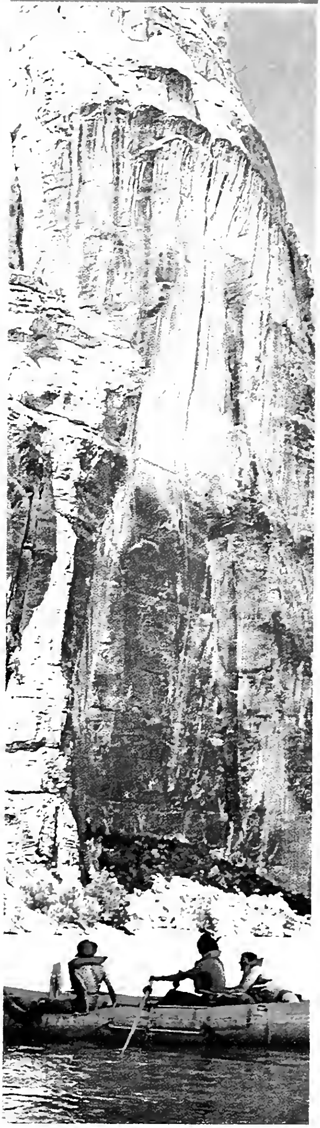
1983 Yearbook of
Agriculture
United States
Department of
Agriculture

Using Our Natural Resources

United States
Department of
Agriculture





Land: Farmland, Range

The United States has a land resource that is the envy of the world. Half our land—more than one billion acres—is in farms and ranches. Another 750 million acres is in forests. The remainder is in cities, transportation, mountains, and deserts.

In the semi-arid region of Montana (right), farmers plant wheat in strips, leaving every other strip fallow to absorb moisture for next year's crop. The wheat strips protect the idle land between from wind erosion.

Below, the Denver, Colo., skyline at sunrise.


Tim McCabe


Joe Larson


Tim McCabe

Forested land in the foothills of Mt. Rainier, Washington State.

Of the 10 major world crops, 9 are grown in the United States. They are corn, soybeans, wheat, barley, potatoes, sweet potatoes, sorghum, sugar cane, and rice. The only one not included is cassava, a tropical plant grown for its starchy root.

Soybeans (below) and corn are the giants in U.S. crop production, planted on 154 million acres in 41 States.

Bob Elbert

Bob El

Don Schuhart

Gene Alexander

An Illinois farmer (above) harvests corn from fields that are contoured and terraced to protect them from soil erosion. Iowa and Illinois are the leading States in corn and soybean production.

The potato (right), probably the most important vegetable crop in the world, grows best in the cool climates of Idaho, Washington, and Maine. Sweet potatoes (below) are primarily a warm climate crop and come frrom North Carolina, Louisiana, and California.

Hugo Bryan

Hugo Bryan

Grain sorghum can stand more heat and drought than other common cereal grain. Harvest (above) is underway in Texas where the climate is hot and dry.

David Warren

Hugo Bryan

Under threatening skies, a farmer hurries his harvest of rice. It is produced mainly in the warm, humid regions of Arkansas, Louisiana, Texas, and California.

Wheat, our most important export crop, grows on a wide range of soils and climates. In the U.S., it's the primary crop of the Great Plains with Kansas, North Dakota, Texas, Oklahoma, and Montana leading in production.

Tim McCabe

Tim McCabe

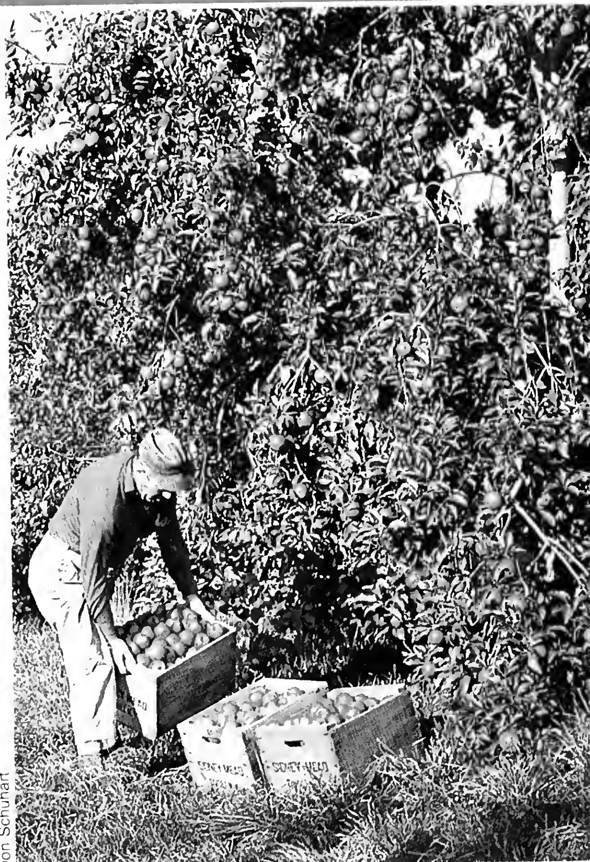
Tim McCabe

Bob Elbert

Much land not suited to cultivation makes excellent range and pasture for livestock. Angus cattle (above) graze on range in Montana.

With an extremely varied climate, the U.S. can produce a wide variety of crops. Apples (right) are being picked in New York State. Peanut harvest (below) is underway in Alabama, and Florida oranges (bottom) are ready for processing.

Don Schuhart



Don Schuhar

Don Schuhart

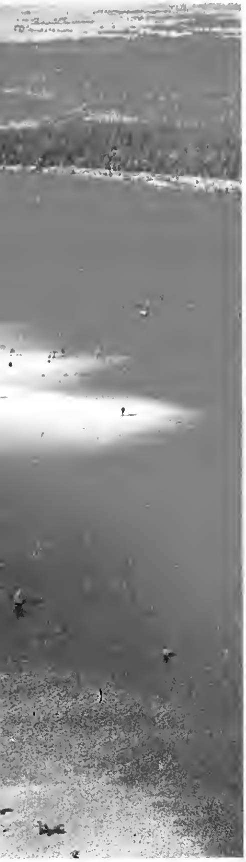
June Davidek

California has a wide range of growing conditions. Dates (above) are being picked in Indio where they thrive in the heat. Walnuts (left) are harvested in the cooler northern climate.

There are thousands of soils in the U.S., and fortunately most are suited to agriculture. Nevertheless our land productivity is threatened by soil erosion.

Tim McCabe

A relatively new method of reducing soil erosion is conservation tillage, in which residue of the previous crop is left on the soil's surface. This residue protects the land from rain and wind.



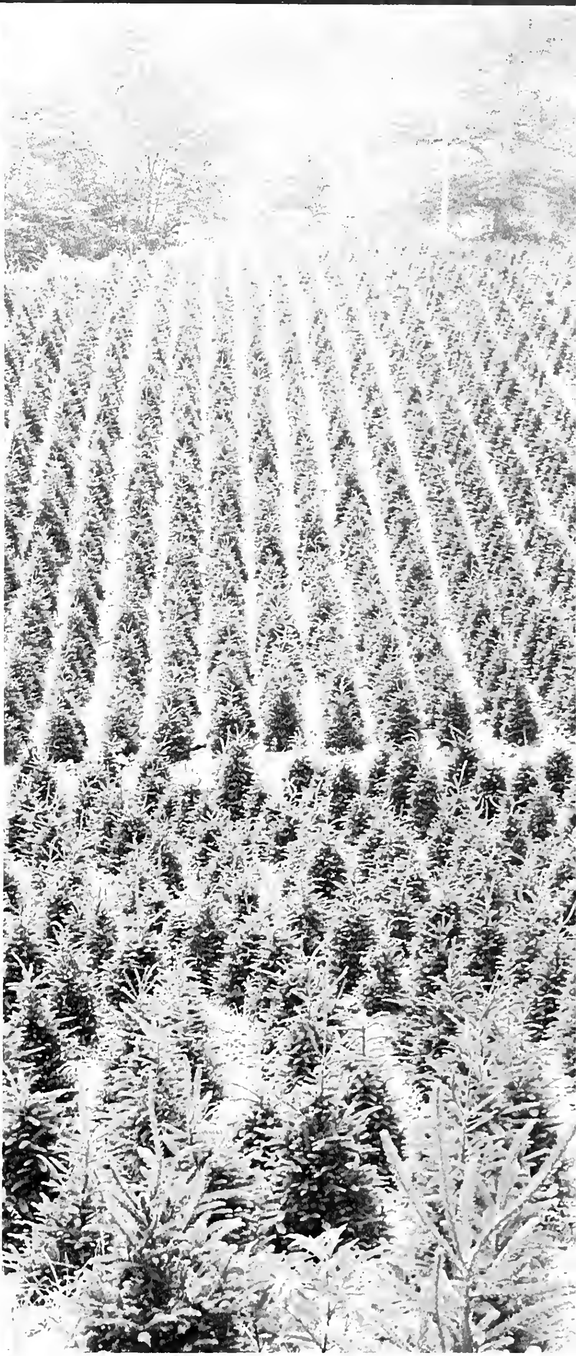
Tim McCabe

Erosion occurs when excessive amounts of soil are washed or blown away (below). Soil washed off the land becomes sediment (left) which pollutes streams and lakes, clogs waterways, and fills reservoirs.

Tim McCabe

Lynn Betts

Forests, Woodland



Our forests enhance the beauty of the countryside and furnish us with timber, firewood, furniture, turpentine, sirup, recreation, and wildlife habitat.

Leigh Fredrickson

Frank Jeter, Jr

Joe Larson

Don Schuhart

Workers (above) check ponderosa seedlings at a tree nursery in Oregon. At far left, baldcypress and water tupelo thrive in a forested wetland on the Mingo National Wildlife Refuge in Missouri.

Christmas trees (left) grow on a hilltop in North Carolina.

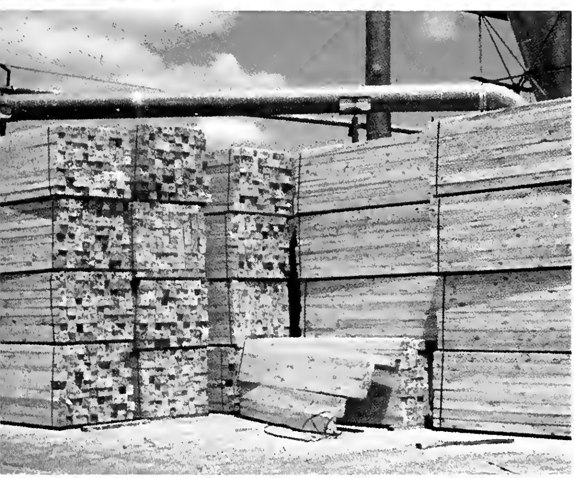
Wood is produced and used throughout the country. Below, pulpwood is unloaded at a Wisconsin papermill. At the bottom, a workman in a Pacific Northwest National Forest gets ready to mark the end of a Douglas fir log with his branding hammer.

Erwin W. Cole

USDA

Gene Alexander

Utility poles (top) arrive at a creosote plant in South Carolina. At the left, lumber is stacked at an Alabama sawmill, and (above) construction is underway at a Las Vegas, Nev., housing development.

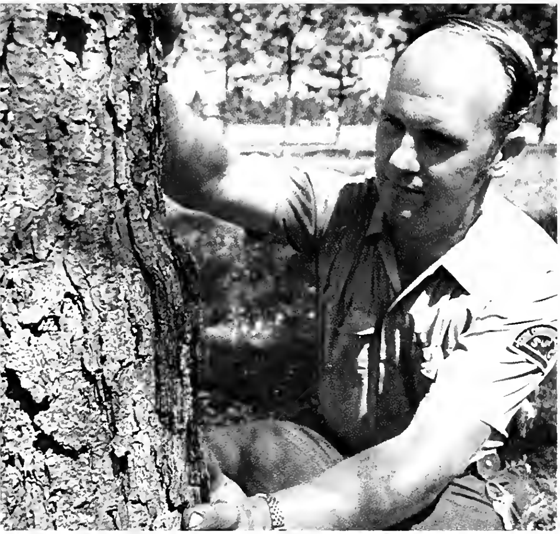


Don Schuhart

Gene Alexander

The "super" southern pine, growing in the forest nursery above, accounts for nearly half of all pine seedlings planted throughout the South today. A forester (below) crosses two genetically superior trees in a continuing program of improvement.

Gene Alexander



Gene Alexander

Southern foresters now have more than 30 years' experience with the "super" pine. Eventually the growth rate of these trees will be 35 to 45 percent above the average "wild" pine.

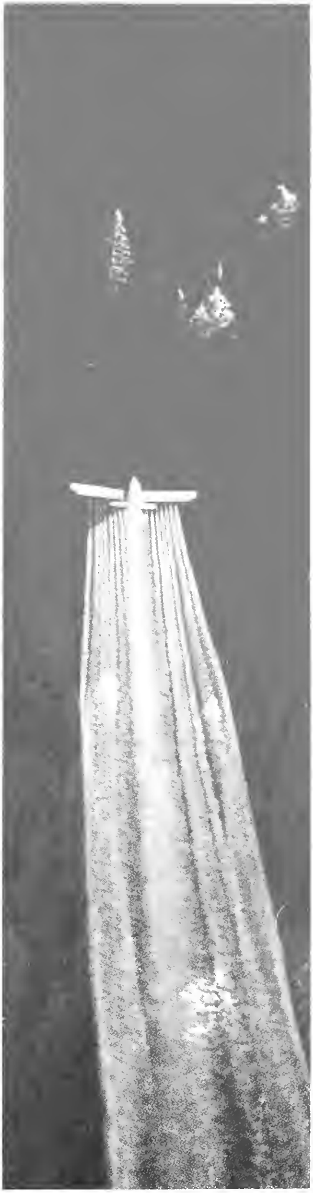
Gene Alexander

Important to the timber industry is the management of insects and diseases. The western spruce budworm (below) can damage millions of acres of forest in a single year. To combat it, aircraft (far right) apply a bacterial insecticide. At the right, spruce bark beetles have practically destroyed a white spruce forest on Alaska's Kenai Peninsula.

Danny C

William Ciesla

William Ciesla



William Ciesla

Left, traps containing an insect-attracting chemical provide early warning that an outbreak may be developing.

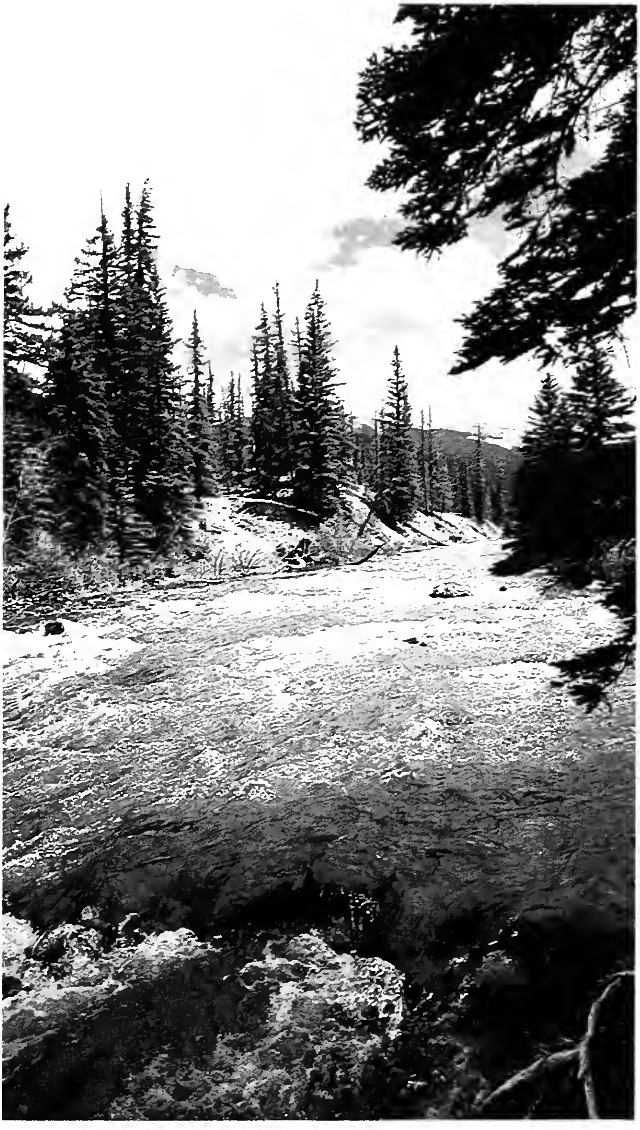
Water, Wetlands

The U.S. gets its water from precipitation, an average of 27 inches a year. But it varies from nearly zero in the desert to more than 100 inches in the Pacific Northwest. At right, rainclouds gather over Montana. Alfalfa (below) grows in Nebraska where ground-water irrigation is expanding. A typical center pivot irrigation system is a quarter of a mile long and covers 130 acres.

