical Report WO-1. U.S. Department of Agriculture Forest Service. Washington, D.C.

Wilbert, D.E. 1963. Some Effects of Chemical Sagebrush Control on Elk Distribution. Journal of Range Management 16:74-78.

Wilcox, B.P., M.K. Wood, and J.M. Tromble. 1988. Factors Influencing Infiltrability of Semiarid Mountain Slopes. Journal of Rangeland Management 41(3):197-206.

Wild, A. 1993. Soils and the Environment. First edition. Cambridge University Press. Cambridge, Massachusetts.

Williamson, A.K., M.D. Munn, S.J. Ryker, R.J. Wagner, J.C. Ebbert, and A.M. Vanderpool. 1998. Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-95. U.S. Geological Survey Circular 1144. Available at: http://water.usgs.gov/pubs/circ1144.

Willis, M.J. and R.F. Miller. 1999. Importance of Western Juniper Communities to Small Mammals. Pages 210-214 *in* Proceedings: Ecology and Management of Pinyon-juniper Communities within the Interior West. Forest Service Proceedings RMRS-P-9. U.S. Department of Agriculture Forest Service Rocky Mountain Research Station. Ogden, Utah.

Wingo, P.A., C.J. Cardinez, S.H. Landis, R.T. Greenlee, L.A. Ries, R.N. Anderson, and M.J. Thun. 2005. Long-term Trends in Cancer Mortality in the United States, 1930-1998. Available at: http://www.ncbi.nlm.nih.gov/.

Wisdom, M.J., R. S. Holthausen, B. C. Wales, C.D. Hargi, V. A, Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin: Broad-scale Trends and Management Implication. Volume 2 – Group Level Results. U.S. Department of Agriculture Forest Service and USDI BLM General Technical Report PNW-GTR-485. Portland, Oregon.

Witherspoon, G. 1983. Navajo Social Organization. Pages 524-535 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 10 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Wong, P.K. 2000. Effects of 2,4-D, Glyphosate, and Paraquat on Growth, Photosynthesis and Chlorophyll-a Synthesis of *Scenedesmus Quadricauda*, Berb 614. Chemosphere 41:177-182.

Wood, J.A., and D.H.J. Anthony. 1997. Herbicide Contamination of Prairie Springs at Ultratrace Levels of Detection. Journal of Environmental Quality 26:1308-1318.

Wood, M.K., E.L. Garcia, and J.M. Tromble. 1991. Runoff and Erosion Following Mechanical and Chemical Control of Creosotebush (*Larrea tridentata*). Weed Technology 5(1):48-53.

________, R.E. Eckert, Jr., W.H. Blackburn, and F.F. Peterson. 1982. Influence of Crusting Soil Surfaces on Emergence and Establishment of Crested Wheatgrass, Squirreltail, Thurber Needlegrass, and Fourwing Saltbush. Journal of Range Management 35(3):282-287.

Wood, W.R., and L. Irwin. 2001. Mandan. Pages 349-364 *in* Plains (R.J. DeMallie, ed.). Handbook of North American Indians, Volumem 13 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Woodburn, K. B., D. D. Fontaine, E. L. Bjerke, and G. J. Kallos. 1989. Photolysis of Picloram in Dilute Aqueous Solution. Environmental Toxicology and Chemistry 8:769-775.

Woodbury, R.B. 1979. Prehistory: Introduction. Pages 22-30 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

________, and E.B.W. Zubrow. 1979. Agricultural Beginnings, 2000 B.C. – A.D. 500. Pages 43-61 *in* Southwest (A. Ortiz, ed.). Handbook of North American Indians, Volume 9 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

World Climate. 2001. What the Weather is Normally Like in Thousands of Places Worldwide. Washington, D.C. Available at: http://www.worldclimate.com.

World Wildlife Fund. 2002. Endangered Spaces, the Global 200. Washington, D.C. Available at: http://www.worldwildlife.org/global200/spaces.cfm?sectionid=25&newspaperid=20.

Wright, J.W. (ed.). 2002. 2003 Almanac: The Almanac of Record. New York Times. New York, New York.

Wright, H.A. 1974. Range Burning. Journal of Range Management 27(1):5-11.

________, and A.W. Bailey. 1980. Fire Ecology and Prescribed Burning in the Great Plains—A Research Review. General Technical Report INT-77. U.S. Department of Agriculture Forest Service Intermountain Forest and Range Experiment Station. Ogden, Utah.

________, F.M. Churchill, and W.C. Stevens. 1976. Effect of Prescribed Burning on Sediment, Water Yield, and Water Quality from Dozed Juniper Lands in Central Texas. Journal of Range Management 29:294-298.

________, ________, and ________. 1982. Soil Loss, Runoff, and Water Quality of Seeded and Unseeded Steep Watersheds Following Prescribed Burning. Journal of Range Management 35(3):382-385.

Wullschleger, J. 2000. River Management and the Upper Colorado River Recovery Implementation Program. Available at: http://www.aqd.nps.gov/pubs/yir/yir2000/index.html.

Young, J.A. 1992. Ecology and Management of Medusahead. Great Basin Naturalist 52:245-252.

________. 1994. Changes in Plant Communities in the Great Basin Induced by Domestic Livestock Grazing. Pages 113-123 *in* Natural History of the Colorado Plateau and Great Basin (K.T. Harper, L.L. St. Clair, K.H. Thorne, and W.M. Hess, eds.). University Press of Colorado. Niwot, Colorado.

________, and R.A. Evans. 1977. Wildfires in Semi-arid Grasslands. Pages 109-115 *in* Proceedings Eighth International Grassland Congress. Leipzig, Germany.

Young, M.K. 1994. Movement and Characteristics of Stream-borne Coarse Woody Debris in Adjacent Burned and Undisturbed Watersheds in Wyoming. Canadian Journal of Forest Research 24:1933-1938.

Youtie, B., J. Ponzetti, and D. Salzer. 1999. Fire and Herbicides for Exotic Annual Grass Control: Effects on Native Plants and Microbiotic Soil Organisms. Pages 590-591 *in* Proceedings of People and Rangelands: Building the Future; Proceedings of the VI International Rangeland Congress (D. J. Eldridge, and D. Freudenberger, eds.). VI International Rangeland Congress. Townsville, Queensland, Australia.

Yurk, J., G. Ward, and J. Wisk. 1992a. Acute Toxicity of AC 262,222 to Bluegill (*Lepomis macrochirus*) Under Static Test Conditions: Project Lab Number 3923013-0400: 954-92-119. Unpublished Study Prepared by Environmental Science and Engineering, Inc. MRID No. 42711434.

________, ________, and ________. 1992b. Acute Toxicity of AC 262,222 to Channel Catfish (*Ictalurus punctatus*) Under Static Test Conditions: Project Lab Number 3923013-0500: 954-92-120. Unpublished Study Prepared by Environmental Science and Engineering, Inc. MRID No. 42711436.

Zanardini, E., A. Arnoldi, G. Boschin, A. D'Agostina, M. Negri, and C. Sorlini. 2002. Degradation Pathways of Chlorsulfuron and Metsulfuron-methyl by a Pseudomonas Fluorescens Strain. Annals Of Microbiology 52:25-37.

Zaranyika, M.F., and M.G. Nydandoro. 1993. Degradation of Glyphosate in the Aquatic Environment: An Enzymatic Kinetic Model That Takes into Account Microbial Degradation of Both Free and Colloidal (or Sediment) Particle Adsorbed Glyphosate. Journal of Agricultural Food Chemistry 41:838-842.