Tim McCabe

Streams and rivers, such as the one in Colorado below, carry snowmelt and rain to areas where it will be used by agriculture, industry, and homes.

Tim McCabe



Joe Larson

To make more efficient use of their water resource in northeastern Oregon, area farmers sponsored the Wolf Creek watershed project (right) which has reduced annual flood damage and has given them a reliable supply of water to irrigate 13,000 acres of land. Gated pipe (below) was one of the early conservation measures applied to irrigation. It eliminated the need for open ditches to carry the water to the fields.

Hugo Bryan

Above right, citrus trees in California are drip irrigated to conserve water, and (far right) the same technique is being tried experimentally on a cotton field in Texas.

Douglas Bishop

Tim McCabe

Tim McCabe

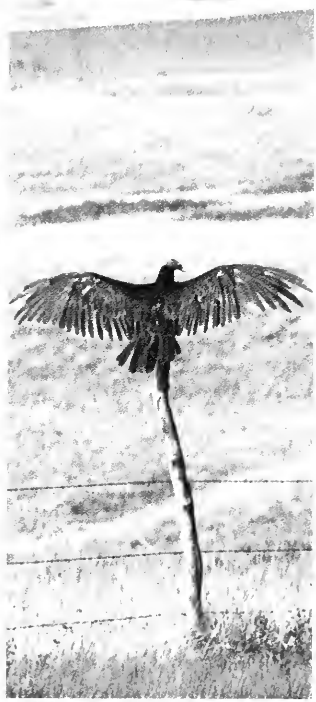
Wildlife

Our waterways, mountains, plains and forests are home to thousands of species of fish and wildlife. Canada geese (right) find habitat on Chesapeake Bay wetlands and the Kirtland's warbler (below) begins a comeback in remote north central Michigan. Below right, antelope graze on western prairie.

James Bull

Erwin W. Cole

Tim McCabe



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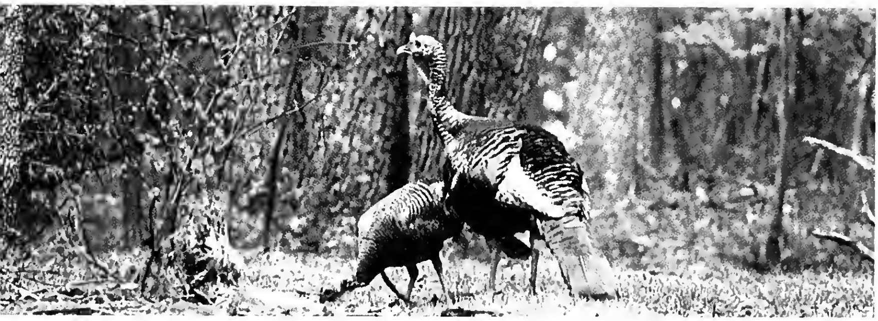
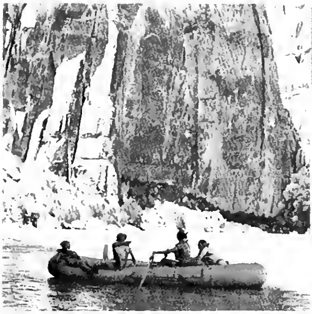


Glenn Smith

A turkey buzzard (top) keeps vigil along the Missouri River breaks. Wild turkeys (above), once nearing extinction, now number 2.5 million a credit to scientific wildlife management.



Recreation

Our land and water resources afford a great variety of recreation opportunities. A hunter (right) scans the hillside for big game in colorful Sun Valley's Upper Trail Creek area. Trail riders (below) make their way along the Yellowstone River Valley.

Robert Lucas

Don Schuhart

Don Schuhart

A fisherman displays a salmon caught in Alaska's Anchor River.

A cross-country skier (right) treks down a logging road in the Roosevelt National Forest in Colorado. Below, a California family goes fishing, and (bottom) a young man challenges the white water of the Selway River as it runs through the Selway-Bitterroot Wilderness Area of Idaho.

William Ciesla

Joe Larson

David Lime

Foreword

Wise use of our natural resources is one of our basic goals in the U.S. Department of Agriculture. This means sound conservation programs—for soil, water, timber, wilderness, and wildlife—and providing for outdoor recreation.

USDA's Forest Service manages 191 million acres of public lands. These Forest Service lands include more than 25 million acres of the National Wilderness Preservation System, or 84 percent of the wilderness areas in the lower 48 States and Hawaii.

Each year under multi-use programs the Forest Service sells some 11 billion board feet of timber harvested from the National Forests—enough wood to build about a million homes. More than 3 million cattle and sheep graze on National Forest lands each year. More recreation visits are made to National Forest lands each year than to any other Federal land system. And the National Forests are the home of about half of the Nation's big game animals.

In addition, consumers and agricultural producers benefit from other USDA soil and water conservation programs designed to maintain and improve our food and fiber potential for the benefit of generations to come. One of our primary concerns is to reduce soil erosion.

USDA has 27 conservation programs for soil, water, private and public woodlands, and wildlife, administered by 8 different agencies. Those agencies include the Soil Conservation Service and the Agricultural Stabilization and Conservation Service.

Besides working with farmers, the Extension Service—which has cooperative offices in virtually every county—provides professional advice to homeowners on gardening and handling soil, erosion, and other problems. It also offers expertise to urban, suburban, and rural area governments. Research is carried on by a number of USDA agencies.

Our vast natural resources are a priceless heritage. Using them wisely is everyone's responsibility and is a major challenge of the eighties. The 1983 Yearbook of Agriculture gives an idea of what's involved in that challenge, and how we can meet it.

John R. Block
Secretary of Agriculture

This Yearbook of Agriculture, *Using Our Natural Resources*, tells the fabulous story of our resources—mainly in terms of land, water, forests and woodlands, wildlife, plants, farmlands, people, and urban and suburban greenbelts. It describes the changes that have taken place in the stewardship of these vast resources, where we are today, and what the future holds. A variety of views are expressed.

The book's authors are from the U.S. Department of Agriculture, the land-grant universities, other organizations, and two companies. Among the authors is a ranch operator.

Merrill L. (Pete) Petoskey of the Extension Service was chairman of the 1983 Yearbook Committee that planned the book and saw it through to the final product. Members of the committee, by agency, were:

Forest Service—Hugh C. Black, Howard W. Burnett, George Castillo, Elinor Cruze, Glen Hetzel, Barbara Holder, Stanley L. Krugman, Kermit N. Larson, Ronald D. Lindmark, Marcus Petty, Ed Schlatterer

Soil Conservation Service—Hubert Kelley, Gary A. Margheim, Gerald Seinwill

Agricultural Research Service—David A. Farrell

Agricultural Stabilization and Conservation Service—Gordell Brown

Cooperative State Research Service—Gary Evans

Economic Research Service—W. Neil Schaller

Food and Nutrition Service—John S. Webster

Farmers Home Administration—George Moore

Rural Electrification Administration—Jeanne Miller

Photography—Joe Larson, Soil Conservation Service

Jack Hayes
Yearbook Editor

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I. Introduction

A Sixth Grader Spells Out Our 'Dependetses' on the Land

By Merrill L. Petoskey

More years ago than one likes to remember, my son John, then a sixth grader, and I were returning home from a business trip. I had been helping with a conservation school for teachers. John had attended every minute of the two-day session.

John had quite a yen for notebooks. In fact he had, for this trip, a new shorthand notebook my secretary had given him. During the sessions he had been doing a lot of writing and, quite obviously to me, more than some of the teachers. During one of the long periods of silence in our ride, I decided to quiz him on what he might have learned. "Just what did you get out of the session, John?"

Without a moment's hesitation he wrote, "Man is dependetses on the land." Sparkling, and to the point! Although the spelling was wrong, his idea was right. I could only hope that the teachers had drawn the same conclusion: Our roots are in the soil.

Too often, many of us—particularly those who live in large cities—forget that we, human beings, depend on the land and on the many things that make up the land.

The rest of the story is John's as he told me what he had learned:

"Man is an animal, just like a fox, a lion or a chimpanzee. Men are luckier than most animals, because they can control all the other animals, but man is on this earth for the same reason they are. The reason is to have young, so that there will always

Merrill L. Petoskey is Deputy Administrator, Natural Resources and Rural Development, for the Extension Service. He was Chairman of the Committee that planned this Yearbook.

be men on the earth. In order to raise children, man needs only food and a place to live and doesn't really need a fancy bicycle, a pretty doll, or a color TV.

"People come in many different colors. Brown people come from the islands and Mideast, white people from Europe, yellow people from the Orient, black people from Africa. Color does not make people different. They are very much like each other and are really all animals, with the three basic needs of food, shelter and reproduction. People are more intelligent than all of the rest of the animals, except themselves.

Community Relationship

"Animals and plants may be grouped in two different ways. One way is by the family relationship, the other, the community relationship. This latter grouping, as communities, is the most interesting way to understand plants, animals, and their interrelationships.

"Two Greek words are used to make a word which describes the grouping of living things together. The two words are *oikos* meaning house, and *logos* meaning reason. Together they make the roots that form the word 'ecology' which, broadly interpreted, means the 'household of nature.' There is a more modern definition of ecology—'The study of living things and their environment'. Plants and animals in this association are known as 'communities.'

John Petoskey about the time he was a sixth grader and impressed Dad with his quick grasp of natural resources fundamentals, if not his spelling.

"An interesting thing about these living communities is that they are always changing. The change is often slow and not easily seen. The process by which a plant community gradually changes so that it is recognized as a different community is called 'succession.'

"Plant communities differ in various parts of our country and the world. They differ primarily because of climate, moisture, latitude, elevation, and soil type.

"There are a variety of stages in this process which is called 'plant succession.' Nature, when left alone, and barring the violence of nature—for example, fire, floods or other disasters—is very orderly in the steps of progression in plant succession.

"This order continues only until people enter the picture. We are able to change the plant community, sometimes good, sometimes bad. If you have ever planted a garden or have seen a farmer's field, you have seen an example of upsetting or changing the order of plant succession.

The Biotic Pyramid

"These plant communities are capable of supporting lots of different kinds of plants and animals. The plants are the base that support everything else. Animals called herbivores eat the plants, and animals called carnivores eat the herbivores. This is known as the 'biotic pyramid' with people at the top.

"Plant communities can support certain numbers of animals without being destroyed. This is called 'carrying capacity.' Some animals, like deer, can multiply very rapidly and can destroy their food supply, causing many to starve. I wonder if people will ever do that, exceed the carrying capacity of the Earth."

My son and I rode the rest of the way in silence. But I did some deep thinking. The boy had a good understanding of the biotic community relationship, and had begun to think in terms of succession, carrying capacity, and the like. He had begun to realize that he was only a small part of this wonderful world of nature. The idea of sharing it with others, with reason and understanding, was there. Nurtured, it could grow to help solve the frightening problems of our times, overpopulation, pollution, the mad clamor to make money despite what happens to the environment. I wonder—will there ever be enough people that really understand?

We have organized this book beginning with the basic resources of soil and water and the plant and animal communities indigenous thereon, range, forests, agricultural lands, and other unique lands. All support varied and different communities. With the different plant communities come different forms of wildlife.

Understanding these "community" relationships can help all of us to realize why a bird like the wild turkey is a creature of the mature forest, the antelope is an inhabitant of the western rangelands, and the quality and quantity of soil and water are essential to our future existence.

This is what the book is all about. We are trying to inform our readers of the kinds of plant and animal communities in North America and what these communities mean to all of us in terms of food, fiber, wildlife, all the good things in life, and some of the bad. If we can create a better understanding of the community relationship, and the realization that we—as human beings—are a part of it, this book will be a success.

That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics. That land yields a cultural harvest is fact long known, but latterly often forgotten.

—Aldo Leopold, *A Sand County Almanac, 1948*

II. Physical, Biological, and Social Components

Soil Sustains Life If We Treat It Right

By Richard W. Arnold

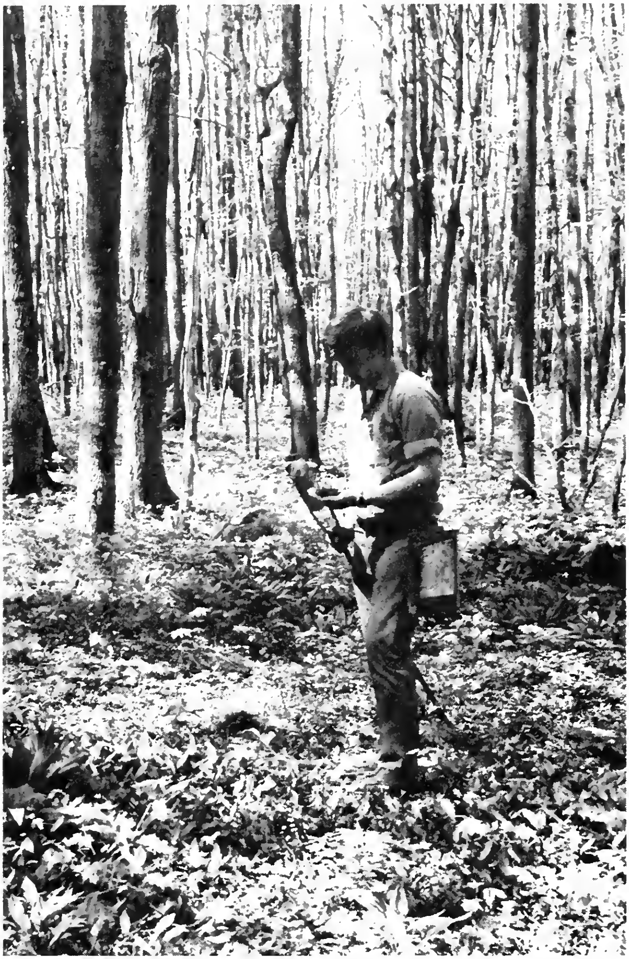
Everybody knows about dirt—it is soil that is out of place and it is a nuisance. Dirt makes hands and clothes need washing, it fills in ditches after heavy rains, and in some places it is blown in your face. People who have a garden are aware of soil as soil—not just dirt. It is a part of the environment they are trying to control and it may or may not reward their efforts.

Nearly everybody knows that farmers plant crops in soils and that cattle eat grass that grows in soils. Not everybody is so aware of soils when strolling in a forest or picnicking along a stream. A lot of people today have read or heard that soil erosion is a serious problem, and in many places this loss of soil is decreasing agricultural productivity.

But what is a soil? A soil is easy to walk on and to dig in but fairly difficult to define. Defining a soil is somewhat like describing your favorite outdoor spot: Blue sky, clouds, rain, trees and grass, maybe flowers, and rocks and small insects and bugs and under it all, the soil. Your favorite spot changes, yet some features look the same for a long time. Soils are a part of the favorite spots of the world; they, too, change with the weather, the vegetation, the insects, and even the presence and activities of people.

The part of soil most people are familiar with is the surface layer, the topsoil into which they drop seeds and from which they pick up the dirt they track

Richard W. Arnold is Director, Soils, for the Soil Conservation Service.



In a forest, trees provide organic raw material to the area that surrounds them. This helps build new soil. Through their roots, trees also help accumulate other enriching compounds deeper in the soil.

across the carpet. This topsoil is a more complex substance than it may seem.

In a handful of topsoil there is a mixture of rock and mineral particles that are referred to as sand, silt, and clay, depending on their size. Included also are air, water, decomposed plant and animal tissues, some live roots, and lots of unseen micro-organisms. You can crush, knead, soak, puddle, and beat the topsoil into a degraded clod of dirt. Yet if it is treated with care and respect, it can grow, sustain, and nourish plants, animals, and man.

Part of an Ecosystem

Soil is not this thin surface layer alone, however. The underlying layers are also part of a soil and part of an ecosystem.

Some soils are several meters thick, and others are only a few centimeters thick over rock.

Soils are a link between the hard rock core of the earth and the living things on its surface. In a handful of soil you hold a microcosm of an ecosystem. That soil has a history of interacting with climate and biota to become what it is today. You too are a part of the history of this soil—of this ecosystem.

Every ecosystem is a complex, interactive, comprehensive fine-tuned system. A change or modification of any component brings about modifications of the others. If some part is damaged, then degradation and major change of the ecosystem may occur.

Disasters such as floods, fire, and severe soil erosion modify the course of ecosystem development. Soils record modifications of the environment; and their stories, if they could be read, would be the history of land, with and without people.

In flood plains where rivers spill over their banks and carry soil-laden waters, layers of mud and silt are left behind. These events are recorded in soils. The alluvial plains of the world record long histories of flooding.

Clearing Forests

In a forest, trees provide organic debris to the surface layer of the soil in which they grow, and contribute to movement of clays within the soil, to bleaching of sand grains, and to accumulation of other compounds deeper in the soil.