Zigmond, M.L. 1986. Kwaiisu. Pages 398-411 *in* Great Basin (W.L. d'Azevedo, ed.). Handbook of North American Indians, Volume 11 (W.C. Sturtevant, general ed.). Smithsonian Institution. Washington, D.C.

Zimmerman, L.J., and B.L. Molyneaux. 1996. Native North America. University of Oklahoma Press. Norman, Oklahoma.

Zoltai, S.C. 1974. Structure of Subarctic Forests on Hummocky Permafrost Terrain in Northwestern Canada. Canadian Journal of Forest Research 5(1):1-9.

CHAPTER 7

GLOSSARY

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A

Absorption: The process by which the chemical or other substance is able to pass through body membranes and enter an organism.

Active ingredient (a.i.): is the chemical or biological component that kills or controls the target pest.

Acute adverse effect level: The level at which a substance can cause adverse effects within a short time of dosing or exposure.

Acute effect: An adverse effect on any living organism in which symptoms develop rapidly and often subside after the exposure stops.

Acute toxicity: The quality or potential of a substance to cause injury or illness shortly after exposure to a relatively large dose.

Additive: A substance added to another in relatively small amounts to impart or improve desirable properties or suppress undesirable properties.

Additive effect: A situation in which combined effects of exposure to two chemicals simultaneously is equal to the sum of the effect of exposure to each chemical given alone.

Adjuvant(s): Chemicals that are added to the pesticide formulation to enhance the toxicity of the active ingredient or to make the active ingredient easier to handle.

Adsorption: The adhesion of substances to the surface of solids or liquids; the attraction of ions of compounds to the surface of solids or liquids.

Adverse impact: Impacts that causes harm or negative result.

Aerobic biodegradation: The breakdown of organic contaminants by microorganisms when oxygen is present.

Air pollutant: Any substance in the air that could, if in high enough concentration, harm humans, animals, vegetation, or material. Air pollutants may include almost any natural or artificial matter capable of being airborne, in the form of solid particles, liquid droplets, gases, or a combination of these.

Air quality: The composition of air with respect to quantities of pollution therein; used most frequently in connection with "standards" of maximum acceptable pollutant concentrations.

Allotment (grazing): Area designated for the use of a certain number and kind of livestock for a prescribed period of time.

Alluvium: General term for clay, silt, sand, or gravel deposited in the bed of a stream during relatively recent geologic time, as a result of stream action.

Alternative: In an EIS, one of a number of possible options for responding to the purpose and need for action.

Ambient air: Any unconfined portion of the atmosphere; open air and surrounding air. Often used interchangeably with "outdoor air."

Anadromous: A term used to describe fish that mature in the sea and swim up freshwater rivers and streams to spawn. Salmon, steelhead, and sea-run cutthroat trout are examples.

Anaerobic biodegradation: The breakdown of organic contaminants by microorganisms when oxygen is not present.

Animal Unit (AU): A standardized unit of measurement for range livestock that is equivalent to one cow, one horse, five sheep, five goats, or four reindeer, all over 6 months of age.

Animal Unit Month (AUM): The amount of feed or forage required by one animal unit grazing on a pasture for one month.

Annual (plant): A plant whose life cycle is completed in 1 year or season.

Antifoamer: A type of adjuvant added to a commercial pesticide that prevents the formation of foam.

Aquatic: Growing, living in, frequenting, or taking place in water; used to indicate habitat, vegetation, or wildlife in freshwater.

Aquifer: Rock or rock formations (often sand, gravel, sandstone, or limestone) that contain or carry groundwater and act as water reservoirs.

Area of Critical Environmental Concern (ACEC): An area within public lands that requires special management attention to protect and prevent irreparable damage to important historic, cultural, or scenic values; fish and wildlife resources; other natural systems or processes; or to protect life or provide safety from natural hazards.

Arid: A term applied to regions or climates where lack of sufficient moisture severely limits growth and production of vegetation. The limits of precipitation vary considerably according to temperature conditions.

Attainment area: A geographic area that is in compliance with the National Ambient Air Quality Standards. An area considered to have air quality as good as or better than the National Ambient Air Quality Standards as defined in the Clean Air Act.

B

Binder: A material used to bind together two or more other materials in mixtures.

Bioaccumulation: The process of a plant or animal selectively taking in or storing a persistent substance. Over time, a higher concentration of the substance is found in the organism than in the organism's environment.

Biodegradability: Susceptibility of a substance to decomposition by microorganisms; specifically, the rate at which compounds may be chemically broken down by bacteria and/or natural environmental factors.

Biodiversity: The variety of life and its processes, including all life forms from one-celled organisms to complex organisms such as insects, plants birds, reptiles, fish, other animals and the processes, pathways, and cycles that link such organisms into natural communities.

Biological Assessment (BA): A document prepared by or under the direction of a federal agency; addresses federally-listed and proposed species and designated and proposed critical habitat that may be present in the action area, and evaluates the potential effects of the action on such species and habitat.

Biological crust: Thin crust of living organisms on or just below the soil surface, composed of lichens, mosses, algae, fungi, cyanobacteria, and bacteria.

Boom (herbicide spray): A tubular metal device that conducts an herbicide mixture from a tank to a series of spray nozzles. It may be mounted beneath a helicopter or a fixed-wing aircraft, or behind a tractor or all-terrain vehicle.

Brackish: Saline water whose salt concentration is between that of freshwater and seawater (ranging from 0.5 to 30 parts per thousand).

Broadcast application: An application of an herbicide that uniformly covers an entire area.

Broad scale: A large, regional area, such as a river basin; typically a multi-state area.

Buffer: A solution or liquid whose chemical makeup is such that it minimizes changes in pH when acids or bases are added to it.

Buffer strip/zone: A strip of vegetation that is left or managed to reduce the impact that a treatment or action on one area might have on another area.

Bunchgrass: A grass having the characteristic growth habit of forming a bunch; lacking stolons or rhizomes.

C

California Puff (CALPUFF): CALPUFF is an advanced non-steady-state meteorological and air quality modeling system adopted by the U.S. Environmental Protection Agency as the preferred model for assessing long range transport of pollutants and their impacts involving complex meteorological conditions.

Carbon-14 dating: The use of the naturally occurring isotope of carbon-14 in radiometric dating to determine the age of organic materials.

Carcinogen: A chemical capable of inducing cancer.

Carnivore: An organism that eats only meat.

Carrier: A non-pesticidal substance added to a commercial pesticide formulation to make it easier to handle or apply.

Carrying capacity: The maximum population of a particular species a particular region can support without hindering future generations' ability to maintain the same population.

Chaining: Vegetation removal that is accomplished by hooking a large anchor chain between two bulldozers; as the dozers move through the vegetation, the vegetation is knocked to the ground. Chaining kills a large percentage of the vegetation, and is often followed a year or two later by burning and/or seeding.

Chemical degradation: The breakdown of a chemical substance into simpler components through chemical reactions.

Chronic adverse effect level: The level at which a substance can cause adverse effects in which symptoms recur frequently or develop slowly over a long period of time.

Chronic exposure: Exposures that extend over the average lifetime or for a significant fraction of the lifetime of the species. Chronic exposure studies are used to evaluate the carcinogenic potential of chemicals and other long-term health effects.