When a forest is cut, stumps removed, land plowed, and crops planted, the processes that gave rise to the particular soil in the forest are altered and characteristics of the soil change. The effects of annual plowing, addition of fertilizers, and modifications of the surface layer will be recorded as part of the life of that particular soil.

Where soils have been farmed for many years without careful control of water, much of the surface layer has eroded, exposing subsoils that are less favorable for the immediate rooting of plants. The reduced productivity of these highly eroded spots is now apparent.

Some changes can be reversed. Imagine a landscape that is barren. Now imagine it replanted as a forest; the trees grow, and the canopy closes. The rains soak in, instead of running off the bare ground, particles of soil no longer move down the slope with every drop of rain, organic matter accumulates, and the landscape stabilizes. This, too, is a story that can be read in the soil.

A bulldozer shapes the front lawn of a new housing development removing old soil layers, mixing others, and modifying them as the material is spread around. Sod is placed on this accumulation of different earthy materials. With time a distinct new soil will form beneath the grass. Yes, the stories of many of people's activities are recorded in soils.

Soil Horizons

For most of us who plant seeds—whether for vast fields of wheat or for a tiny urban garden—soil is the earthy material outdoors at the earth's surface that is capable of supporting plant life. For engineers, who are concerned with soil as a possible construction material, soil is all the unconsolidated earthy material down to bedrock. By either definition, soil is not static but changes in response to factors in the environment and in response to activities of people.

Soils develop from earthy materials that have accumulated in a given landscape. These accumulated materials are called the "parent material" of soils. For example, mud deposited on a flood plain becomes parent material in which a soil can develop. In other landscapes, rocks are weathered and the altered materials accumulate. In most landscapes, geologic materials are moved away from the initial site of rock weathering by gravity, water, or wind. Deposits of parent materials range in size from narrow bands of sediments along a meandering river, to many square kilometers of wind-deposited loess.

After parent materials have accumulated, they are acted on by processes that change the material into distinct layers called soil horizons. Horizons usually parallel the ground surface. They differ from each other in color, size of aggregates, and other features. Soil scientists identify soils on the basis of the kinds of soil horizons and their vertical arrangement in the soil.

Interactions of climate, living organisms, and topography on the parent material over time determine how and what kind of soil will develop. These factors control the interactions that change geologic material into soil horizons.

Soils change through additions, losses, translocations, and transformations of materials. Water, radiant energy, organic matter, and dust are natural additions to the system. Percolating water moves chemicals in solution deep into substrata or laterally down a slope. Erosion physically moves soil materials from one site to another.

Translocations are usually internal adjustments within a soil, such as the movement of carbonates from upper horizons to lower horizons. Biological and chemical alterations of minerals are transformations from one form into a different one. The development of structural aggregates is another type of transformation.

Climate a Driving Force

Climate is the driving force that provides the energy needed to alter parent materials. The amount of precipitation, and when and how it falls, influence the solution and breakdown of rock materials. Sunshine provides energy to plants and animals that occupy the ecosystem. Climate influences the abundance and kinds of flora and fauna of an ecosystem.

Topography modifies the interactions of climate and biota. Steep slopes lose water faster than gentle slopes, thus droughty and moist sites may occur next to each other. North-facing slopes are often cool and moist and support vegetation different from that on south-facing slopes. Topography also changes throughout time—gullies cut into uplands and hills erode away to form plains. Each modification is reflected in the processes of an ecosystem. A new succession of plants may occur, animal species may change with the habitat, and the soil will be affected.

The soil-forming processes that create soil horizons must be at work hundreds, thousands, even tens of thousands of years before some differences in a profile can easily be seen with the naked eye or felt with the hand. Time is necessary for landscapes to change, for vegetation to pass through successions. Within the lifespan of a human, most changes of soil properties are relatively small, and the soils may appear to be static. Catastrophic events such as landslides and floods cause rapid changes, but they usually are of small extent relative to the slow processes that occur everywhere.

L. F. Bredemeier

Soil-forming processes, such as lichens growing on rock, go on for many thousands of years.

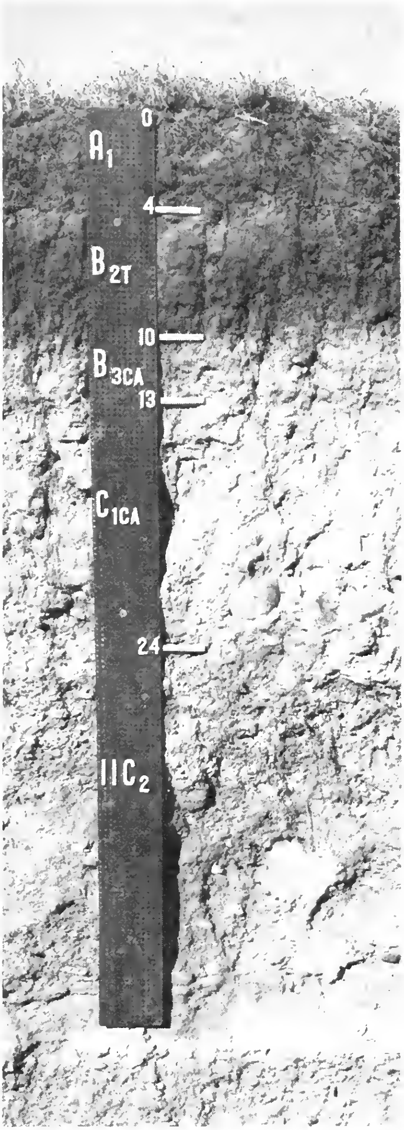
Each soil is the result of an ecosystem that was, and is, unique to its location on the earth's surface. For example, the soils of tundra and rain forest ecosystems are vastly different. These differences result mainly from differences in climate and vegetation.

In a tundra ecosystem, the long frigid winter and brief cool summer are not favorable for the weathering of minerals or for the decay of organic matter. Many of the soils in Arctic or subarctic tundra ecosystems have thin horizons, only slight alteration of minerals, and relatively high nutrient content.

In tropical rain forests, the continually warm, moist conditions permit rapid alteration of minerals and recycling of nutrients in the biomass. Many of the soils in rain forests have thick horizons, evidence of strong weathering of minerals, and relatively low reserves of plant nutrients.

Mapping Soils

Because each ecosystem commonly has a unique soil, soil scientists and others who use information about soils need ways to describe and refer to the thousands of different soils in the world. Soil scientists have developed standard terminology for identifying soil horizons and describing features in soil profiles. They observe and record data on particle size distribution (texture), aggregation or structure of soil, pore space, color, firmness, roots, and reaction



Alan E. Amen

The separate soil horizons or layers are easy to distinguish in this profile of Alaska loam, a moderately deep, dark, well-drained soil named for the State in which it was first recognized.

(pH) in each horizon; type of boundary between horizons; and other special properties in a soil.

A soil has three important zones: A topsoil, a subsoil, and a substratum. Russian soil scientists in the 19th century referred to these zones as the A, B, and C horizons. Some of their nomenclature is still in use. Horizons that develop at or near the surface, the A horizons, generally accumulate organic matter and are darker than subsoil horizons.

In some subsoil horizons, called B horizons, color and structure indicate that transformations of the parent material have occurred; in others, clay, organic matter, or chemical components have been moved from other horizons and have accumulated. Subsoil horizons from which materials have been removed (eluviated) are called E horizons. In the substratum, or C horizon, the influence of soil-forming processes—primarily biologic ones—has been slight.

Soil scientists in the United States have developed a classification system called *Soil Taxonomy*. The system groups soils into classes and categories so that scientists can share information with each other. *Soil Taxonomy* was developed over a 25-year period and was published in 1975. Scientists are expanding this system to include more soils in the world so that information can be shared about more ecosystems.

There are six categories in *Soil Taxonomy*. The highest category consists of 10 broadly defined *orders* of soil. The lowest category, for which the most detailed soil information is provided, is called *soil series*.

Soil scientists have identified over 12,000 soil series. Each soil series is given a name associated with the area where it was first recognized and described. For example, the Webster series was first described near Webster, Iowa. The U.S. Department of Agriculture has stored descriptions of general characteristics of the soil series on computer tapes to assist in mapping and interpreting soils in the United States.

Airphoto Base Maps

U.S. soil scientists have been identifying soils and making maps and interpreting soils for more than 80 years. Scientists from universities, state organizations, and Federal agencies work together as the National Cooperative Soil Survey to provide information about the Nation's soil resources.

To make soil maps, soil scientists delineate landscape patterns on airphotos or other suitable base maps. They dig pits or take samples with augers to study horizons of the soils. These observations permit them to identify the dominant soil series in each area. Delineated areas are reasonably similar in their physical, biological, and chemical properties.

Physical features—such as land slope, soil texture, and

Gene Alexander

To make soil maps, soil scientists outline landscape patterns on airphotos or other suitable base maps and take soil samples to identify the dominant soil series in each land area.

kinds of horizons—are easily recognized in the field. Specific chemical properties, although important, are more difficult to describe and consistently map. Many chemical features—such as content of nitrogen, phosphorus, and potassium—can be determined only with laboratory tests and are not suitable criteria for identifying map areas because they can change with land use and management.

Soil maps provide information about the kind, extent, and location of unique kinds of soils. On maps at a scale of 1:20,000, soil areas as small as 2½ acres can be consistently shown.

Soil areas this small are usually identified as texture and slope phases of the dominant soil series. For example, a soil map unit named "Webster silt loam, 0 to 2 percent slopes" is dominated by soils whose properties are defined by the Webster soil series, has a surface soil texture of silt loam, and occurs on gentle slopes with gradients to 0 to 2 percent. Each area identified on a soil map as Webster silt loam, 0 to 2 percent slopes, has similar properties.

Areas designated on the map as Clarion loam, 0 to 5 percent slopes, have sets of properties that differ from those of Webster soils; consequently they behave differently when used for the same purposes.

Behavior Predictions

Soil information is useful when it enables us to make satisfactory predictions about soil behavior. As we learn more about soils in natural and people-made ecosystems, we can use that knowledge and experience in other areas with the same or similar kinds of soils.

Potential use of any soil depends mainly on its location and its physical, chemical, and biological responses to events. If people leave a soil alone, it responds to the natural forces active in that ecosystem. The tendency of an ecosystem is to achieve a balance among its components.

When we disturb an ecosystem, we may damage the ecosystem or we may use management practices to improve conditions. Soil properties change in response to management of the environment.

When people move from one agricultural place to another, they take along their knowledge and experience. If the new environment is much drier than the previous one, they soon learn that water management requires new skills. If the adapted plants are not the same, and the soil has different nutrient supplies, they change their tillage practices.

In east-central Iowa, for example, windblown calcareous materials called loess were deposited some 17,000 years ago. Forest vegetation became established, and changes in the soil material began. Carbonates were leached into the substrata; clay particles were slowly moved into the subsoil B horizons from the overlying E and A horizons.

Prairie Grasses Take Over

Then the climate changed. As the climate became drier, and possibly warmer, the vegetation changed. Prairie grasses were better suited than trees to the new conditions and eventually became the dominant vegetation.

Organic matter from dying leaves and roots began to accumulate throughout the upper horizons, masking the E horizon that had developed when the land was forested. Soon (in geologic terms) the soil had a dark-colored A horizon almost 2 feet thick, the clay-enriched B horizon was stained brown with organic matter, and the soil structure consisted of small, stable aggregates.

Each year there was a sequence of flowers as the early spring forbs completed their cycle before the grasses began. It was as though each component was a player waiting for cues for its stage entrance, lines, and exit in harmony with the other players.

Then new players entered the stage. People came over the mountains and onto the prairies. This broad undulating land where the grass grew thick and tall looked ideal for farming. Newly developed steel plows slowly turned under the prairie sod. Corn and wheat waved in the summer breezes.

But the soil began to change. The friable, loose topsoil became more compact and sometimes washed away during heavy thunderstorms. Less organic matter was returned to the soil than when the prairie grasses were there. Some nutrients supplied from the soil were no longer being recycled. Instead they were harvested and hauled away in the corn and wheat crop.

As damage to the soils became apparent, farmers tried to find ways to increase yields and to maintain or improve the condition of the soils. New higher yielding varieties were developed and bigger tractors and other specialized equipment built. Fertilizers and pesticides were introduced. Today many farmers are adopting management practices that include crop residues to rebuild the tilth and organic matter content of topsoils and protect the surface from erosion.

Ideal Soil Sought

People's uses of soils are related primarily to the desire to have a suitable medium for plant growth—in fact most interventions are to achieve the ideal soil for each type of production. Whether starting with a natural soil, or one that has been cultivated previously, the farmer wants to grow certain plants of interest that are adapted to the region.

The farmer is interested in a soil that has a zone in which plants can establish a foothold and develop a root system. The soil must have a capacity to hold enough water for plant growth. It should supply adequate amounts of the nutrients needed by the crops to be grown.

The soil must have a capability to readily transmit air and water so it is not too wet or too low in oxygen at the wrong times. The ideal soil should also be physically stable in the sense that it resists wind and water erosion or downslope slips and slides.

Most soils are not ideal, however, and people must either try to improve the soils so they approach the ideal or manage soils to minimize their limitations.

Some restrictive features can be overcome. If water cannot easily move through a soil, plant roots may not receive enough oxygen and nutrients. Where such a soil can be drained with tile or by shaping the surface, the moisture-air-nutrient relationships can be improved.

Economic conditions affect the degree to which restrictive soil properties limit actual use of soils. When cheap hand labor is readily available or when gasoline prices are low, some lands are used that would be left idle as the costs of labor or energy narrow the margin of profit.

Gene Alexander

Today many farmers are adopting management practices such as growing new crops in old crop residue. This rebuilds the tilth and organic content of the topsoil and protects the soil from erosion.

Other soil management practices—such as drainage, land shaping, and irrigation and inputs of fertilizer and pesticides—vary widely with changes of economic conditions.

Salts Cut Production

Environmental factors limit the degree to which modifications of the soils can be maintained. Where soils are irrigated with low-quality water and without providing adequate drainage, salts slowly accumulate. High levels of salts drastically reduce crop production, and may flocculate the soil surface, making the soil more susceptible to wind and water erosion. Severe physical or chemical degradation can make the soil worthless, even if attempts are made to reclaim it.

Soil has limits beyond which its use cannot be economically sustained. Where the limits have been ignored or misjudged, results have been disastrous.

Important lessons are to be learned from those who live with and care for their ecosystems. How we care for and intervene in ecosystems depends on our goals—individually and collectively. We are the stewards, not owners, of soil. Soil is a key to life. Good soil stewardship is a responsibility we all can share—and help open the door to an improved quality of life for all people.

New Efficiencies in Water Use Vital for Nation

By Marvin E. Jensen and John D. Bredehoeft

Water is essential for all biological systems. Without water for plant growth there would be no food for humans and animals. Without water there would be no animal or human life.

Water has a key role in photosynthesis—the process of converting sunlight energy, carbon dioxide and water into carbohydrates—first for plant life and then for the animals that consume plants.

A renewable resource, water is made available by the hydrologic cycle. In this cycle, water evaporates from oceans and land and the water vapor is transported by the atmosphere over land where it condenses and falls as precipitation in the form of rain or snow. Ultimately, precipitation is the source of all our freshwater resources.

Successful management of water resources in U.S. agriculture has been instrumental in development of one of the most productive agricultural systems in the world. This in turn has been a major factor in our quality of life.

The future success of U.S. agriculture and the quality of environment will depend on how we cope with decreasing water supplies for agriculture as ground water is depleted in some regions, as competition for surface supplies increases, and as the quality of water is degraded with increasing intensity of water use.

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Available Water in the U.S.

The quantity of water in transit in the hydrologic cycle is nearly constant. Below-normal precipitation in parts of the world is offset somewhere else by above normal precipitation.

About 45,000 million acre-feet per year (maf) of water in the form of water vapor passes over the conterminous United States. About 10 percent falls as precipitation and is dissipated. One acre-foot is the quantity of water that will cover an acre of land to a depth of a foot.

Average annual precipitation for the United States is about 27 inches, but it varies from near zero in desert regions to over 100 inches in the Pacific Northwest. Average annual runoff is related to the amount of precipitation. Much of the land in the western United States has less than 1 inch of runoff, mostly from snowmelt in the mountains.