Class I area: Under the 1977 Clean Air Act amendments, all international parks, parks larger than 6,000 acres, and national wilderness areas larger than 5,000 acres that existed on August 7, 1977. This class provides the most protection to pristine lands by severely limiting the amount of additional air pollution that can be added to these areas.

Climate: The composite or generally prevailing weather conditions of a region throughout the year, averaged over a series of years.

Coarse woody debris: Pieces of woody material derived from tree limbs, boles, and roots in various stages of decay, generally having a diameter of at least 3 inches and a length greater than 3 feet.

Code of Federal Regulations (CFR): A codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.

Compaction: Making soil hard and dense, decreasing its ability to support vegetation because the soil can hold less water and air and because roots have trouble penetrating the soil.

Consultation: Exchange of information and interactive discussion; when the "C" in consultation is capitalized it refers to consultation mandated by statute or regulation that has prescribed parties, procedures, and timelines (e.g. Consultation under National Environmental Policy Act or Section 7 of the Endangered Species Act).

Council on Environmental Quality (CEQ): An advisory council to the President of the United States; established by the National Environmental Policy Act of 1969. It reviews federal programs for their effect on the environment, conducts environmental studies, and advises the President on environmental matters.

Countervailing: A type of cumulative impact where negative effects are compensated for by beneficial effects.

Cover: Trees, shrubs, rocks, or other landscape features that allow an animal to partly or fully conceal itself. The area of ground covered by plants of one or more species.

Criteria: Data and information that are used to examine or establish the relative degrees of desirability of alternatives or the degree to which a course of action meets an intended objective.

Criteria pollutants: Air pollutants designated by the U.S. Environmental Protection Agency as potentially harmful and for which ambient air quality standards have been set to protect the public health and welfare. The criteria pollutants are carbon monoxide, sulfur dioxide, particulate matter, nitrogen dioxide, ozone, hydrocarbons, and lead.

Critical habitat: 1) Specific areas within the habitat a species occupies at the time it is listed under the Endangered Species Act that have physical or biological features (a) that are essential to the conservation of the species and (b) that may require special management considerations or protection; and 2) specific areas outside the habitat a species occupies at the time it is listed that the Secretary of the Interior determines are essential for species conservation.

Cultural resources: Nonrenewable evidence of human occupation or activity as seen in any area, site, building, structure, artifact, ruin, object, work of art, architecture, or natural feature, which was important in human history at the national, state, or local level.

Cumulative effects: Impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions. Cumulative effects can result from individually minor, but collectively significant, actions taking place over a period of time.

D

Degradation: Physical or biological breakdown of a complex compound into simpler compounds.

Density: The number of individuals per a given unit area.

Diluent: An inert diluting agent added to a commercial pesticide formulation that decreases the viscosity of the formula.

Dilution: The act of mixing or thinning, and therefore decreasing a certain strength or concentration.

Direct effects: Impacts on the environment that are caused by the action and occur at the same time and place.

Dispersant: A type of inert ingredient added to a herbicide formulation that reduces the cohesive attraction between like particles.

Dispersion: The act of distributing or separating into lower concentrations or less dense units.

Dominant: A group of plants that by their collective size, mass, or number exerts a primary influence onto other ecosystem components.

Dose: The amount of chemical administered or received by an organism, generally at a given point in time.

Dose-response: Changes in toxicological responses of an individual (such as alterations in severity of symptoms) or populations (such as alterations in incidence) that are related to changes in the dose of any given substance.

Draft Environmental Impact Statement (DEIS): The draft statement of the environmental effects of a major federal action which is required under Section 102 of the National Environmental Policy Act, and released to the public and other agencies for comment and review.

Drift: That part of a sprayed chemical that is moved by wind off a target site.

E

Ecosystem: Includes all the organisms of an area, their environment, and the linkages or interactions among all of them; all parts of an ecosystem are interrelated. The fundamental unit in ecology, containing both organisms and abiotic environments, each influencing the properties of the other and both necessary for the maintenance of life.

Ecosystem-based management: The use of an ecological approach to achieve multiple-use management of public lands by blending the needs of people and environmental values in such a way that public lands represent diverse, healthy, productive, and sustainable ecosystems.

Ecotone: A boundary or zone of transition between adjacent communities or environments, such as the boundary between a forest and a meadow. Species present in an ecotone are intermixed subsets of the adjacent communities.

Edge effect: The influence of two communities on populations in their adjoining boundary zone or ecotone, affecting the composition and density of the populations in these bordering areas.

Effect: Environmental change resulting from a proposed action. Direct effects are caused by the action and occur at the same time and place, while indirect effects are caused by the action but are later in time or further removed in distance, although still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems. Effect and impact are synonymous as used in this document.

Endangered species: Plant or animal species that are in danger of extinction throughout all or a significant part of their range.

Endemic species: Plants or animals that occur naturally in a certain region and whose distribution is relatively limited to a particular locality.

Environment: The physical conditions that exist within an area (e.g., the area that will be affected by a proposed project), including land, air, water, minerals, flora, fauna, ambient noise, and objects of historical or aesthetic significance. The sum of all external conditions that affect an organism or community to influence its development or existence.

Environmental Assessment (EA): A concise public document, for which a federal agency is responsible, that serves to: 1) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; 2) aid an agency's compliance with the National Environmental Policy Act when no environmental impact statement is necessary; and, 3) facilitate preparation of an environmental impact statement when one is necessary.

Environmental Impact Statement (EIS): A required report for all federal actions that will lead to significant effects on the quality of the human environment. The report must be systematic and interdisciplinary, integrating the natural and social sciences as well as the design arts in planning and decision-making. The report must identify 1) the environmental impacts of the proposed action, 2) any adverse environmental effects which cannot be avoided should the proposal be implemented, 3) alternatives to the proposed action, 4) the relationship between short-term uses of human environment and the maintenance and enhancement of long-term productivity, and 5) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Epidemiology study: A study of human population or human populations. In toxicology, a study which examines the relationship of exposures to one or more potentially toxic agent to adverse health effects in human populations.

Eradication: Removal of all traces of a population or elimination of a population to the point where individuals are no longer detectable.

Erosion: The wearing away of the land surface by running water, wind, ice, gravity, or other geological activities; can be accelerated or intensified by human activities that reduce the stability of slopes or soils.

Essential Fish Habitat (EFH): As defined by Congress in the interim final rule (62FR 66551): "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." For the purpose of interpreting the definition of EFH habitat, "waters" include aquatic areas and their associated physical, chemical, and biological properties; "substrate" includes sediment underlying the waters; "necessary" refers to the habitat required to support a sustainable fishery and the managed species contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types utilized by a species throughout its life cycle.

Exotic species: Includes species introduced into an area that may have adapted to the area and compete with resident native (indigenous) species.

F

°F: Degrees Fahrenheit.

Fate: The course of an applied herbicide in an ecosystem or biological system, including metabolism, microbial degradation, leaching, and photodecomposition.

Fauna: The vertebrate and invertebrate animals of the area or region.

Feasible: Capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors.

Final Environmental Impact Statement (Final EIS): A revision of the Draft Environmental Impact Statement based on public and agency comments on the draft.

Fire dependent: An ecosystem evolving under periodic perturbations by fire and that consequently depends on periodic fires for normal ecosystem function.

Fire intolerant: Species of plants that do not grow well with or die from the effects of too much fire. Generally, these are shade-tolerant species.

Fire return interval: The average time between fires in a given area.

Fire tolerant: Species of plants that can withstand certain frequency and intensity of fire. Generally, these are shade-intolerant species.

Fire use: The combination of prescribed fire and wildland fire use for resource benefit to meet resource objectives.

First order dermal absorption: Absorption of a material (herbicide) that occurs over 24 hours, taking into consideration the potential for some herbicide to not be absorbed.

Fisheries habitat: Streams, lakes, and reservoirs that support fish populations.

Fishery: The act, process, occupation, or season of taking an aquatic species.

Food Quality Protection Act (FQPA) safety factor: The Food Quality Protection Act safety factor is applied to pesticides that exhibit threshold effects to "take into account potential pre- and post-natal toxicity and completeness of the data with respect to exposure and toxicity to infants and children." The Act requires 1) an explicit determination that exposure tolerances are safe for children; 2) an additional safety factor of up to 10-fold, if necessary, be used to account for uncertainty in data relative to children (this is in addition to the current 100-fold safety factor which is already used to account for the use of animals, versus humans, in laboratory testing, and the variability in potential adult response to pesticide exposure); and 3) an analysis of exposure risks to children that takes into account the special sensitivity and exposure of children to pesticides.

Forage: Vegetation eaten by animals, especially grazing and browsing animals.

Forbs: Broad-leafed pants; includes plants that commonly are called weeds or wildflowers.

Formulation: The commercial mixture of both active and inactive (inert) ingredients.

Fossilization: The process of fossilizing a plant or animal that existed in some earlier age; the process of being turned to stone.

Fragmentation (habitat): The break-up of a large land area (such as a forest) into smaller patches isolated by areas converted to a different land type.

Fuel (fire): Dry, dead parts of trees, shrubs, and other vegetation that can burn readily.

G

Gavage: Introduction of material in the stomach by a tube.

Groundwater: Subsurface water that is in the zone of saturation. The top surface of the groundwater is the "water table." Source of water for wells, seeps, and springs.

H

Habitat: The natural environment of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influences affecting living conditions. The place where an organism lives.

Half life: The amount of time required for half of a compound to degrade.

Hazardous fuels: Includes living and dead and decaying vegetation that form a special threat of ignition and resistance to control.

Hazard quotient (HQ): The ration of the estimated level of exposure to a substance from a specific substance from a specific pesticide application to the reference dose (RfD) for that substance, or to some other index of acceptable exposure or toxicity. A HQ less than or equal to 1 is presumed to indicate an acceptably low level of risk for that specific application.

Herbaceous: Green and leaf-like in appearance or texture; includes grasses, grass-like plants, and forbs, with little or no woody component.

Herbicide: A chemical pesticide used to control, suppress, or kill vegetation, or to severely interrupt their normal growth process.

Herbicide resistance: Naturally occurring heritable characteristics that allow individual weeds to survive and reproduce, producing a population, over time, in which the majority of the plants of the weed species have the resistant characteristics.

Herbivore: An animal that feeds on plants.

Herd Management Areas (HMAs): Areas established for wild and free-roaming horses and burros through the land use planning process. The Wild Free-roaming Horse and Burro Act of 1971 requires that wild free-roaming horses and burros be considered for management where they were found at the time Congress passed the Act. The BLM initially identified 264 areas of use as herd management areas.

Home range: The area around an animal's established home that is visited during the animal's normal activities.

Horizon: A layer of soil or soil material approximately parallel to the land surface and differing from adjacent related layers in physical, chemical, and biological properties and characteristics.

Hydrologic cycle (water cycle): The ecological cycle that moves water from the air by precipitation to the earth and returns it to the atmosphere; a variety of processes are involved, including evaporation, run-off, infiltration, percolation, storage, and transpiration.

Hydrologic unit code (HUC): A hierarchical coding system developed by the U.S. Geological Survey to identify geographic boundaries of watersheds of various sizes.

Hydrolysis: Decomposition or alteration of a chemical substance by water.

I

Impermeable: Cannot be penetrated.

Indigenous: Living or occurring naturally in an area; native, endemic people, flora, or fauna.

Indirect effects: Impacts that are caused by an action, but are later in time or farther removed in distance, although still reasonably foreseeable.

Inert ingredient(s): Those ingredients that are added to the commercial product (formulation) and are not herbicidally active.

Infiltration: The movement of water through soil pores and spaces.

Insectivore: An organism that feeds mainly on insects.

Intermittent stream: A stream that flows only a certain times of the year when it receives water from other streams or from surface sources such as melting snow.

Invasive plants: Plants that are not part of (if exotic), or are a minor component of (if native), the original plant community or communities that have the potential to become a dominant or co-dominant species on the site if their future establishment and growth is not actively controlled by management interventions, or are classified as exotic or noxious plants under state or federal law. Species that become dominant for only one to several years (e.g. short-term response to drought or wildfire) are not invasive plants.

Invertebrate: Small animals that lack a backbone or spinal column. Spiders, insects, and worms are examples of invertebrates.

Irretrievable commitment: A term that applies to losses of production or commitment of renewable natural resources. For example, while an area is used as a ski area, some or all of the timber production there is "irretrievably" lost. If the ski area closes, timber production could resume; therefore, the loss of timber production during the time the area is devoted to skiing is irretrievable, but not irreversible, because it is possible for timber production to resume if the area is no longer used as a ski area.

Irreversible commitment: A term that applies to non-renewable resources, such as minerals and archaeological sites. Losses of these resources cannot be reversed. Irreversible effects can also refer to the effects of actions on resources that can be renewed only after a very long period of time, such as the loss of soil productivity.

Issue: A matter of controversy, dispute, or general concern over resource management activities or land uses.

J

K

K_{oc}: Organic carbon-water partition coefficient.

L

LC_{50} (median lethal concentration50): A calculated concentration of a chemical in air or water to which exposure for a specific length of time is expected to cause death in 50 percent of a defined experimental animal population.

LD_{50} (median lethal dose50): The dose of a chemical calculated to cause death in 50% of a defined experimental animal population over a specified observation period. The observation period is typically 14 days.

Land management: The intentional process of planning, organizing, programming, coordinating, directing, and controlling land use actions.

Landscape: All the natural features such as grasslands, hills, forest, and water, which distinguish one part of the earth's surface from another part; usually that portion of land that the eye can comprehend in a single view, including all of its natural characteristics.

Land use allocation: The assignment of a management emphasis to particular land areas with the purpose of achieving the goals and objectives of some specified use(s) (e.g., campgrounds, wilderness, logging, and mining).

Large woody debris: Pieces of wood that are of a large enough size to affect stream channel morphology.

Leaching: Usually refers to the movement of chemicals through the soil by water; may also refer to the movement of herbicides out of leaves, stems, or roots into the air or soil.

Level of concern (LOC): The concentration in media or some other estimate of exposure above which there may be effects.

Lichens: Organisms made up of specific algae and fungi, forming identifiable crusts on soil, rocks, tree, bark, and other surfaces. Lichens are primary producers in ecosystems. They contribute living material and nutrients, enrich the soil and increase soil moisture-holding capacity, and serve as food sources for certain animals. Lichens are slow growing and sensitive to chemical and physical disturbances.

Lifeways: The manner and means by which a group of people lives; their way of life. Components include language(s), subsistence strategies, religion, economic structure, physical mannerisms, and shared attitudes.