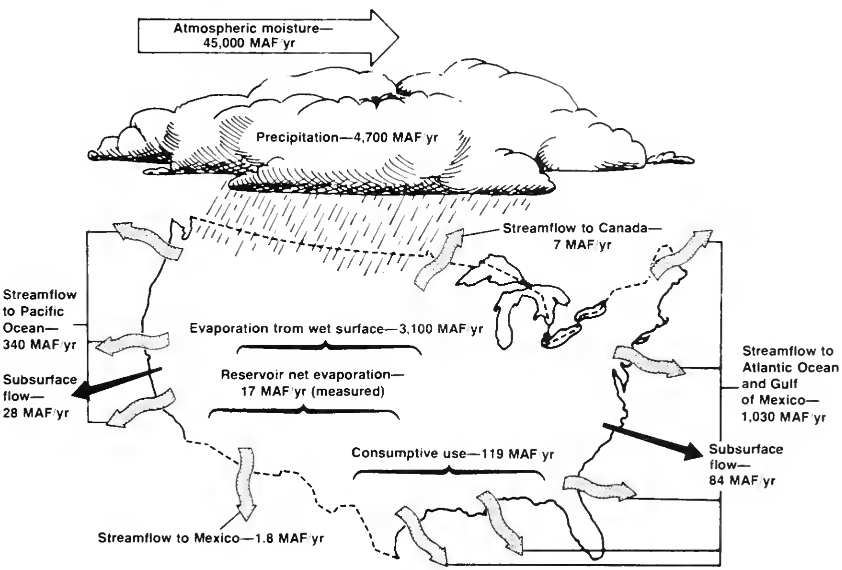
The major western rivers and their tributaries used as a surface water supply for irrigated agriculture are

1) The Columbia River in the Pacific Northwest;

2) The Sacramento River in California;

3) The Colorado River that originates in Colorado and Wyo-

Water budget of the conterminous United States in million acre-feet per year (maf/yr)



ming, flows through Utah and Arizona and forms the border between the States of Arizona and Nevada and between Arizona and California;

4) The Missouri River in the northern Great Plains;

5) The Arkansas River in Colorado and Kansas;

6) The Red River in the Texas-Oklahoma area; and

7) The Rio Grande River that originates in Colorado and flows through New Mexico and forms the border between Texas and Mexico.

Precipitation and runoff vary greatly from year to year and from region to region. Effective use of available surface water supplies—by agriculture, municipalities and industry—requires facilities to store runoff during high flows for use during low-flow periods as needed. The most common storage method is a surface reservoir in which storage capacity provides for one or more purposes such as flood control, irrigation, municipal use, recreation and hydroelectric power generation.

Reservoir capacity development in the United States increased rapidly from 1930 to 1970, but is beginning to level off near 500 maf. The potential limit is about 1,200 maf, but the costs for the remaining potential are high because low-cost sites have been used. Environmental concern may rule out some sites. Recharge of ground water is used to a limited extent to store runoff.

Selected Conversion Factors

Multiply	*by*	*To obtain*
inches	0.0254	meters
inches	25.4000	millimeters
acres	0.405	hectares
billion gallons per day (bgd)	1,120.0000	thousand acre-feet per year
	1.3820	billion cubic meters per year
million gallons per day (mgd)	1.1200	thousand acre-feet per year
	1.3820	million cubic meters per year
acre-inch	102.8000	cubic meters
acre-feet	1,233.5000	cubic meters
million acre-feet (maf)	1.2335	billion cubic meters

Average Annual Runoff Volumes In Western Water Resources Regions Where Supplies Are Limited

Region	*bgd*	*maf/year*
Pacific Northwest	255.3	286.0
California	47.4	53.1
Upper Colorado	10.0	11.2
Lower Colorado	1.6	1.8
Missouri	44.1	49.4
Arkansas-White-Red	62.6	70.1
Rio Grande	1.2	1.3

Ground-Water Supplies

Ground water is also a major source of water in the United States. Ground water and surface water often are interconnected and must be considered conjunctively in projecting long-term water withdrawal and consumption.

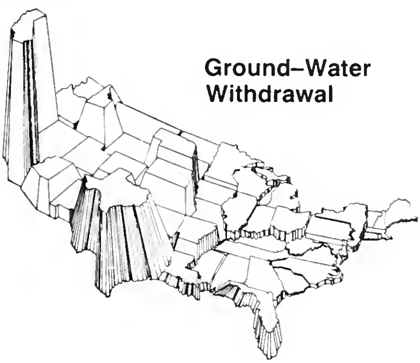
Some ground-water supplies are very large, and except for increasing costs of pumping, they can provide water supplies for many decades. Ground-water storage is especially important in arid and semiarid areas because water can be stored for decades with little or no evaporation loss.

The major disadvantage of ground-water storage is that water must be pumped to be recovered. This disadvantage is offset by the ability to extract water at the point of use. Major expansion of irrigation since 1944 has occurred in those States that have economically attainable ground-water supplies. For example, water storage in the Ogallala aquifer under Nebraska is estimated to be about 2,100 maf.

California and Texas are the two largest users of ground water, accounting for 37 percent of the Nation's total. Nebraska, Idaho, Kansas and Arizona account for an additional 26 percent. Much of the U.S. ground water is being mined. This means that withdrawal exceeds the net natural recharge, that is, the natural recharge less undiverted natural discharge. Major areas of ground-water mining are in the southern Great Plains (Ogallala aquifer) and in Arizona.

In 1980, Arizona passed a Ground-water Management Act which provides for a State-managed reduction in the percentage of water used by agriculture. The goal is to achieve a balance between ground-water withdrawal and recharge by the year 2025 in several major problem areas.

Relative withdrawal of ground water



Water Requirements

The average person in a temperate climate requires 5 to 6 pints of water to replace daily losses in perspiration, exhalation and excretion. About 3 pints are taken in by fluids and the rest is taken in by food or produced in the body by oxidation of food. This amount is insignificant compared to the average amount of 183 gallons per day delivered per person for home use—washing, cleaning, and lawn watering—and very small compared to the 38 gallons per day consumed per person for these uses.

Water requirements for livestock are variable depending on the type of feed available and, for milk cows, on the amount of milk produced. Range cattle may drink 4 to 8 gallons per day, but high producing milk cows drink up to 25 gallons per day.

Plants lose water to the atmosphere by transpiration as their stomates open in sunlight to absorb carbon dioxide during photosynthesis. Internal plant cells must be covered by a water film to absorb carbon dioxide, and water evaporates from these cells and diffuses through the stomates into the atmosphere.

The rate of transpiration depends primarily on the heat energy received from solar radiation and, in arid areas, on heat energy received from both solar radiation and warm, dry air. Very little water is stored in plant tissue at any time compared to that transpired during the growing season.

In addition to transpiration, water evaporates from the soil. The two processes are not independent and we usually consider them as a combined process called evapotranspiration (ET).

Needs of Green Crops

During a clear, warm summer day a well-watered green crop will consume water equivalent to a depth of about 0.25 inch in moderate climates and 0.4 inch or more in warm, arid climates. The amount of water consumed by a crop from planting to harvest varies with the length of the growing season, the climate and available soil water.

The amount consumed by a

Harry W. Oneth

Livestock often get piped-in well water from specially constructed water storage tanks like this one on the Great Plains. Their water needs vary from 4 to 8 gallons a day for range cattle to 25 gallons a day for some milk cows.

crop like corn for the whole season may range from 500 to 1,000 pounds of water per pound of grain produced, depending on the yield per acre. More grain is produced per unit of water consumed as yield per acre increases.

Water requirements for industrial uses vary greatly. For some uses, water withdrawals are large, but water consumption is relatively low.

Water required for evaporative cooling of thermal-electric plants varies inversely with power plant efficiency. For example, a fossil-fueled plant operating at a thermal efficiency of 38 percent may consume 0.5 gallon of water per kilowatt-hour (kWh) of energy produced, or 15 acre-feet per year would be required per megawatt (MW) capacity. A geothermal plant operating at 14 percent efficiency would require 1.8 gallons/kWh or 48 acre-feet/MW capacity.

Water consumption for oil shale retorting ranges from 5,000 to 8,000 acre-feet annually for a 50,000-barrel per day retort plant. For coal gasification it is about 7,500 acre-feet per year for a 250 million standard cubic feet per day gas plant. Most of this water is required for evaporative cooling.

Other Water Needs

Freshwater withdrawals for manufacturing vary widely with the process and are projected to decrease as plant technology improves and as more water is recycled within plants. Freshwater consumption for manufacturing is projected to increase, however.

Wetland water needs are similar to evaporative losses per unit area of reservoirs where these water bodies do not freeze. Where water surfaces freeze, they would have about the same consumptive use per acre as a crop like alfalfa.

Animals may require water only once a day and, depending on their food supplies, some animals can survive for days without water. Plants are different. Because most crop plants have little or no internal storage capacity for water, they must absorb water from the soil essentially as fast as they lose it. Otherwise growth of plants slows or stops, and unless water becomes available, they die.

The amount of available water that can be stored in soil depends on its texture (sandy soils store very little water), plant rooting characteristics, and the depth of soil that roots can penetrate.

A deep-rooted crop grown on a deep, fine-textured soil may not need rain or irrigation more often than every three weeks. Shallow-rooted crops grown on a sandy soil may need rainfall or irrigation as often as every five days for high yields. This is why irrigation is needed on the sandy soils of humid areas in Georgia and Florida. In arid areas, with essentially no summer rain, almost all the water that crops use must be provided by irrigation.

Water Use

Water use in the United States has increased steadily during the past 30 years. Most reports of U.S. water use refer to water withdrawal from both surface and ground-water supplies for various uses. Freshwater is classified as water containing less than 1,000 parts per million of salts.

In 1980, about 23 percent of water withdrawals came from ground water. The balance was from surface supplies. About 91 percent of the total water withdrawn for irrigation was in the West, and California accounted for 25 percent. Irrigation accounted for 81 percent of total water consumption in the Nation.

Use of precipitation by evapotranspiration (ET) in producing food and fiber on nonirrigated crop and pasture lands exceeds ET of water applied by irrigation by a factor of 12.

Freshwater Withdrawals For Offstream Use and Consumption For Various Uses in 1980

Use	*Withdrawals* (maf)	*Consumption* (maf)
Public-supplied fresh water	38.0	7.1
Rural domestic and livestock	6.3	3.9
Irrigation	170.0	93.0
Self-supplied industrial:	210.0	8.2
Total	424.0	112.0

Although the water needed for consumption per person is less than 1 gallon per day, the per capita withdrawal for public use in 1980 was 183 gallons per day and the per capita consumption for all domestic uses was 38 gallons per day.

Future Freshwater Supplies

Over the long term, water demand and consumption must nearly equal the renewable annual water supply. To achieve this balance in the West, irrigated agriculture—the largest user of water supplies—will need to reduce its consumptive demand about 20 percent as available water supplies decrease.

Water supplies for agriculture will decrease as ground-water mining depletes water supplies in some areas and as competition for water by other users increases.

Agriculture will partially offset the loss of freshwater by reusing moderately saline drainage water; reducing surface runoff in downstream irrigation projects; developing mildly saline or brackish ground water for irrigation; and by reusing waste effluents from food processing, industrial plants and municipalities.

In some arid areas, freshwater supplies will be increased by reducing water consumed by low-value riparian vegetation as the value of water increases. Conveyance systems will be improved to reduce seepage in those areas where much of the seepage does not return to river systems for

Tim McCabe

Control of salinity is a major problem facing irrigated agriculture in the West. A USDA technician in California examines land on which productivity has been seriously damaged by salinity.

reuse downstream or recharge ground-water aquifers.

Increasing the importation of water from water-surplus regions to water-short regions is unlikely in the near future because of the high cost of delivering water. Two major factors are energy costs for pumping water from rivers 1,200 to 1,500 feet in altitude to land situated 3,500 to 4,000 feet above sea level, and conveyance costs.

Controlling Salinity

In the future, water quality must be managed as well as water supplies for maximum public benefit. Control of salinity is a major problem facing irrigated agriculture in the West.

Salinity of water in rivers and reservoirs increases naturally as salts are concentrated by evaporation from water surfaces and ET from agricultural, forest and range lands, low-economic riparian vegetation along rivers, and wet wildlife habitats.

In some areas of the Upper Colorado Water Resources Region, soils are underlain by geologic formations that contain crystalline salts. When excessive irrigation water is applied in those areas, it percolates through the high salt substrata, greatly increasing the salt load as the excess flow returns to the river. Increasing irrigation efficiency in these areas could decrease salt loading in proportion to the reduction in deep percolation.

In addition to the adverse effects of total salinity, some specific ions such as boron and chloride are toxic to plants. For example, some plants are sensitive to more than four parts per million of boron.

Because of recent control efforts, surface water quality is no longer deteriorating despite increases in population and the gross national product.

Ground-Water Problems

Ground-water contamination from toxic organic and inorganic chemicals has become a major worry. Detection of contamination from synthetic organic chemicals is of special concern because soil and rock do not filter out these chemicals and they are not degraded biologically. Once contaminated, ground water may remain so indefinitely.

Regions with extensive manufacturing and high population densities have the largest impacts on ground water. A high proportion of industrial landfills contaminate ground water. Discharges from septic tanks and cesspools often contaminate private wells.

In rivers and streams, contamination by heavy metals is the most widely reported toxic substance. Pollution by pesticides also is a serious problem, especially in warm, intensively farmed areas.

The water quality of lakes is largely determined by the quality of feeder streams, disposal of wastes, and local land use practices.

Acid Rain Affects Lakes

Airborne pollutants also affect lake-water quality and are difficult to control. For example, acid rain currently affects lakes over much of the Northeast and part of Canada and the sources of the pollutants are widely dispersed.

Water in all Water Resources Regions is degraded with use, and additions of various materials have different effects. To cite some examples: Bacterial contamination can make water unsafe for domestic use, recreation and shellfish harvesting. Oxygen depletion can kill fish. Nutrients such as nitrogen and phosphorus can stimulate nuisance growths of algae and other aquatic plants in lakes, reservoirs and canals. Nitrates are toxic in high concentrations. And excessive erosion resulting in high concentrations of suspended solids can damage or destroy aquatic organisms and habitats through sedimentation.

High nutrient concentrations occur in waters in Midwest farming areas and in urban industrialized parts of the Northeast and Great Lakes regions. Improved farming practices will significantly reduce pollution from agricultural lands.

Farm Use Efficiency

During the past several decades, we have learned how to increase water use efficiency in agriculture by increasing production per unit of water consumed. This has been accomplished by:

1) Managing crop residues to increase infiltration of precipitation and reduce evaporation from the soil

2) Reducing runoff from non-irrigated croplands

3) Managing snow on croplands to increase water storage in the soil

4) Providing adequate plant nutrition for plants so they use water more efficiently

5) Applying limited irrigation at critical stages of crop growth when rainfall is inadequate to complete the growth cycle

6) Using pipelines and lined canals to reduce seepage losses

7) Using irrigation systems that apply water more uniformly and in limited amounts

8) Scheduling irrigations to reduce excess water applications and avoid water stress in plants; and

9) Preventing overdrainage of agricultural lands.

Similarly, others have increased their water use efficiencies. Not all improved technologies are being utilized yet because of economic and other constraints. Overcoming these constraints is one of our future challenges. Another challenge is to explore developing totally new concepts of managing water resources to optimize the benefits for the entire population.

Further Reading

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Climate—A Key Natural Resource Often Overlooked in Agriculture

By James E. Newman and Robert F. Dale

Climate is often defined as average weather. But this rather trite statement becomes inadequate when one considers that average weather does not explain the variability in climate. Climate is more adequately described as a composite of weather conditions over a period of time.

It is a standard practice to relate climate in terms of statistical "Norms". But normal values do not adequately define the climatic risk. The frequency of occurrences among the various weather elements provides a more complete understanding of climate.

As a natural resource, climate is often overlooked in agricultural planning. Some reasons for this lack of concern are:

1) Climate, as a composite of weather events over a period of time, is very abstract,

2) It is not fixed in time and space like most other natural resource considerations, and

3) Climate is often viewed as given and uncontrollable, therefore nothing can be done anyway.

These erroneous views produce a lack of appreciation for climate information and its use in decisionmaking. This lack of use has in turn led to a lack of development in needed climatological data, their acquisition and analysis, in agricultural planning over the past several decades.