Litter: The uppermost layer of organic debris on the soil surface, which is essentially the freshly fallen or slightly decomposed vegetation material such as stems, leaves, twigs, and fruits.

Long term: Generally refers to a period longer than 10 years.

Lowest observed adverse effect level (LOAEL): The lowest dose of a chemical in a study, or group of studies, that produces statistically or biologically significant increases in frequency or severity of adverse effects between the exposed and control populations.

Lymphatic: Pertaining to lymph, a lymph vessel, or a lymph node.

Lymph: A clear water fluid containing white blood cells. Lymph circulates throughout the lymphatic system, removing bacteria and certain proteins from body tissue. It also is responsible for transporting fat from the small intestine and supplying mature lymphocytes to the blood.

M

Material safety data sheet (MSDS): a compilation of information required under the OSHA Communication Standard on the identity of hazardous chemicals, health and physical hazards, exposure limits, and precautions.

Macrophytes: Terrestrial or aquatic plants that are large enough to be seen without the aid of a microscope.

Memorandum of Understanding (MOU): Usually documents an agreement reached amongst federal agencies.

Microbial degradation: The breakdown of a chemical substance into simpler components by bacteria or other microorganisms.

Microbiotic crust: See biological crust.

Minimize: Apply best available technology, management practices, and scientific knowledge to reduce the magnitude, extent, and/or duration of impacts.

Minimum tool rule: Apply only the minimum-impact policy, device, force, regulation, instrument, or practice to bring about a desired result.

Mitigation: Steps taken to: 1) avoid an impact altogether by not taking a certain action or parts of an action; 2) minimize an impact by limiting the degree or magnitude of the action and its implementation; 3) rectify an impact by repairing, rehabilitating, or restoring the affected environment; 4) reduce or eliminate an impact over time by preserving and maintaining operations during the life of the action; and, 5) compensate for an impact by replacing or providing substitute resources or environments (40 CFR Part 1508.20).

Mitigation measures: Means taken to avoid, compensate for, rectify, or reduce the potential adverse impact of an action.

Monitoring: The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives.

Multiple uses: A combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources. These may include recreation, range, timber, minerals, watershed, wildlife, and fish, along with natural scenic, scientific, and historical values.

N

National Ambient Air Quality Standards (NAAQS): Standards set by the Environmental Protection Agency for the maximum levels of pollutants that can exist in the outdoor air without unacceptable effects on human health or the public welfare.

National Back Country Byways: A program developed by the BLM to complement the National Scenic Byway program. The Bureau of Land Management's Byways show enthusiasts the best the West has to offer – from waterfalls to geology sculpted by volcanoes, glaciers, and rivers. Back Country Byways vary from narrow, graded roads, passable only during a few months of the year, to two-lane paved highways providing year-round access.

National Conservation Areas: Areas designated by Congress so that present and future generations of Americans can benefit from the conservation, protection, enhancement, use, and management of these areas by enjoying their natural, recreational, cultural, wildlife, aquatic, archeological, paleontological, historical, educational, and/or scientific resources and values.

National Environmental Policy Act (NEPA): An act of Congress passed in 1969, declaring a national policy to encourage productive and enjoyable harmony between people and the environment, to promote efforts that will prevent or eliminate damage to the environment and the biosphere and stimulate the health and welfare of people, and to enrich the understanding of the ecological systems and natural resources important to the nation, among other purposes.

National Historic Trails: Trails established to identify and protect historic routes; they follow as closely as possible the original trails or routes of travel of national historic significance.

National Landscape Conservation System (NLCS): A single system that encompasses some of the BLM's premier land designations. By putting these lands into an organized system, the BLM hopes to increase public awareness of these areas' scientific, cultural, educational, ecological, and other values.

National Monument: An area designated to protect objects of scientific and historic interest by public proclamation of the President under the Antiquities Act of 1906, or by the Congress for historic landmarks, historic and prehistoric structures, or other objects of historic or scientific interest situated upon the public lands: designation also provides for the management of these features and values.

National Recreation Area: An area designated by Congress to assure the conservation and protection of natural, scenic, historic, pastoral, and fish and wildlife values and to provide for the enhancement of recreational values.

National Recreation Trails: Trails established administratively by the Secretary of the Interior to provide for a variety of outdoor recreation uses in or reasonably close to urban areas. They often serve as connecting links between the National Historic Trails and National Scenic Trails.

National Scenic Areas: Refers to the one national scenic area managed by the BLM: The Santa Rosa Mountains National Scenic Area in California, which encompasses approximately 101,000 acres. This area was designated by the Secretary of the Interior in 1990 to provide for the conservation, protection, and enhancement of scenic, recreation, and pastoral values.

National Scenic Trails: Trails established by an Act of Congress that are intended to provide for maximum outdoor recreation potential and for the conservation and enjoyment of nationally significant scenic, historical, natural, and cultural qualities of the areas through which these trails pass. National Scenic Trails may be located to represent desert, marsh, grassland, mountain, canyon, river, forest, and other areas, as well as land forms that exhibit significant characteristics of the physiographic regions of the nation.

National Wild and Scenic Rivers: Rivers designated in the National Wild and Scenic Rivers System that are classified in one of three categories, depending on the extent of development and accessibility along each section. In addition to being free flowing, these rivers and their immediate environments must possess at least one outstandingly remarkable value: scenic, recreational, geologic, fish and wildlife, historical, cultural, or other similar values.

Native species: Species that historically occurred or currently occur in a particular ecosystem and were not introduced.

Natural community: An assemblage of organisms indigenous to an area that is characterized by distinct combinations of species occupying a common ecological zone and interacting with one another.

Natural resources: Water, soil, plants and animals, nutrients, and other resources produced by the earth's natural processes.

Neurotoxicity: Materials that affect nerve cells and may produce muscular, emotional, or behavioral abnormalities, impaired or abnormal motion, and other physiologic changes.

Neutralizer: A type of inert ingredient added to a herbicide that modifies the effect of, or counteracts the properties of, something within the herbicide or spray solution.

No **action alternative:** The most likely condition to exist in the future if current management direction were to continue unchanged.

No observed adverse effect level (NOAEL): The exposure level at which there are no statistically or biological significant differences in the frequency or severity of any adverse effect in the exposed or control populations.

No observed effect level (NOEL): Exposure level at which there are no statistically or biological significant differences in the frequency or severity of any effect in the exposed or control populations.

Non-target: Any plant, animal, or organism that a method of application is not aimed at, but may accidentally be injured by the application.

Non-selective herbicide: An herbicide that is generally toxic to plants without regard to species.

Noxious weed: A plant species designated by federal or state law as generally possessing one or more of the following characteristics: aggressive and difficult to manage; parasitic; a carrier or host of serious insects or disease; or non-native, new, or not common to the United States.

Nutrient cycle: Ecological processes in which nutrients and elements such as carbon, phosphorous, nitrogen, and others, circulate among animals, plants soils, and air.

O

Objective: A concise, time-specific statement of measurable planned results that respond to pre-established goals. An objective forms the basis for further planning to define the precise steps to be taken and the resources to be used to achieve identified goals.

Omnivore: An animal that eats a combination of meat and vegetation.

Oregon and California lands: Public lands in Western Oregon that were granted to the Oregon Central Railroad companies (later the Oregon and California Railroad Company) to aid in the construction of railroads, but that were later forfeited and returned to the federal government by revestment of title.

Overgrazing: Consumption of rangeland grass by grazing animals to the point that it cannot be renewed, or can be only slowly renewed, because of damage to the root system.

Overstory: The upper canopy layer.

P

Paleontological resources: A work of nature consisting of or containing evidence of extinct multicellular beings and includes those works or classes of works of nature designated by the regulations as paleontological resources.

Paleontology: A science dealing with the life of past geological periods as known from fossil remains.

Particulate matter (PM): A complex mixture consisting of varying combinations of dry solid fragments, solid cores with liquid coatings, and small droplets of liquid. These tiny particles vary greatly in shape, size and chemical composition, and can be made up of many different materials such as metals, soot, soil and dust.

Particulates: Solid particles or liquid droplets suspended or carried in the air.

Pathogen: An agent such as a fungus, virus, or bacterium that causes disease.

Payments in lieu of taxes: Payments made to counties by the BLM to mitigate for losses to counties because public lands cannot be taxed.

Per capita income: Total income divided by the total population.

Perennial: A plant that lives for at least 2 or more years.

Permit: A revocable authorization to use public land for a specified purpose to for up to 3 years.

Persistence: Refers to the length of time a compound, once introduced into the environment, stays there.

Petroglyph: An image recorded on stone, usually by prehistoric peoples, by means of carving, pecking or otherwise incised on natural rock surfaces.

Pictograph: A symbol that represents an object or a concept by illustration.

pH: A measure of how acidic or alkaline (basic) a solution is on a scale of 0 to 14 with 0 being very acidic, 14 being very alkaline, and 7 being neutral. The abbreviation stands for the potential of hydrogen.

Photodegradation: The photochemical transformation of a molecule into lower molecular weight fragments, usually in an oxidation process. This term is widely used in the destruction (oxidation) of pollutants by UV-based processes.

Photolysis: Chemical decomposition induced by light or other radiant energy.

Phytotoxicity: The ability of a material such as a pesticide or fertilizer to cause injury to plants.

Piscivore: Fish that feed on other fishes.

Plant community: A vegetation complex, unique in its combination of plants, which occurs in particular locations under particular influences. A plant community is a reflection of integrated environmental influences on the site, such as soils, temperature, elevation, solar radiation, slope aspect, and precipitation.

Playas: Flat land surfaces underlain by fine sediment or evaporate minerals deposited from a shallow lake on the floor of a topographic depression.

$PM_{2.5}$: Fine particulates that measure 2.5 microns in diameter or less.

PM_{10}: Particulate matter that measures 10 microns in diameter or less.

Population adjusted dose: The acute or chronic reference dose (RfD) divided by the Food Quality Protection Act safety factor.

Porosity: The ratio of the volume of void space in a material (e.g., sedimentary rock or sediments) to the volume of its mass.

Predator: An organism that captures and feeds on parts or all of a living organism of another species.

Preferred alternative: The alternative identified in an EIS that has been selected by the agency as the most acceptable resolution to the problems identified in the purpose and need.

Prescribed fire: A management ignited wildland fire that burns under specified conditions and in predetermined area, and that produces the fire behavior and fire characteristics required to attain fire treatment and resource management objectives.

Prescribed fire projects: Includes the BLM's efforts to utilize fire as a critical natural process to maintain and restore ecosystems, rangeland, and forest lands, and to reduce the hazardous buildup of fuels that may threaten healthy lands and public safety.

Prevention of Significant Deterioration (PSD): A U.S. Environmental Protection Agency program in which state and/or federal permits are required in order to restrict emissions from new or modified sources in places where air quality already meets or exceeds primary and secondary ambient air quality standards.

Productivity: The innate capacity of an environment to support plant and animal life over time. Plant productivity is the rate of plant production within a given period of time. Soil productivity is the capacity of a soil to produce plant growth, due to the soil's chemical, physical, and biological properties.

Programmatic EIS: An area-wide EIS that provides an overview when a large-scale plan is being prepared for the management of federally-administered lands on a regional or multi-regional basis.

Proper functioning condition: Riparian and wetland areas achieve proper functioning condition when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high water flows. This reduces erosion and improves water quality; filters sediment, captures bedload, and aids in floodplain development; improves floodwater retention and groundwater recharge; develops root masses that stabilize streambacks against cutting; develops diverse ponding and channel characteristics to provide habitat and water depth, duration, and temperature necessary for fish production, avian breeding habitat, and other uses; and support greater biodiversity.

Proposed action: A proposal by a federal agency to authorize, recommend, or implement an action.

Public domain lands: One category of public lands that have never left federal ownership; also, lands in federal ownership that were obtained by the government in exchange for public domain lands or for timber on public domain lands.

Public lands: Any land and interest in land owned by the United States that are administered by the Secretary of the Interior through the BLM, without regard to how the United States acquired ownership, except for (1) lands located on the Outer Continental Shelf, and (2) lands held for the benefit of Indians, Aleuts, and Eskimos. Includes public domain and acquired lands.

Public scoping: A process whereby the public is given the opportunity to provide oral or written comments about the influence of a project on an individual, the community, and/or the environment.

Q

Qualitative: Traits or characteristics that relate to quality and can't be measured with numbers.

Quantitative: Traits or characteristics that can be measured with numbers.

R

Rangeland: Land on which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs; not forests.

Raptor: Bird of prey; includes eagles, hawks, falcons, and owls.

Receptor: An ecological entity exposed to a stressor.

Record of Decision (ROD): A document separate from, but associated with, an Environmental Impact Statement, which states the decision, identifies alternatives (specifying which were environmentally preferable), and states whether all practicable means to avoid environmental harm from the alternative have been adopted, and, if not, why not.

Recovery plan: Identifies, justifies, and schedules the research and management actions necessary to reverse the decline of a species and ensure its long-term survival.

Reference dose (RfD): An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to not result in an appreciable risk of deleterious effects during a lifetime. It is derived from the no-observed-adverse-effect-level, the lowest-observed-adverse-effect-level, or a benchmark dose. Uncertainty factors are generally applied when developing the reference dose to reflect the limitations of the data used.

Registered herbicide: All herbicides sold or distributed in the United States must be registered by the U.S. Environmental Protection Agency, based on scientific studies, showing that they can be used without posing unreasonable risks to people or the environment.

Research Natural Areas: Special management areas designated either by Congress or by a public or private agency to preserve and protect typical or unusual ecological communities, associations, phenomena, characteristics, or natural features or processes for scientific and educational purposes. They are established and managed to protect ecological processes, conserve biological diversity, and provide opportunities for observation for research and education.

Resident fish: Fish that spend their entire life in freshwater (e.g., bull trout).

Residue: The quantity of an herbicide or its metabolites remaining in or on soil, water, plants, animals, or surfaces.

Resource Management Plan (RMP): Comprehensive land management planning document prepared by and for the BLM's administered properties under requirements of the Federal Land Policy and Management Act. Bureau of Land Management lands in Alaska were exempted from this requirement.

Restoration: Actions taken to modify an ecosystem to achieve desired, healthy, and functioning conditions and processes.

Revegetation: Establishing or re-establishing desirable plants on areas where desirable plants are absent or of inadequate density, by management alone (natural revegetation) or by seeding or transplanting (artificial revegetation).

Rights-of-way: A permit or an easement that authorizes the use of lands for certain specified purposes, such as the construction of forest access roads or a gas pipeline.