As a result, much of the current soil erosion, flood damage and land management problems in agriculture are traceable, in

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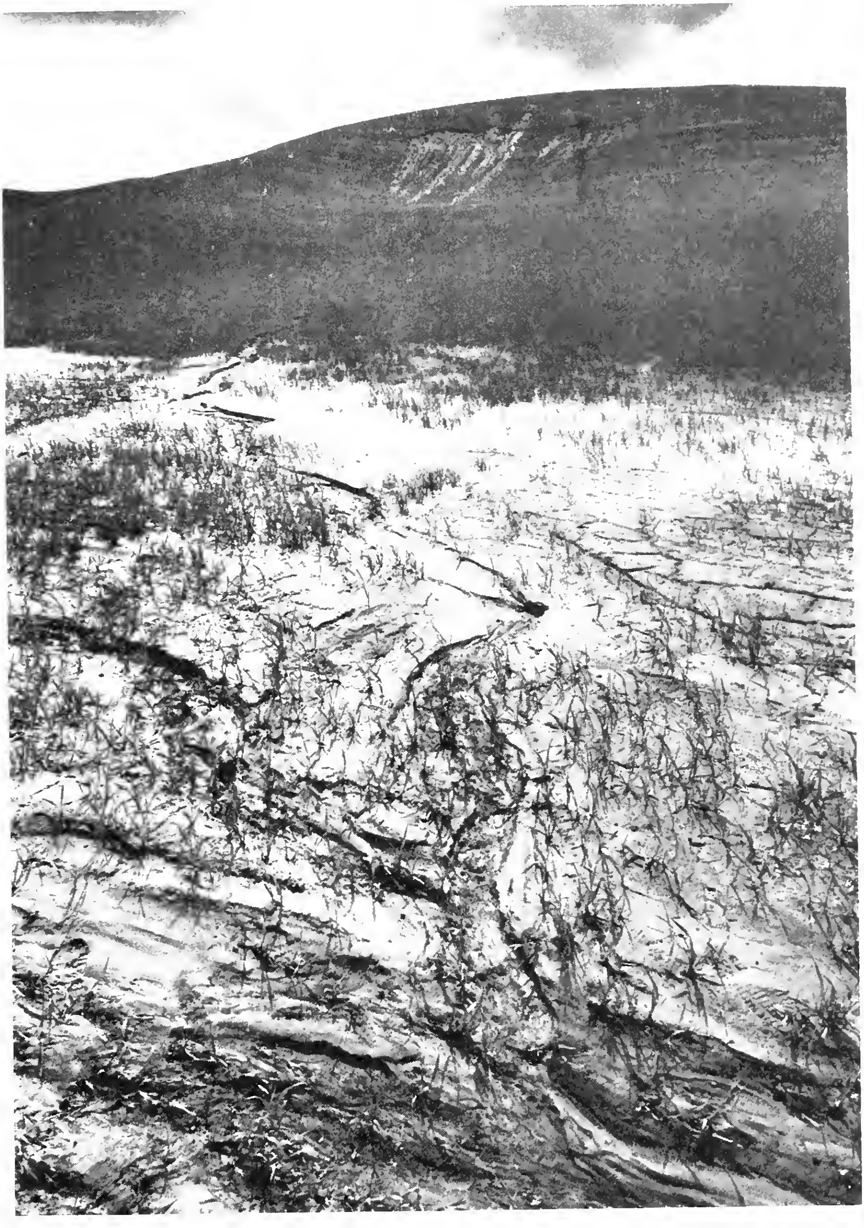


Much of the current soil erosion and flood damage in agriculture can be traced to a lack of understanding of climate as a manageable resource.

part, to lack of appreciation and understanding of climate as a manageable resource. The omission of climate information needs to be corrected in future agricultural systems planning.

U.S. Climatic Diversity

An understanding of climate as a natural resource can be gained from examining the general climates in major food crop production regions of the world. The ten largest volume food crops, as well as almost all other crops, are adapted to certain latitude ranges and general climatic conditions.

Ten Major World Food Crops
(Source: U.N.-FAO 1980)

Crop	*Climate type (dryland or rain-fed croppings)*	*Latitudinal Range*
Wheat	temperate humid, subhumid to semiarid	25° to 55°
Rice	tropical-subtropical humid	0° to 45°
Maize (Corn)	tropical-warm temperate humid	0° to 45°
Potato	cool temperate	30° to 60°
Barley	cool temperate	35° to 65°
Sweet Potato	subtropical to warm temperate	25° to 40°
Cassava	humid tropical	0° to 30°
Soybeans	subtropical to warm temperate	25° to 45°
Sorghum	semiarid tropics to semiarid warm temperate	0° to 40°
Sugarcane	humid tropics	0° to 30°

Botanically, six of these ten major food crops are members of the grass family. They are wheat, rice, maize (corn), barley, sorghum and sugarcane. Five of the crops produce most of the world's food and feed grains, sugarcane being the only grass family crop not grown for grain production. Of the four remaining major food crops, three are staple root crops—potatoes, cassavas and sweet potatoes—and one is an oilseed-protein crop, soybeans. When grown under dryland or rain-fed cropping practices, all of these crops have some rather specific climatic *resource* requirements.

Eight out of ten of these world food and feed crops are successfully grown within the continental limits of the 48 contiguous States. Crops requiring true tropical climates, such as sugarcane and cassava, are not extensively grown within the contiguous States. But true tropical climates do exist in Hawaii and Puerto Rico. As a result, climatic resources of the 50 States and Puerto Rico are diverse enough to contain almost all crop-producing climates in the world.

These extensive and diverse crop-producing climatic resources are a central reason why the United States leads the world in food and feed production.

Crop Belts and Climate

A number of regions within the continental limits of the United States are named for their dominant topographic fea-

Five grass family crops — wheat, barley (shown here), rice, maize, and sorghum—produce most of the world's feed and food grains.

tures and associated climatic conditions. Some of these regional labels are used in reporting weather crop-climate conditions.

These general topographic features and associated climates frequently determine the principal crops and cropping systems within a geographical area. This is particularly true for dryland (rain-fed or nonirrigated) cropping systems.

Within the continental United States, several geographical areas are devoted to growing one or two crops. These agricultural patterns or systems are known as "crop belts." Some examples are the Cotton Belt, Corn Belt, Spring Wheat Belt and Winter Wheat Belt.

Climate is usually the dominant natural resource which determines these principal crop production belts. An example of climate as the leading resource is the high latitude spring grain producing area in the United States, Canada and around the entire world. These spring grain belts of wheat, barley and oats are adapted to the high latitude subhumid temperate climates.

On a worldwide basis, the areas are known as cool-temperate grasslands. Spring grain production dominates these geographical areas largely because their annual growth cycle and grain-filling period climatic requirements are met in most years, while requirements of other possible competitive crops are not met in many years.

Grasslands Unique

The mid latitude cool-temperate grassland areas are unique the world over in their annual distribution of precipitation, temperature and solar energy. These climatic elements maximize in phase during late spring or early summer.

Precipitation usually reaches its annual maximum in late May, June and early July. Temperature reaches maximum levels in July and early August. Sunlight energy peaks in late June and early July during the longest days of the year.

Bismark, N. Dak., typifies the spring grain belt of the United States and Canada. The spring grain-cropping areas of North America normally receive between 12 and 18 inches of annual precipitation. Bismark receives an annual average of 16 inches. But the important feature from a climatic resource viewpoint is the annual distribution of precipitation. Over 60 percent occurs in the 3 months of May, June and July.

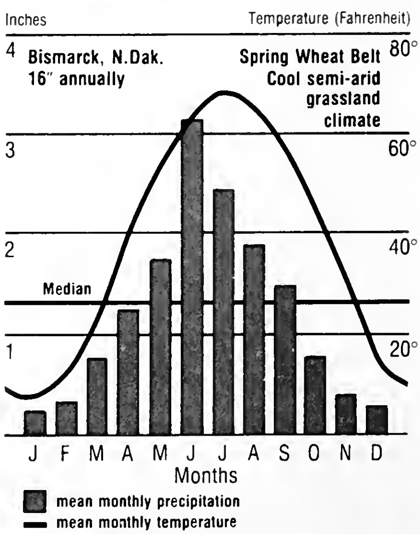
During this same period spring grain crops are growing rapidly, and crop water use in the form of evapotranspiration is greatest. As a result, the seasonal distribution of precipitation is in phase with annual spring grain crop needs.

The fact that precipitation, temperature and sunlight all reach their annual maximum values during the growth and grain-producing season of these annual spring grain crops is the key point of this unique climatic resource.

Winter Grain Areas

The winter grain crops of wheat, rye, barley and oats are grown in the lower mid latitude grassland climates in all conti-

Annual Distribution of Mean Monthly Precipitation and Temperature, 1921-70

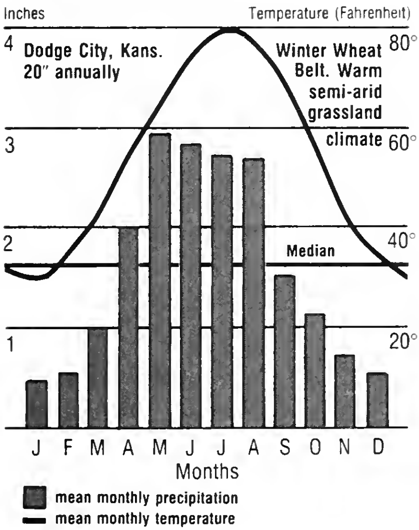


nents. In the United States, the hard red winter wheat belt lies in the southern half of the Great Plains from Nebraska to Texas.

Climatic resource features of these grassland winter grain areas are roughly similar to the higher latitude spring grain areas of the northern Great Plains. But there are some differences.

In the winter grain belts the warm season precipitation begins to increase about a month or more earlier. The mean annual maximum period occurs in late May or early June. Therefore, the growing season distribution of precipitation is about a month earlier in the winter grain areas when compared to those in the spring grain areas.

Annual Distribution of Mean Monthly Precipitation and Temperature, 1921-70



The mean monthly air temperatures are 5° to 10° F warmer during the warmest 6 months of the year in these winter grain areas. But there is a 10° to 20° or more difference between the spring and winter grain areas during the winter months within the Great Plains of North America. In fact the geographical division between spring grain and winter grain cropping belts of both the North American and Eurasian continents is determined largely by winter seasonal minimum air temperatures and snow cover.

More Research Needed

The critical overwintering tillering node temperature at 1 to 2 inches below the soil surface is near 3° F for winter wheat. As a general rule the ground must lack snow cover and the air temperature must drop to about −7° to produce this critical or lethal temperature at the living tillering nodes at 1 to 2 inches under the soil surface. When snow cover exists, the seasonal minimum air temperatures must drop below −7° to produce a lethal temperature at the overwintering tillering nodes.

The lethal temperature of overwintering tillering nodes among winter grains varies slightly between species and varieties within species, but this is an example of the specific relationships within seasonal climate conditions which determine crop adaptation. It is these specific crop-weather-climate relationships and their frequency of occurrence which need more research emphasis in the future.

Normally, winter grains will outyield spring grains in these grassland climates. Therefore, farmers are willing to take some climatic risk of crop failure in favor of growing winter grains rather than spring grains.

In the Great Plains of the United States, the transition from winter grains to spring grains occurs in northern Nebraska and southern South Dakota. This transitional area has a climatic risk of a winter grain crop failure due to winter kill of about 20 to 25 percent, or 1 year in 4 or 5. Winter kill in these transitional areas is caused by the normally dry winters with lack of snow cover and low winter minimum air temperatures.

Corn Belt Uniformity

The Corn Belt of the North Central United States is the most valuable and extensive rain-fed cropland area in the world. It covers the three States of Iowa, Illinois and Indiana completely, plus large portions of the nine surrounding States. Much of the value of this vast mid-continental cropland comes from its climate resource. On an annual basis the climate over the Corn Belt varies from subhumid tallgrass prairie in the western portions to a humid deciduous forest climate in the eastern portions.

From North to South it is a transition climate from a continental cool temperate to a continental warm temperate. The U.S. Corn Belt climate varies considerably when analyzed on an annual basis. But the uniqueness of that climate occurs during the crop-growing season. The precipitation amounts and temperature levels are amazingly uniform over the entire area from May through September.

Normal growing season rainfall during these 5 months is about 20 inches. This occurs with high frequency in both western and eastern portions. Des Moines, in central Iowa, receives an average of about 30 inches annually, but over 65 percent occurs during the warmest half of the year from April through September. At Indianapolis, Ind., the warmest 7 months from March through September are all above the median. The annual seasonal maximum precipitation occurs in late May and early June at both locations.

The annual temperature change characteristics are slightly more continental in western portions of the Corn Belt. This means the winter temperatures are a little colder and the summer a little warmer in western than in eastern portions.

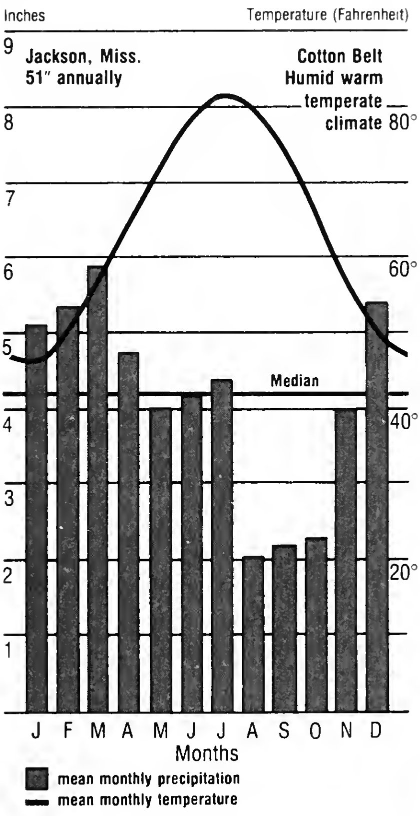
There are more days above 90° F in the western areas, primarily because of less carryover soil moisture from dry winters and hot dry winds from the High Plains in the West. Except for higher hail frequency in the western portion, most other forms of climatic risks are exceptionally uniform across the

Corn Belt during the growing season.

Dryland Cotton

Dryland or rain-fed cotton is grown in most of the Southern and Southeastern States. The main dryland cotton belt begins in east Texas and continues eastward across the States of Louisiana, Mississippi, Alabama, Georgia and South Carolina.

Annual Distribution of Mean Monthly Precipitation and Temperature, 1921-70



Lesser acreages of cotton are grown in several other Southern States. The climate varies from warm temperate subhumid in eastern Texas to warm temperate humid climate in the States further east.

Annual distribution of mean monthly precipitation and temperature at Jackson, Miss., provides a good example of the dryland cotton belt climate of the southern continental United States. Nearly 60 percent of the annual precipitation normally occurs from November through April. The Cotton Belt usually experiences wet winters which extend well into the early spring planting season. The late summer and early fall months of August, September and October are usually the driest period of the year.

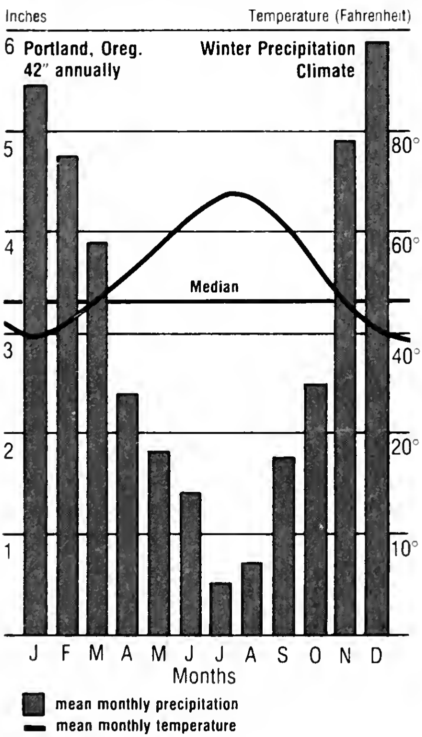
On an annual basis the U.S. Cotton Belt has a humid warm temperate climate, but the annual distribution of precipitation is somewhat out-of-phase with the summer crop-growing seasonal water demands. This is particularly true for cotton.

Driest months occur in late summer and early fall toward the end of a long annual growing season. This explains why much of the dryland summer crop production in the South and Southeastern States experience drought in a high percentage of the years within a humid climate. The annual precipitation distribution, along with soil resources having limited water-retention capacities, produce crop water stress in most years.

West Coastal States

The West Coastal States of Washington, Oregon and California are dominated by the winter precipitation climates. Worldwide, these climates are known as the Mediterranean type. They are characterized by wet winters and dry summers. This type of climatic resource is illustrated by Portland, Oreg. Nearly 30 inches of the normal 42 inches of annual precipitation occurs during the coldest half of the year.

Annual Distribution of Mean Monthly Precipitation and Temperature, 1921-70



Annual winter grain crops and many perennial forage and tree crops are well adapted to these wet winter—dry summer climates. The well-adapted winter annual crops are planted in fall, become dormant in winter due to low temperatures, then complete their growth and reproduction phases before onset of the dry summer. Many perennial forage crops are well adapted to these climates for the same reasons. Forests and perennial tree crops can adapt or survive summer dry climates that are not too hot or too long.

These climates are well suited for irrigated agriculture. The low winter temperatures and relatively high effective precipitation produces water surpluses during the winter season. Therefore, management of stored water is necessary during the annual summer growing season.

Irrigation in these climates makes it possible to bring the surplus winter seasonal precipitation in phase with the summer seasonal temperatures and solar energy. That is why irrigated agriculture is so productive in these warm temperate and subtropical Mediterranean climates the world over.