Riparian: Occurring adjacent to streams and rivers and directly influenced by water. A riparian community is characterized by certain types of vegetation, soils, hydrology, and fauna and requires free or unbound water or conditions more moist than that normally found in the area.

Risk: The likelihood that a given exposure to an item or substance that presents a certain hazard will produce illness or injury.

Risk assessment: The process of gathering data and making assumptions to estimate short- and long-term harmful effects on human health or the environment from particular products or activities.

Runoff: That part of precipitation, as well as any other flow contributions, that appears in surface streams, either perennial or intermittent.

S

Salmonids: Fishes of the family Salmonidae, including salmon, trout, chars, whitefish, ciscoes, and grayling.

Scoping: The process by which significant issues relating to a proposal are identified for environmental analysis. Scoping includes eliciting public comment on the proposal, evaluating concerns, and developing alternatives for consideration.

Section 3: Lands administered under Section 3 of the Taylor Grazing Act. This section of the law provided for the lease of grazing district lands to landowners and homesteaders in or adjacent to the reserves first and issuance of 1 to 10 year leases.

Section 15: Lands administered under Section 15 of the Taylor Grazing Act. Under Section 15, public lands outside of grazing districts could be leased to ranchers with contiguous property.

Sediments: Unweathered geologic materials generally laid down by or within waterbodies; the rocks, sand, mud, silt, and clay at the bottom and along the edge of lakes, streams, and oceans.

Sedimentation: The process of forming or depositing sediment; letting solids settle out of wastewater by gravity during treatment.

Semi-arid: Moderately dry; region or climate where moisture is normally greater than under arid conditions, but still definitely limits the production of vegetation.

Sensitive species: Plant or animal species susceptible or vulnerable to activity impacts or habitat alterations. Species that have appeared in the Federal Register as proposed for classification or are under consideration for official listing as endangered or threatened species.

Short-term impacts: Impacts occurring during project construction and operation, and normally ceasing upon project closure and reclamation. For each resource the definition of short-term may vary.

Significant: The description of an impact that exceeds a certain threshold level. Requires consideration of both context and intensity. The significance of an action must be analyzed in several contexts, such as society as a whole, and the affected region, interests, and locality. Intensity refers to the severity of impacts, which should weighted along with the likelihood of its occurrence.

Snag: A standing dead tree, usually larger than 5 feet tall and 6 inches in diameter at breast height.

Sociocultural: Of, relating to, or involving a combination of social and cultural factors.

Socioeconomic: Pertaining to, or signifying the combination or interaction of social and economic factors.

Soil compaction: The compression of the soil profile from surface pressure, resulting in reduced air space, lower water holding capacity, and decreased plant root penetrability.

Soil horizon: A layer of soil material approximately parallel to the land surface that differs from adjacent genetically related layers in physical, chemical, and biological properties.

Southern Nevada Public Land Management Act: Act that provides for the disposal of public land within a specific area in the Las Vegas Valley and creates a special account into which 85% of the revenue generated by land sales or exchanges in the Las Vegas Valley is deposited. The remaining 15% goes to state and local governments.

Special status species: Refers to federally-listed threatened, endangered, proposed, or candidate species, and species managed as sensitive species by the BLM.

Spot treatment: An application of an herbicide to a small selected area as opposed to broadcast application.

Stabilizer: A type of inert ingredient added to a commercial pesticide that makes the mixture more stable.

Stand: A group of trees in a specific area that is sufficiently alike in composition, age, arrangement, and condition so as to be distinguishable from the forest in adjoining areas.

Standard Operating Procedures (SOPs): Procedures that would be followed by the BLM to ensure that risks to human health and the environment from treatment actions were kept to a minimum.

Step-down: Refers to the process of applying broad-scale science findings and land use decisions to site-specific areas using a hierarchical approach of understanding current resource conditions, risks, and opportunities.

Stressor: Any event or situation that precipitates a change.

Subalpine: A terrestrial community that generally is found in harsher environments than the montane terrestrial community. Subalpine communities are generally colder than montane and support a unique clustering of wildlife species.

Subchronic: The effects observed from doses that are of intermediate duration, usually 90 days.

Subsistence: Customary and traditional uses of wild renewable resources (plants and animals) for food, shelter, fuel, clothing, tools, etc.

Succession: A predictable process of changes in structure and composition of plant and animal communities over time. Conditions of the prior plant community or successional stage create conditions that are favorable for the establishment of the next stage. The different stages in succession are often referred to as seral stages.

Surfactant: A material that improves the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of liquids.

Surrogate: A substitute or stand-in..

Synergistic: A type of cumulative impact where total effect is greater than the sum of the effects taken independently.

T

Tank mixture: The mixture of two or more compatible herbicides in a spray tank in order to apply them simultaneously.

Target species: Plant species of competing vegetation that is controlled in favor of desired species.

Teratogenic: Causing structural defects that affect the development of an organism; causing birth defects.

Terrestrial: Of or relating to the earth, soil, or land; inhabiting the earth or land.

Threatened species: A plant or animal species likely to become an endangered species throughout all or a significant portion of its range within the foreseeable future.

Threshold: A dose or exposure below which there is no apparent or measurable adverse effect.

Tier: In an EIS, refers to incorporating by reference the analyses in an EIS or similar document of a broader scope. For example, BLM field offices could prepare environmental assessments for local projects that tier to this PEIS.

Total suspended particles (TSP): A method of monitoring airborne particulate matter by total weight.

Toxicity: A characteristic of a substance that makes it poisonous.

Toxicokinetics: The process of the uptake of potentially toxic substances by the body, the biotransformation they undergo, the distribution of the substances and their metabolites in the tissues and the elimination of the substances and their metabolites from the body.

Transpiration: Water loss from plants during the course of photosynthesis.

Tribe: Term used to designate any Indian tribe, band, nation, or other organized group or community (including any Alaska Native village or regional or village corporation as defined in or established pursuant to the Alaska Native Claims Settlement Act) which is recognized as eligible for the special programs and services provided by the U.S. to Indians because of their status as Indians.

U

Understory: Plants that grow beneath the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or shrub canopy.

Undesirable plants: Species classified as undesirable, noxious, harmful, exotic, injurious, or poisonous under state or federal law, but not including species listed as endangered by the Endangered Species Act, or species indigenous to the planning area.

Upland: The portion of the landscape above the valley floor or stream.

V

Vascular plants: Plants that have specialized tissues which conduct nutrients, water, and sugars along with other specialized parts such as roots, stems, and reproductive structures. Vascular plants include flowering plants, ferns, shrubs, grasses, and trees.

Vertebrate: An animal with a backbone. Fishes, amphibians, reptiles, birds, and mammals are vertebrates.

Visual resources: The visible physical features of a landscape.

Volatilization: The conversion of a solid or liquid into a gas or vapor.

W

Water quality: The interaction between various parameters that determines the usability or non-usability of water for on-site and downstream uses. Major parameters that affect water quality include: temperature, turbidity, suspended sediment, conductivity, dissolved oxygen, pH, specific ions, discharge, and fecal coliform.

Watershed: The region draining into a river, river system, or body of water.

Weed: A plant considered undesirable and that interferes with management objectives for a given area at a given point in time.

Wetlands: Those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstance do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include habitats such as swamps, marshes, and bogs.

Wilderness: Land designated by Congress as a component of the National Wilderness Preservation System. For an area to be considered for Wilderness designation it must be roadless and possess the characteristics required by Section 2(c) of the Wilderness Act of 1964. These characteristics are: 1) naturalness - lands that are natural and primarily affected by the forces of nature; 2) roadless and having at least 5,000 acres of contiguous public lands; and 3) outstanding opportunities for solitude or a primitive and unconfined types of recreation. In addition, areas may contain "supplemental values," consisting of ecological, geological or other features of scientific, educational, scenic, or historical importance.

Wildfire: Unplanned human or naturally caused fires in wildlands.

Wildland fires: Occur on wildlands, regardless of ignition source, damages, or benefits, and include wildfire and prescribed fire.

Wildland fire use for resource benefit: A fire ignited by lightening but allowed to burn within specified conditions of fuels, weather, and topography, to achieve specific objectives.

Wildland Urban Interface (WUI): An area where structures and other human development intermingle with undeveloped wildlands or vegetative fuels.

X

Xeric: Very dry region or climate; tolerating or adapted to dry conditions.

YZ

CHAPTER 8

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ACEC	Area of Critical Environmental Concern
a.e./ac	Acid equivalent per acre
a.i.	Active ingredient
a.i./ac	Active ingredient per acre
a.i./ha	Active ingredient per hectare
a.i./L	Active ingredient per Liter
AGL	Above ground level
ALS	Acetolactate synthase
AML	Appropriate management level
AMP	Allotment management plan
ARI	Aggregate risk index
ATV	All-terrain vehicle
AUM	Animal use months
BA	Biological Assessment
BO	Biological Opinion
BEE	Butoxyethyl ester
BLM	Bureau of Land Management
BP	Before the present
BW	Body weight
CALPUFF	California Puff
CDC	Centers for Disease Control and Prevention
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cm	Centimeter
CO	Carbon monoxide
CREAMS	Chemical Runoff Erosion Assessment Management System
DCPMU	3-(3,4-dichlorophenyl)-1-methyl-urea
EA	Environmental Assessment
EEC	Estimated exposure concentration
EF	Exposure factor
EFR	Emergency fire rehabilitation
EIS	Environmental Impact Statement
EO	Executive Order
ERA	Ecological risk assessment
ERMA	Extensive Recreation Management Area
ESA	Endangered Species Act
ESR	Emergency stabilization and rehabilitation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FLPMA	Federal Land Policy and Management Act
ft	Foot/feet
FQPA	Food Quality Protection Act
FR	Federal Register
FRCC	Fire regime condition class
FY	Fiscal year
gal	Gallon(s)
gal/day	Gallons per day
GBRI	Great Basin Restoration Initiative
GCVTC	Grand Canyon Visibility and Transport Commission
GLEAMS	Groundwater Loading Effects of Agricultural Management Systems
HHRA	Human health risk assessment
HMA	Herd management areas
HQ	Hazard quotient
IWM	Integrated weed management
kg	Kilogram(s)
km	Kilometer(s)
km^2	Square kilometer(s)
K_{oc}	Organic carbon-water partition coefficient
L	Liter
lb(s)	Pound(s)
LC_{50}	Lethal concentration at which half of the organisms die
LD_{50}	Lethal dose at which half of the organisms die
LMR	Land Management Regulation
LOAEL	Lowest observed adverse effect level
LOC	Levels of Concern
LUP	Land use plan
m	Meter(s)
m^2	Square meter(s)
Mcf	thousand cubic feet (of gas)
Meq/L	Milliequivalents per liter
MFP	Management framework plan
mg	Milligram(s)
mg/kg	Milligrams per kilogram
mg/kg-day	Milligrams of herbicide per kilogram of body weight per day
mg/L	Milligrams per Liter
mi	Mile(s)
mi^2	Square mile(s)
MOE	Margin of exposure
MOS	Margin of safety
MOU	Memorandum of understanding
mph	Miles per hour
MRID	Master Record identification
MSDS	Material safety data sheets
NA	Not applicable
NAAQS	National Ambient Air Quality Standard
NAS	National Academy of Sciences

NAWQA	National Water Quality Assessment
NCIPC	National Center for Injury Prevention and Control
NE	Not evaluated
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NLCS	National Landscape Conservation System
NO_2	Nitrogen dioxide
NOA	Notice of availability
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observable adverse effect level
NOEC	No observable effect concentration
NOEL	No observable effect level
NOI	Notice of Intent
NRHP	National Register of Historic Places
NWIS	National Water Information System
O_3	Ozone
OHA	Office of History and Archaeology
OHV	Off-highway vehicle
OPP	Office of Pesticide Programs
PAD	Population adjusted dose
Pb	Lead
PEIS	Programmatic Environmental Impact Statement
PER	Programmatic Environmental Report
PHED	Pesticide Handlers Exposure Database
PM	Particulate matter
$PM_{2.5}$	Fine particulates
PM_{10}	Particulate matter less than 10 micron in diameter
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act of 1976
RfD	Reference dose
RMP	Resource management plan
ROD	Record of Decision
ROW	Rights-of-Way
RQ	Risk quotient
SDTF	Spray Drift Task Force
SERA	Syracuse Environmental Research Associates, Inc.
SHPO	State Historic Preservation Officer
SIP	State Implementation Plans
SRMA	Special Recreation Management Areas
SRP	Special Recreation Permit
SO_2	Sulfur dioxide
SOP	Standard operating procedure
TDS	Total dissolved solids
TEA	Triethylamine salt
TEP	Threatened, endangered, and proposed
TES	Threatened, endangered, and sensitive
THPO	Tribal Historic Preservation Office
TSP	Total suspended particles
TSS	Total suspended solids
TIP	Tribal Implementation Plan
TPY	Tons per year
TRV	Toxicity reference value
UE	Unit exposure
UF	Uncertainty factor
USC	United States Code
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile organic compounds
VRM	Visual resource management
WRAP	Western Regional Air Partnership
WSA	Wilderness Study Areas
WSR	Wild and Scenic Rivers
WSRA	Wild and Scenic Rivers Act
WUI	Wildlife urban interface
yd	Yard(s)
yd^3	Cubic yard(s)
$\geq$	Greater than or equal to
$\leq$	Less than or equal to
$>$	Greater than/more than
$<$	Less than
µg/kg	Micrograms per kilogram
$\mu g/m^3$	Micrograms per cubic meter
µg/L	Micrograms per Liter
°F	Degrees Fahrenheit
2,4-D	2,4 dichlorophenoxyacetic acid
2,4-DP	Dichlorprop
3,4-DCA	3,4-dichloraniline

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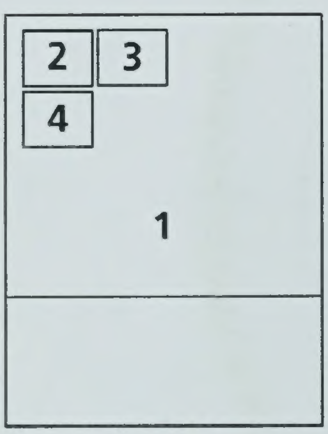

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1. Arrowleaf balsamroot (*Balsamorhiza sagittata*) in bloom near Elko, Nevada (courtesy of Stan White, Bureau of Land Management Volunteer)
2. Helicopter spraying (courtesy of Keith Duncan, New Mexico State University Cooperative Extension Service)
3. All-terrain vehicle spraying (courtesy of L. D. Walker, Bureau of Land Management)
4. Herbicide spraying using a llama (courtesy of Cindy Lair, Colorado State Department of Agriculture)

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