Intermountain Areas

The intermountain regions of the western United States are dominated by a complex of cool semiarid climates in the northern and central portions and arid desert climates in the southern areas. These climatic areas exist largely because of the effect of mountain ranges to the west and east of the region.

The Coastal and Sierra ranges to the west block sources of winter seasonal precipitation from the west, and the Rockies to the east are a barrier to the source of the grassland summer seasonal precipitation from the east. As a result, the dryland agriculture of this intermountain region is largely confined to open range grazing.

The climatic record of Salt Lake City, Utah, provides a good example of these intermountain rangeland climates. The annual precipitation distribution reflects some of the Pacific Coast wet winter climates to the west as well as some lesser influences from the summer maximum precipitation climates to the east.

Irrigated croplands have been developed in many areas where water can be made available through water storage and management. Many different crops are grown with irrigation under highly varied growing season temperature zones in the intermountain regions. These varied growing season temperature conditions are caused by both elevation and latitude throughout the region.

Northeast Forest Climates

Climatic conditions leading to forest vegetation of the Northeastern United States approach the ideal from the standpoint of annual and perennial crop moisture needed.

Mean monthly precipitation and temperature distributions are closely in phase with seasonal crop and forest growth. The highest mean monthly precipitation normally occurs in midsummer when crop and forest water demands are highest. A good example of these cool temperate humid forest climates of the northeast region is Albany, N.Y.

These climates exist from the upper Ohio Valley eastward across Pennsylvania into New Jersey, then northward through New York and the New England States. The northeast forest climates are characterized by a rather uniform mean monthly distribution of precipitation, with the highest amounts com-

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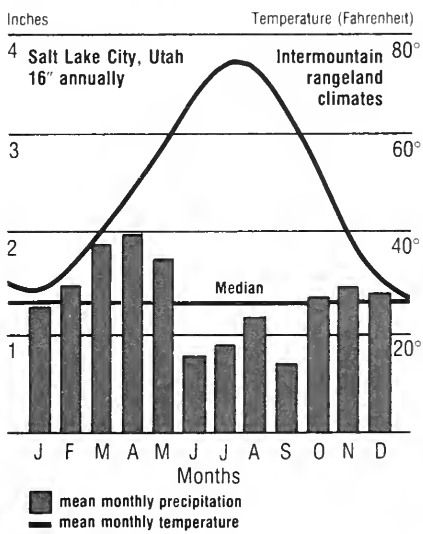
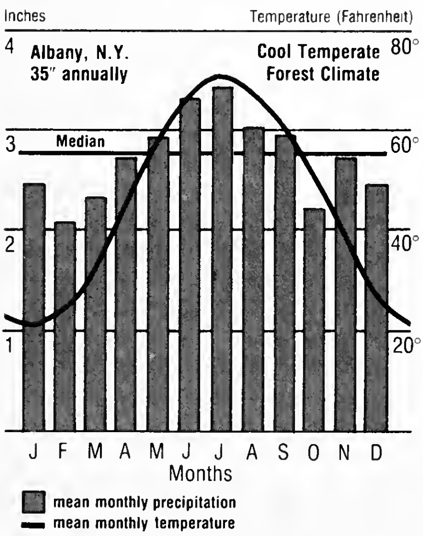


ing in midsummer in phase with the highest mean monthly temperature and evaporation.

Driest months of the year are February and October. The fact that the lowest annual mean monthly precipitation months do not occur consecutively is another unique feature of these climates. This is particularly true for large geographical regions.

Unfortunately, water supply systems in climates with relatively uniform and dependable precipitation are often underdesigned and overcommitted. As a result, when the inevitable drought occurs an acute water shortage develops. This has happened repeatedly in the densely populated northeast United States.

Annual Distribution of Mean Monthly Precipitation and Temperature, 1921-70



There are other unique climate regions within the continental United States, such as the Great Lakes region and those areas surrounding the Gulf of Mexico.

Great Lakes Region

Climate in and around the Great Lakes can best be described as humid and cool with snowy winters and cool pleasant summers. Annual precipitation is rather evenly distributed during the year.

Many small-scale climates exist in land areas surrounding the Great Lakes. There are several snow belts, fruit belts and other special small-scale climatic areas within the Great Lakes region, which are utilized to produce particular fruit or vegetable crops.

Land areas surrounding the Gulf of Mexico are known as the Gulf Coast Region. The climate varies from humid warm temperate to humid subtropical. The frost-free crop growing season is 300 days or more in most of this region. Crops requiring long growing seasons such as sugarcane, cotton, and rice are produced.

The peninsular State of Florida is dominated by humid tropical, subtropical and warm temperate climates. The main crops are citrus, winter vegetables and sugarcane in the tropical and subtropical areas. The northern humid warm temperate areas are devoted to several special crops and cattle grazing.

Low desert areas of Arizona and California produce a number of tropical and subtropical crops requiring frost-free climates. Almost all crop production is under irrigation in these southwestern desert climates.

Climatic Niches

The large subcontinental land areas of Alaska has a variety of high latitude climates. They range from true Arctic to subarctic and cool marine climates. The agricultural worth of these high latitude climates is limited to certain climatic niches within this huge State.

Much of the true agricultural potential of Alaskan climate resources have not yet been exploited because of a mix of transportation, labor and energy cost considerations.

A wide diversity of crops are grown within the limits of the 50 States and Puerto Rico. Many of these crops require special climatic niches within the larger or more general climate type briefly discussed here. Some examples are pineapple, cranberries, tobacco, peanuts, and grapes.

These numerous climatic niches within the 50 States add much to the agricultural worth of the United States. Therefore, continued assessment of our collective climatic resources are of great economic value to all U.S. citizens.

'User Friendly' Systems

Widespread practical employment of climatic data in agriculture will come when the data are readily available in a usable format for analysis.

The dynamic and statistical nature of climate makes it difficult to provide summaries that will answer the many ongoing strategic and tactical questions involved in management decisions. This is true for every level within the agricultural industry, from the basic farm unit to international marketing questions. The answer to these many climate resource management questions lies in data base availability and analysis.

There are at least three primary matters to be solved in data base management for widespread application purposes:

1) Data must be made available to the potential user through electronic computers with systems of access that are "user friendly." This demands compatible software development plus their availability to the potential user.

2) There must be a uniform geographic information system consisting of two parts: A, common geographic districts of climate and associated agricultural statistics, and B, a geographic grid system for finer interpolation of results.

3) The needed climate and weather measurements must be observed at representative locations and exposures with sufficient frequency to allow time and geographic interpolative analysis.

These essential matters have not been addressed adequately and collectively in an operational service mode for agriculture.

Most climatological data in the

United States are collected and documented by the National Oceanic and Atmospheric Administration (NOAA), Environmental Data and Information Service (EDIS) now in the U.S. Department of Commerce (USDC), but much of this work was done in the U.S. Department of Agriculture (USDA) from 1891 to 1941.

Largest generator of climate data is another government agency within NOAA, the National Weather Service (NWS). In addition, other Federal, State, and local agencies generate climatological data. They include the Federal Aviation Administration, several services within USDA, the U.S. Department of the Interior, and the Environmental Protection Agency.

The 'A' Network

The climatological data needs of agriculture require a rather uniform geographic distribution density of reporting stations. The 2,000 plus stations, known as the climatological "A" network, best meet this need. These stations are managed by NWS and published by EDIS within NOAA. They are summarized individually and by State climatic divisions.

USDA's Statistical Reporting Service is the agency charged with securing statistics on agricultural production throughout the Nation. This is done through a system of Federal offices located in each State.

These State offices conduct numerous information surveys during the year. The surveys are timed to develop statistics concerning agricultural production or production potential in each crop reporting district in each State.

The crop reporting districts (CRD) and the climatic divisions (CD) are geographically consistent in some States, but they are not in others. Since weather is the most important uncontrolled variable in agricultural production, a possible first step in improving agricultural and climatological data base management would be making these CRD's and CD's compatible geographically.

Existing Data Inadequate

Data base availability is necessary for any analysis of climate resources. The biological systems of agricultural production respond to several measurable weather variables not generally available in existing observational networks. Further, the current approach of using existing weather and climate data for agricultural purposes will usually result in inadequate data bases.

This is true for two reasons:

1) Most of the existing weather and climate data now available to agriculture are taken primarily for other purposes, and

2) Advancements in the atmospheric sciences applied to agriculture too often are not used because the necessary operational agro weather and climate station networks and resulting data bases do not exist.

These matters must be addressed on a local, State and national scale before adequate data base development can take place for agricultural purposes.

The vast majority of stations in the climatological "A" network observe only daily maximum and minimum temperatures and precipitation. Further, most of these stations are nonreporting. This means the observer records the observations daily and mails them once monthly, making them unavailable for several weeks to months after the observation.

Daily, Hourly Needs

Computerized models addressing agricultural production systems often demand an expanded weather and climate data base in near real-time. This usually means daily reporting if used in an operational mode.

Further, many crop, livestock, and pest management computerized systems require both daily and hourly values reported for air temperature, atmospheric humidity, precipitation, solar or net radiation, evaporation, dew or surface wetting duration, and windflow.

Special soil, crop, livestock and pest data are needed at various seasons during the year. Soil measurements include soil temperature, freezing depths, soil moisture levels, depth of perched soil water tables, water runoff and water storage.

Seasonal timely observations of crops, pests, and livestock are necessary for the practical use of weather and climate information. Currently these observations may be recorded, but only in a fragmented way without any network standards. That makes it difficult to develop an adequate data base for management decision purposes.

The collective agricultural interests within the United States cannot continue to expect that agricultural weather and climatic research and service needs will be developed and sustained by NOAA.

There are several reasons for this. First, development of professional personnel requires academic training in both atmospheric and agricultural sciences. This is not likely to occur in the necessary numbers outside the schools or colleges of agriculture within the land-grant university system.

Second, the special agro-weather-climate station networks, the resulting data base management, and analysis systems are of primary value to those with agricultural or forestry interests. Therefore, it is not realistic for agricultural interests to expect institutions and enterprises outside agriculture to develop the necessary professional personnel, observational networks, and analysis systems for agriculture, forestry and other closely associated food and fiber interests.

In short, the research institutions and services, both private and public, outside agriculture really cannot address this massive task in a sustainable way.

Tundra to Tropics: Living Tapestry of Our Plant Communities

By John M. Safley, Jr., and Donald T. Pendleton

John M. Safley, Jr., and Donald T. Pendleton are in the Ecological Sciences Division, Soil Conservation Service.

The first Americans came from northeast Asia during the last Ice Age. Entering North America in the area of the Bering Strait, they encountered a continent untouched by human culture. The plant communities they saw were shaped by the environment—an environment that did not include humankind.

The land they occupied had meadows and steppe-tundra in the uplands. Shrub thickets grew on moist sites, and trees lined rivers and smaller streams. Grazing animals roamed in small herds across the land.

Although the millennium of their arrival is still in doubt, it is likely that those peoples arrived over 20,000 years ago. By 10,000 years ago, at the end of the Pleistocene epoch, human cultures were to be found over most of North America. These first American cultures had far-reaching impacts upon the native flora and fauna.

In contrast to the stone-and-bone technology of the first Americans, Europeans brought iron, steel, and the horse. These enabled those settlers to succeed, but not without significant alteration of the land. Clearing forests for settlements, farms, and wood products profoundly changed the landscape.

Later chapters will address uses to which the land and its resources have been put. This chapter will present a broad picture of the native vegetation encountered by European colonists. We shall show how these plant communities have mutual relationships among themselves and to the physical environment.

Habitat Factors

Plant communities consist of plants that are adapted to conditions of soil, climate, and topography. Some factors within these broad classes such as water, light, temperature, humidity, and soil fertility affect plants directly. Others, such as soil structure and slope aspect, tend to affect plants indirectly.

Each habitat has a different combination of environmental factors. Plants that tolerate a specific combination can survive in that habitat, depending upon their ability to compete for site resources. In a community, many individual plants of many species interact with their environment and with each other.

Plants produce material for their growth and survival by photosynthesis. This process of converting solar energy into chemical energy can also be called primary production. Net primary production is the amount of plant material stored or remaining as plant tissue after a plant has used what it needs for maintaining its life processes.

In general, plants require about 450 grams of water to produce one gram of dry matter. Thus, the abundance and distribution of precipitation are major factors controlling the distribution and abundance of plants.

Some plants are more efficient than others in extracting moisture from their environments. In general, trees require more moisture so they are associated with more humid areas. Many grasses and shrubs require less water and can grow in drier climates.

Evaporation, Change

Evaporation is also an important physical factor in determining the distribution of plants. It affects both the amount of water directly available for plants and the amount of water needed by plants. The ratio of precipitation to evaporation is quite important. Evaporation potential tends to increase from northern to southern latitudes; it also increases from higher to lower elevations.

Change occurs in all plant communities. Change in general is orderly and follows a trend from simplicity to complexity. This orderly change is called succession.

Early stages of succession are characterized by low species diversity and low biomass (plant matter). The ratio of gross production to biomass is high and production exceeds respiration. Energy is used by many individuals of a few species and production per unit is high. An ecosystem in the early stages of succession is very sensitive to disturbance.

In mature communities, there is a greater accumulation of biomass and, although production may be high, the ratio of gross production to biomass is low, and production equals respiration. There is an increase in biomass, stratification, complexity, and diversity of flora. Thus disturbance to one component does not have so serious an effect on the total system. These communities have a high degree of stability.

The Tundra Carpet

Tundra vegetation grows between the northern limit of trees and the region of perpetual snow and ice in the northernmost region of Alaska (arctic tundra). It occurs on mountains as far south as Mexico that have a timber line (alpine tundra).

Vegetation is low, dwarfed, and grows in a thin mat. In areas of more moderate climate, there is a high proportion of sedges and grasses and there are various heath species, broad-leaved herbs, lichens, and mosses. In areas where soil moisture is not limiting, shrub species are dominant. On wetter sites, there are sedge-dominated meadows and bogs.

In drier locations, and in the northernmost harsher environments, tundra vegetation is not continuous. In these areas, small variations in topography and exposure cause marked differences in vegetation in only a few feet. On the harshest sites, lichens are the only plant life.

Tundra looks like a carpet with its lack of tree-form vegetation. The number of species is small compared with temperate floras, and the number of species decreases markedly northward. The growing season is short and temperatures are low. Sunlight is continuous and intense throughout the arctic growing season and is high in ultraviolent light in alpine habitats.

Precipitation comes mostly as snow; permafrost and the depth to which it thaws in summer are important in determining available soil water. Summer winds produce high rates of drying and place the vegetation under considerable stress.

Two Types in Arctic

Arctic tundra communities are of two types, Low and High Arctic. The Low Arctic tundra occurs just north of the timberline and is characterized by low shrubs, predominantly willows and birches up to about three feet in height. The understory consists of dwarf heath species, cottongrass, many species of sedge, mosses and lichens, and a wide variety of herbs. Along rivers and streams, a tall shrub community dominated by alders, birches, and willows occurs; these species can grow up to 10 feet high.

The second type of Arctic tundra is the High Arctic. Along coastal areas and in areas of adequate soil moisture, this community resembles Low Arctic tundra. However, High Arctic tundra is more likely to resemble a semidesert. In drier, more severe climates, plants may occupy only 2 percent of the ground surface. In these areas, mosses and lichens predominate.

Alpine tundra occurs on mountains that are high enough to have a timberline. In the eastern United States, tundra occurs only on a few peaks in New England.

Alpine tundra in western mountains lies far south of the Arctic at high elevations. In Canada, alpine tundra occurs as low as 600 feet. Southward its lowest elevation increases about 360 feet per degree of latitude into lower California. In the Rocky Mountains, alpine tundra communities can be found between 10,000 and 14,000 feet.

Alpine tundra consists of sedges, grasses, and herbs. On wet sites these plants form a dense mat; on alpine boulder fields, plants occupy spaces between the rocks.

Productivity of all tundra communities is very low because of the cold temperatures, short growing season, and low soil fertility. Net primary production ranges from 900 to 3,600 pounds of dry weight per acre yearly. Production of some High Arctic communities is as low as 80 pounds an acre.

Because its productivity is low, tundra was not much used by humans in premodern times. In recent years, grazing by sheep and other livestock, oil exploration and extraction, agriculture, and recreational pursuits have contributed to a deterioration in tundra. Time required for regrowth and restoration of damaged tundra is measured in decades, not years.

Coniferous Forest

The boreal forest, a coniferous forest, forms the southern boundary of the Arctic Tundra. Its northern limit—the treeline—is irregular because of the effects of topography on microclimate.

Climate is generally less severe than that of the tundra; the growing season is cool and short (June through August). Annual precipitation averages between 1½ and 2 inches; because summer temperatures are cool (usually less than 86° F), evapotranspiration is low and there are many lakes and bogs.

Soils are thin where the region was glaciated. Along the boreal forest's southern boundary, soils are deep, having resulted from moraine deposits and glacial outwash. In its northernmost areas, soils may be permanently frozen.

Along its southern border, boreal forest blends subtly into the Hemlock-White Pine-Northern Hardwoods forests in the East. In south central Canada, the forest is dominated by aspen and coniferous stands which form the transition into grassland. In the West, it blends into the Rocky Mountain and northwest coastal coniferous forests.

Spruce and fir are the dominant species of this forest type. White spruce, black spruce, and balsam fir are common. Black spruce and larch are common in bogs in the southern part of the forest; in northern reaches these trees occupy drier, more exposed sites.

Reindeer Lichen

There are relatively few secondary, or subdominant, species in the boreal forest. Paper birch is one common subdominant. Most shrubs are either heaths or willows.

Reindeer lichen is the predominant lichen, as it is in the tundra. Sphagnum species are important in bog formation and succession.

As with tundra, net primary productivity for the boreal forest is low. Cool temperatures, short growing season, and low soil fertility limit production to only about 4,500 pounds of dry matter per acre yearly. During the growing season, however, daily net primary production rates are comparable to those of some temperate communities.

Montane coniferous forests are along the higher ridges and mountain crests of the Appalachian Mountains, and in similar situations in the Rocky Mountains and Cascade Mountains of the West. They are quite similar to the boreal forest in physical environment and in species and life forms as well.

In the Appalachians, the montane forest extends from New England to North Carolina and Tennessee. In its northern portion, it occurs at elevations from 2,600 to 4,000 feet. Southward from New England it occurs at ever higher elevations; at its southernmost limit it is found above 5,300 feet.

Along its range from north to south, red spruce replaces balsam fir as the dominant species. Subdominant species include birches, eastern hemlock, and various heaths, azaleas, and rhododendrons.

Range in Rockies

In the Rocky Mountains, montane forests occur from northern Alberta to New Mexico and from western South Dakota to central Utah. They are not continuous over this range, and where they do occur can be divided into upper and lower zones; each has an elevational range of about 2,100 feet.

The forests grade into subalpine communities upslope and deciduous forests downslope. They are dominated by Douglas-fir in the upper zone and ponderosa pine in the lower. Blue spruce and white fir grow in the southern Rockies on wetter sites. Ponderosa pine forests are open and park-like with a grassy ground cover of fescues, bluegrasses, and wheatgrasses.

In the Cascades and Sierra Nevadas, montane forests are narrowly distributed from British Columbia southward to California. Douglas-fir and white fir dominate the upper montane in the Cascades; Douglas-fir does not grow in upper montane forests in the Sierras.

Upslope this forest intergrades into a subalpine forest dominated by mountain hemlock and lodgepole pine. Downslope the upper montane grades into a ponderosa pine lower montane forest very similar to forests in the Rocky Mountains.

Frank M. Roadman

Montane forests of the Cascades and Sierra Nevadas are distributed from British Columbia to California.

Coastal Forest

The northwest coastal conifer forest parallels the Pacific Coast from Alaska to central California. It occurs from sea level to 5,000 feet and for distances up to 100 miles from the ocean. It also parallels the montane forest of the Sierra Nevadas and Cascades.

Its climate is temperate because of the moderating effect of the Pacific. Annual precipitation varies from about 28 inches to 100 inches. Humidity is always high, and heavy fogs provide much of the soil moisture during dry summer months.

In general, final dominants of this forest are grand fir, western hemlock, and western redcedar. Douglas-fir is the most widespread species; however, because of its intolerance to shade and its role in succession following fire, it is considered dominant on disturbed sites. North of Puget Sound, Sitka spruce is an important species.

The southern part of this forest is dominated by redwood. These giants occur in pure stands in areas of heavy coastal fog, especially coastal valleys and river bottoms in California.

From the semiarid regions of the southwestern United States northwest to the Great Basin (between the Rockies and the Sierras) and southward into Mexico, an association of pinyon pine and juniper species forms a widespread vegetation type of dwarf trees and large shrubs. It occupies the landscape between the ponderosa pine forests of the Rockies and the grasslands and deserts of lower elevations.

Pinyon-juniper stands generally grow in association with big sagebrush, bitterbrush, oak species, and other shrubs. Where the stands are more open, grasses such as bluegrama, indianricegrass, needlegrasses, wolftail, and muhlys often form a herbaceous ground cover.

Deciduous Forest

The deciduous forest of North America occurs in the eastern United States from the Great Lakes south to the Florida peninsula and westward to the Ozark Mountains. It extends about halfway down the Florida peninsula, where it merges with tropical flora. In the north it gradually blends into the boreal forest from Minnesota to Maine.

At its western limits, the deciduous forest grades into grassland as the climate becomes drier. The western boundary closely follows a line marking rainfall equal to 80 percent of evaporation potential. Fire has also played a role in maintaining this western limit.

Although the deciduous forest is extensive, it is far from uniform. The terrain varies, as do the principal species.

Where glaciers covered the northern section, the land is relatively flat; there are few sharp boundaries between forest associations here. The mountains in the east trend northeast to southwest; in this section, distinct boundaries generally exist between forest communities.

Productivity Varies

For all this diversity, there are some common and consistent environmental factors: Distinct seasons, the occurrence of frosts and/or freezes in winter, precipitation distributed throughout the year, and moderate- to long-growing seasons (from 140 to 365 frost-free days).

Net primary productivity of deciduous forests varies greatly. Because of their latitude, these forests tend to have a longer growing season than do most boreal forest associations. Soil moisture, exposure, and topographic position all influence productivity in forests and account for most of the variation in net production per acre.

Net primary productivity for these forest associations ranges from 3,600 pounds per acre to 22,500 pounds annually, or roughly twice the rate for the boreal forest.

The mixed mesophytic forest association occurs at the center of the forest throughout the Cumberland and Appalachian plateaus. It is the most diverse deciduous forest.

There are 25 to 30 species that may have climax status, depending upon topography, microclimate, and soil moisture. The most widespread dominants include sweet buckeye, American beech, several basswoods, and tuliptree.

Away from the central area, this forest type is increasingly restricted to specific habitats. To the south, it is in moist coves in the Appalachian and Unaka Mountains; to the west and east, it is in valleys. Toward Ohio, it is a mixed hardwood forest with fewer species.

Beech, Maple, Basswood

In the northward arm of the mixed mesophytic forest, both American beech and sugar maple increase in dominance. This beech-maple association occurs north and west of the Alleghenies from New York to Ohio into Wisconsin. Common species are red maple, elm, and black cherry. Forests of this association grow best in well-drained soils.

The maple-basswood association is the smallest of deciduous forests in extent. Its range includes southwestern Wisconsin, southeastern Minnesota, and northeastern Iowa. Beech is replaced by basswood; otherwise this forest differs very little from the beech-maple association.

The hemlock-hardwoods association, a transitional forest, lies between the boreal coniferous forests and deciduous forest. It extends from Nova Scotia through the Lake States to Minnesota. Across this range, hemlock stands are interspersed among hardwood stands.

Hardwood stands are dominated by sugar maple, American beech, birches, and aspen. Species associated with hemlocks include white pine and red pine. Bogs in the region support larch, white cedar, and black spruce.

Disturbance of the forest by fire or clearing initiates secondary succession, which typically ends in a white pine or aspen stand.

Oak, Chestnut, Hickory

The oak-chestnut association extends from New England to Georgia along the mountains. It retains the name chestnut even though chestnut blight has nearly eliminated American chestnut from the forest. Before the blight this forest was widespread on slopes and uplands east and southeast of the mixed mesophytic forest.

Because blight gradually killed the chestnut, associated species maintained their dominance.

The oak-hickory association is the most widespread of the deciduous forests because its species are drought-tolerant. It extends across much of the Piedmont Plateau and the Atlantic and Gulf States Coastal Plains to eastern Texas. From this area it is more or less continuous to Minnesota.

In its northwestern limit it becomes parklike. In Texas and Oklahoma, post oak and blackjack oak form open stands, known as the cross timbers, which mark the transition to grassland.

White oak, red oak, black oak, post oak, blackjack oak, mockernut hickory, bitternut hickory, and shagbark hickory are among the dominant species throughout the oak-hickory association. Beech, sugar maple, willow oak, and overcup oak are on moister sites. Subdominant species include flowering dogwood and sweetgum.

Old field succession typically passes through a pine stage before the hardwood climax forest is achieved.

Bottom Land, Fire-Swamp

Flood plain or bottom land forests occur throughout the deciduous forests. Those in the southern part of the deciduous forests are dominated by oak, baldcypress, and gums. Those of the northern deciduous forests are dominated by elms,

cottonwoods, and willows. The northern flood plain forests extend into the grasslands, forming what have been called "gallery forests."

The coastal plain of the eastern U.S. extends from Texas to New Jersey. In many places the soils are sandy and drainage is poor. Fire in dry seasons and the height of the water table in wet seasons are critical to plant community development in this region.

Forests of loblolly pine in the South and of pitch pine in the Mid-Atlantic States were and are maintained by fire; stands protected from fire are replaced by oak-hickory forest.

Undrained depressions form upland bogs, pocosins (swamps) and "Carolina bays" in which evergreen shrubs predominate. Permanent standing water in the lower coastal plain results in extensive marshes dominated by rushes and grass. Areas that are periodically flooded develop swamp forests dominated by gum and baldcypress.

Areas in the South influenced by salt spray and intermittent flooding have an evergreen variant of the oak-hickory association dominated by live oak.

Hugo Bryan

Periodically flooded areas of the eastern coastal plain are dominated by gum and cypress.

Truth About Deserts

Desert formations extend throughout much of western North America. The common conception of them is a dry, hot, and often dusty landscape in which there is little life.

While it is true that precipitation is low, temperatures can fluctuate widely and in the northern formations frosts can occur throughout the year. Strong winds and low relative humidity are characteristic too.

Dominant plants can survive long periods without rainfall through adaptations such as shedding leaves or storing water in their tissues.

There are two desert formations: The Cold Desert, which corresponds to the Great Basin area, and the Hot Desert, which occurs in the southwestern United States and extends into Mexico. Net primary production is low, ranging from 60 to 2,250 pounds per acre yearly in the Hot Desert. The wide variability is a function of rainfall.

The Cold Desert has two major plant communities. One, dominated by big sagebrush, is in the northern part or at higher elevations throughout. The other is dominated by shadscale (or salt desert shrub). Rainfall in this desert ranges from 4 to 12 inches per year.

Parts of the Hot Desert

The Hot Desert formation has three subunits: The Mojave, Chihuahuañ, and Sonoran deserts.

The Mojave, the smallest desert, extends from the southern tip of Nevada into adjacent California. Though vegetationally similar to the Great Basin, it is a transitional area to the Sonoran Desert farther south.

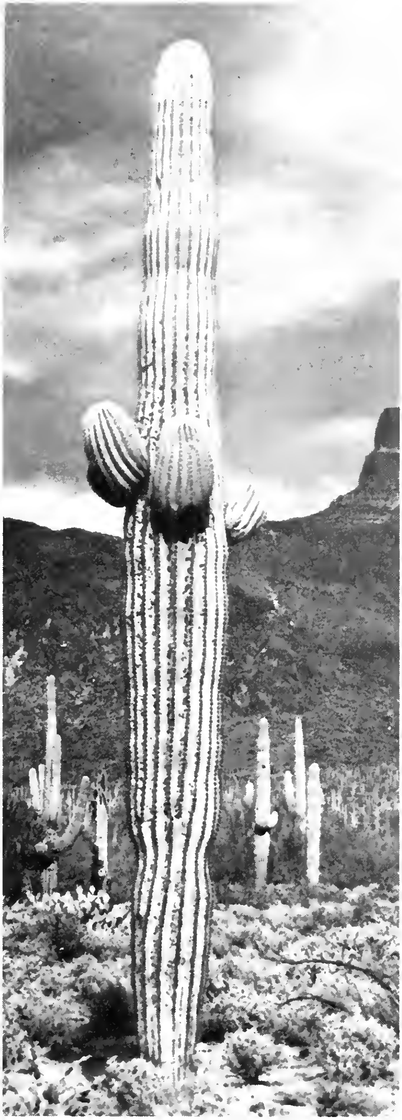
Precipitation, usually less than 10 inches annually, falls mainly in winter. Summers are very hot and dry; temperatures over 100° F are common. Joshua tree is important in areas of lesser elevation and rainfall.

The Sonoran Desert occurs in southeastern California eastward into Arizona and southward into Baja California. This lowland area (less than 3,000 feet in elevation) has level plains with some small mountains. Precipitation varies, ranging from about 2 inches in the west to about 28 inches in the mountains.

The Sonoran Desert is the most diverse of all North American deserts. Low plains there are dominated by creosote bush and bur sage, with palo verde and saguaro cactus becoming prevalent as elevation increases.

The Chihuahuañ Desert occurs at elevations from 4,000 to 6,100 feet from west Texas and southern New Mexico into Mexico. Rainfall comes mostly in summer and varies from 3 to 12 inches yearly; winter frosts do occur.

Many shrub species grow, as do a variety of succulents. Creosote bush, mesquite, ocotillo, and tarbush are found across this desert. Many species of yucca and agave are also members of this flora.



B. Brixner

The Sonoran Desert extends from southeastern California eastward into Arizona and south into Baja California. It is the most diverse of all North American deserts. Saguaro cactus becomes prevalent as elevation increases.

Grasslands

Grasses are found in almost all plant communities. Plant communities dominated by grasses are subject to wide variations in season-to-season and year-to-year temperature and precipitation.

Because grasses can tolerate these fluctuations better than can trees, there is a broad grass-dominated region from southern Saskatchewan and Alberta to eastern Texas and from Indiana westward to the woodland zone in the Rockies. Grasses are a co-dominant type of vegetation east of the tallgrass prairie; they occur as an understory of savanna ecosystems.

Net primary productivity of U.S. grasslands ranges from 700 to 4,000 pounds per acre annually. Many wet meadows and subirrigated sites exceed 5 tons per acre yearly. Nationwide, however, 40 percent of U.S. grasslands yield less than 1,800 pounds per acre annually and 75 percent less than 2,700 pounds.

Tallgrass: The tallgrass prairie, often referred to as the true prairie, once dominated a landscape of over 40 million acres along the eastern edge of the Great Plains and eastward into Illinois, Indiana, and Missouri.

At its southern extremity in Texas and Oklahoma, average annual precipitation ranges from 30 to 40 inches and evaporation is correspondingly high. At the northern end, precipitation ranges from 20 to 26 inches.

Deep-rooted, tall-growing grasses—including bluestem, indiangrass, little bluestem, and switchgrass—were the dominant plants. Woody vegetation was found only along water courses.

Soils and the Corn Belt

The soils, which formed under these tall grasses and which in turn supported these productive plant communities, are the deep, dark, fertile soils that now constitute the prime farmlands of the Corn Belt.

It was not uncommon for the best sites in the tallgrass prairie to produce from 3,000 to over 5,000 pounds of dry matter per acre annually.

Shortgrass: The shortgrass prairie stretches from the Canadian border to west central Texas. East to west, this grassland extends from the middle of the Great Plains to the foothills of the Rocky Mountains. It encompasses some 280 million acres; the topography is gently sloping to extremely flat. Average annual precipitation ranges from one-third to one-half of potential evaporation, or from 10 inches in the north to more than 25 in the south.

Dominant vegetation of this grassland consists of buffalograss, wheatgrass, and blue grama. Net primary production ranges from 450 to 2,700 pounds per acre.

Sandwiched between the tallgrass prairie and the shortgrass plains is a narrow belt transitional between the two and dominated by grasses common to both. This area is often referred to as the mixed prairie or mixed grass prairie.

Sagebrush and Grass

West of the plains grasslands, grasses are often codominant

Claude C. Dillon

with drought-resistant shrubs. The big sagebrush ecosystems of the Great Basin, Columbia and Colorado Plateaus, and the Wyoming Basin are examples.

Several wheatgrass, bluegrass, fescues, and bromes are codominant herbs. Associated shrubs include bitterbrush, rabbitbrush, and other sagebrush species.

These plant communities occur in areas 600 to 9,900 feet in elevation where average annual precipitation ranges from 5 to 16 inches. Average annual herbage production ranges from 180 to 1,800 pounds per acre depending on the soil, climate, topography, and vegetation on the site.

Tropical communities: Within the United States, tropical vegetation occurs only on the southern tip of Florida and on the Florida Keys. This flora occurs at or below 25 feet sea level and receives over 50 inches of rain from February through October. The mean temperature for this period is 64° F. There is a moderate dry season from October to February.

Forests on the Florida coast and on the Keys are made up of trees with hard, evergreen leaves; twisted trunks; and dense wood. The trees make a deep shade that allows few herbaceous species. Lignumvitae, gumbo limbo, Florida strangler fig, and palms are among the more common species.

Hammocks, Mangroves

In the glades south of Lake Okeechobee are habitats called hammocks, which are raised above their wetter surroundings. Their dominant species are mixed with some tropical species and a few northern deciduous species. Sabal palmetto is a common hammock species, as are live oak and pignut hickory.

Coastal areas in this region tend to have a mangrove climax. Red mangrove grows offshore and merges into black mangrove which, in turn, intergrades into button mangrove on the shore. The tangle of mangrove roots and stems can help to build the shoreline by trapping sediment. Productivity of these tropical communities is high due to a long growing season and the intense sunlight.

In areas west of the plains grasslands, wheatgrass, bluegrass, fescues and bromes are codominant with drought-resistant shrubs.

The Animal Kingdom and the Way We Look at It

By W. B. Clapham, Jr.

W. B. Clapham, Jr., is Associate Professor of Environmental Geology, Cleveland State University, Cleveland, Ohio.

Most of us are aware of animals all around us: They range in size from microscopic protozoa to the blue whale. They live from the ocean bottoms to the heights of soaring birds. Livestock provide us with meat, while pets provide companionship. Other animals are crop pests or disease vectors.

For all this diversity, it's easy to overlook the patterns that characterize all animals. We don't often look for the principles underlying why animals are as they are, or what it is about them that determines whether we think of them as "good" or "bad."

These two questions are closely related, and they are fundamental to understanding any group of organisms that impinges on human life: What are their basic characteristics, and how do we make value judgments about them?

The two questions are opposite sides of the same coin, as it were. We care about animals *because* they have the useful or detrimental qualities that bring about value judgments, and they have those qualities *because* their basic characteristics are oriented toward a particular role in their ecological system.

As we look at animals, we need to understand how they fulfill their role in nature. Then we can see how society sees animals as it does, and whether our perception of the value of the animal kingdom is actually a reflection of solid ecological realities.

The fundamental structure of a living system is based on energy: How does it enter living tissues, and how is it passed from organism to organism throughout the system?

With so few exceptions that one can virtually ignore them, the energy of the living system comes from the sun. It is fixed by the process of photosynthesis in plants. Animals gain energy by eating plants or by eating other animals that have themselves eaten plants.

The Food Chain

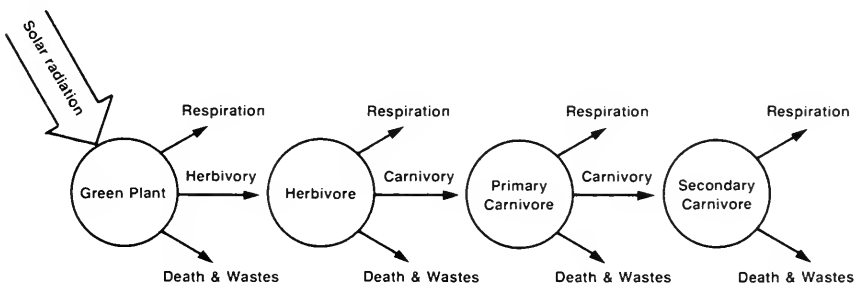
The notion that animals eat other organisms in a predictable pattern is called the food chain. Animals whose food consists of plants are called *herbivores;* those that eat other animals are called *carnivores*. Let us follow energy through the food chain, beginning with plants.

Plant tissues can survive as such, they may be eaten, or they may die and decay. Herbivores may live out their lives, or they may be eaten by carnivores adapted to eat them. These so-called primary (herbivore-eating) carnivores may, in turn, be captured and eaten by secondary (carnivore-eating) carnivores, and so on.

The categories are functional levels linked to each other like the links of a chain. This image of linkage is what gives the food chain its name. The levels themselves (often termed *trophic levels*) define an order for the passage of energy through the food chain. It is an abstract notion, but it is a meaningful way to orient people to the flow of energy in a living system.

The amount of energy available in any given living system is not infinite: It is limited by the production of fixed carbon by plants. As the conduit for solar energy into the living system, plant production limits not only the amount of plant material that can exist in any place but also the amount of energy theoretically available to all animal

Passage of Energy Through the Food Chain



populations—both herbivores and the carnivores feeding in turn upon them.

The way these limits work is subtle, and it is also highly significant to human populations. The actual amount of energy available to animals is much less than the gross amount of plant materials consumed by herbivores. It is related rather to the assimilation of energy by herbivore populations, or the total plant consumption less the materials lost as feces. It is the food energy that actually passes through the walls of the gut.

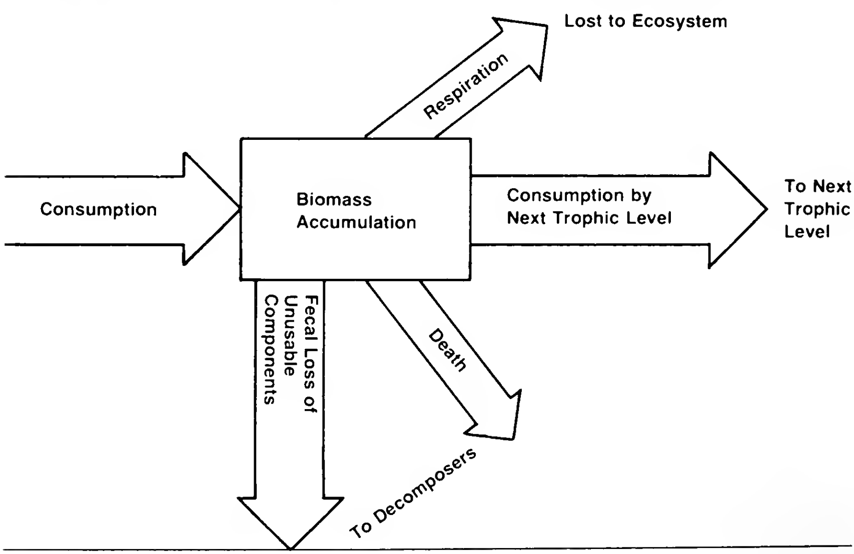
Five End Uses

Food assimilated by animals can have one of five end uses. It can be stored as carbohydrate, protein, or fat. It can be transformed into relatively simple substances or rebuilt by the animal into much more complex organic molecules. It can be broken down by the process of respiration to supply the energy required by the animal's metabolism to do these chemical transformations. It may pass to a carnivore when the animal is eaten by it, or it may pass to the soil when the animal dies and its tissues are broken down by bacteria and other decomposer organisms.

The practical point is this clarifies why only a relatively small percentage of the total amount of plant material eaten by herbivores is actually available to animals.

Most of the energy is lost in respiration, and much of the rest is passed either higher up the food chain or to decomposers.

Disposition of Energy by an Animal Within the Food Chain



Indeed, much energy is lost at every link of the food chain. As a general rule of thumb, about 90 percent of the energy consumed by an animal in a natural environment is lost through defecation, respiration, or death. Only about 10 percent is available for the direct use of the animal in question.

Rule of Thumb

Of course this 10 percent figure is a rule of thumb for natural communities. It is an average based on a great deal of observation of many areas, but there is wide variation around this average. Some animals are much less efficient at converting food to useful energy and materials, while others are more efficient.

Animal food conversion efficiency has been carried to a very high level with domestic livestock, where many species are much more than 10 percent efficient. But this efficiency is possible only because farmers or ranchers provide certain things to their animals that a wild animal would do for itself.

Protection from enemies and disease, veterinary care, and scientifically formulated feed are all significant aspects of the very high food conversion efficiency of modern livestock.

How Many Levels?

How many trophic levels can a food chain contain? The ability of a species to exist at a given trophic level depends on its ability to assimilate sufficient energy to offset the losses to respiration and predation and to allow normal growth, tissue maintenance, metabolism, and reproduction.

Because about 10 percent of the energy available at one trophic level typically can be passed to the next level, the total energy available to animals decreases dramatically as one passes up the food chain.

The number of trophic levels that can be maintained in any ecosystem is finite and small. The limit is reached when animals can no longer assimilate sufficient energy to balance their energy expenditures. This may be at the primary carnivore level in small ecosystems. Only rarely are ecosystems sufficiently productive and stable to have more than five trophic levels; most familiar communities have about four.

Some Fit, Some Don't

I indicated that the food chain was a useful model for orienting people to the basic principles of energy flow in ecosystems. But it *is* abstract.

Many animals fall clearly into specific trophic levels (for example, cattle and spruce budworms are herbivores; screwworms and trout are carnivores). But other animals may eat different kinds of food, and it may be difficult to apply the notion of trophic levels to them in any meaningful way. For example, bears, raccoons, and even humans may eat both plants and animals, thus behaving as herbivores at some times and as carnivores at others.

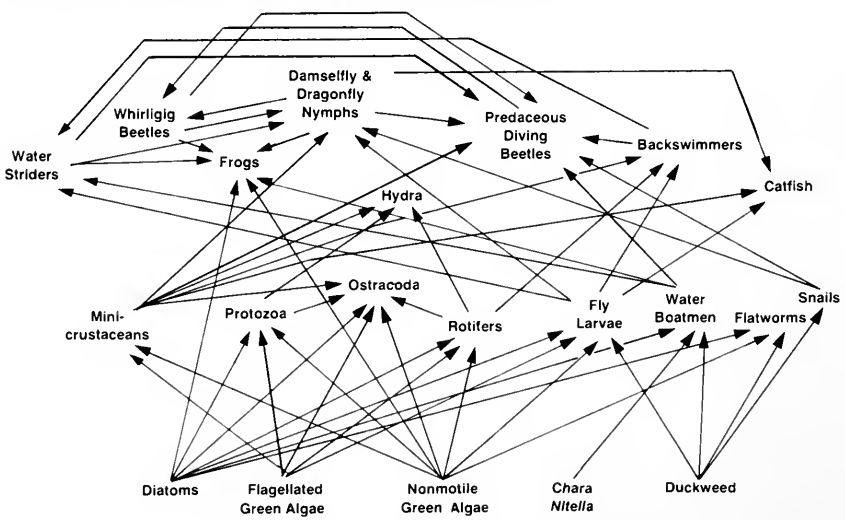
For this reason, it is often useful to describe the actual flow patterns for energy in a living system, considering the interactions among the populations making up the community in question. This is the *food web*. Populations are arrayed as completely as possible into trophic levels and can be diagrammed with arrows indicating the flow of energy from one population to another (that is, through consumption of the one by the other). Take as an example a simple New England meadow pond.

Most of the organisms in this pond example fit into trophic levels, but some do not. Some herbivores consistently eat only plants (except when they ingest an animal by mistake, of course). Others, like the ostracod, regularly eat animals if they can catch them, although their usual diet consists of plants and dead organic material.

Carnivores are still less consistent. Some species are predominantly primary carnivores; that is, they eat mainly herbivores. Others are mainly secondary carnivores, with a diet composed largely of primary carnivores, and so forth. But few carnivores will avoid eating any animal they can catch if they are hungry.

The food web in the pond example demonstrates that the patterns of energy flow are tremendously flexible even in a tiny community. Animals have some choice of food supply, some of them a great deal. As a result, adaptations of the different species provide an interlinked sys-

Simplified Diagram of the Passage of Energy Among Species Inhabiting a Small New England Meadow Pond



Many animals fall clearly into specific trophic levels. For example, cattle are strictly plant eaters.

tem much more complex than the simple food chain model would suggest. The signals linking elements of the community may be far more varied and complex than would seem at first glance.

On the other hand, a pond diagram also illustrates that we can describe the role of different animals in the living system, at least as far as their role in energy transfer. This ability to describe roles of different species is significant, as it is a basis for managing those species, whether they be livestock, game, or pests.

Ecological Niche

The importance of energy flow in defining an animal's role in the living system should be clear. But there is more to it than this. Organisms are found where they are because the living system is organized. Individual species are found in specific places, or *habitats*, and they have specific functions, or an *ecological niche*.

Perhaps the key concept is the ecological niche. It expresses a population's role in the living system and reflects the bonds between the population and all other populations with which it interacts, directly and indirectly, as well as the bonds between the population and its inorganic environment. As such, it includes not only the animal's role in energy flow, but also its structural, physical, and behavioral adaptations.

It is never easy to define a population's niche. Some factors are more significant, others more obvious. Likewise, the contribution of any single factor to a population's niche may change as the environment changes.

Nevertheless, understanding an animal's niche can provide a powerful insight into the interactions binding it to other populations. It is these interactions that make it possible for people to manage species or to realize the benefit of their presence.

How Populations Interact

To see how this works, let us first see the patterns by which animal populations interact with each other. In principle, we can recognize three ways in which one species can affect another: positive (species A is beneficial to species B), neutral (there is no effect), and negative (species A is detrimental to species B).

The interactions that affect people most directly are competition, parasitism, and predation.

We can summarize the other interactions quickly: In neutralism, neither population directly affects the other. In commensal and amensal interactions, one population affects the other positively (commensalism) or negatively (amensalism), but there is no reciprocal effect. Mutualism, sometimes known as symbiosis, occurs when the interaction is mutually beneficial to both species.

Economic Dislocation

Competition refers to the interaction in which two individuals or species vie for limited amounts of food, water, nesting space, or other resources. Its result is that fewer individuals of both species inhabit the area in question than would have been the case in the absence of competition.

If humans, or an organism on which we depend, are one of the species in a competitive interaction, the result may be considerable economic dislocation. Indeed, one of the best known examples of competition is the interaction between crop plants and weeds in farmers' fields.

It is not that weeds are inherently bad in any way; they simply compete with the crop for space, nutrients, and water. As a result, they reduce production of the crop, and thereby reduce the farmer's income. In the same way, rats and other vermin compete with people and livestock for stored grain.

Parasites and predators obtain food at the expense of their hosts and prey. Animals eating plants and other animals is the basis of the food chain, and the animal species we typically are most concerned about gain their significance from some sort of parasitic or predatory relationship either with us or with a crop or livestock species.

Most insect pests, for example, are herbivores that feed on our crops. The specific interaction in the field is the operation of the food chain embodied in the "predation" by the pest on the crop. The reason it concerns us is that the pest competes with the human population for the crop resource. The same is true for the spruce budworm (or other defoliator) in a forest: It competes with humans for the trees.

Screwworms, tapeworms, intestinal parasites, ticks, and similar parasites on livestock are all smaller than their hosts and consume them either from within their bodies or from the surface. Parasitism may kill the host animal, or it may debilitate. In either case, if the host is a valuable animal, parasitism can do considerable economic damage, and the parasite is in direct competition with humans for the resource represented by the livestock.

Role of Predators

It is tempting to put a value judgment on predation, both since it involves destruction of an individual of the prey species and because so many of the populations that are the object of predation are species desired by the human community. But predation as such is neither "good" nor "bad." It is, after all, the basis of the food chain, and we ourselves fill this role when we consume beef, pork or chicken.

John Kucharski

Parasites can do considerable economic damage. The screwworm, for example, is an insect that feeds on livestock. It can kill or debilitate the host animal.

One of the most pervasive conclusions drawn to predator-prey interactions is that predation is somehow detrimental to desirable prey populations, especially wild game. This belief has led to extensive "predator control" efforts in the name of wildlife conservation.

In fact, predation is so basic to the food chain that game populations are innately adapted to withstand a certain amount of predation from wolves, mountain lions, etc. Indeed, predators on large game tend to concentrate on infirm individuals, so that they keep the genetic stock of the game population at its peak.

One would probably not argue that predation was "good" for an individual deer or moose locked in the jaws of a hungry wolf. But it is undeniably true that the genetic fitness of the prey population benefits far more from animal predators who selectively remove ill and less fit individuals from the population than from hunters who selectively remove the most fit trophy animals.

Wolves Control Moose

Instances of the role of predation in managing game populations abound. For example, a population of moose became established on Isle Royale, Mich., in 1908. The herd expanded to such a high density by 1930 that the moose seriously damaged forest and pond vegetation and experienced periodic die-offs because of inadequate winter food supply.

A population of wolves became

established on Isle Royale around 1948. Wolves and moose quickly formed a close predator-prey pair, with the wolf as the only predator of the moose and the moose constituting 75 percent of the wolves' food supply.

Predation of moose by the wolves has resulted in a substantial drop in the moose population to a relatively stable equilibrium level. Regrowth of vegetation is now much greater than at high moose density, and die-offs of moose have ceased.

Predation has also been applied successfully to pest control. Remember that insect pests typically consume desirable plant species, and that they compete directly with people for the crop resources. The strategy of biological control is to extend the food chain one step further and add an animal that can serve as a predator on the insect pest.

There are numerous well-documented examples of this. One of the best understood involves the cottony-cushion scale insect and the vedalia beetle.

Citrus Threatened

The scale insect was unintentionally imported from Australia into California about 1870. It is not an important pest in Australia, and it serves as the main food source for several insects, notably the vedalia beetle and a predaceous fly.

But these natural predators were not introduced into North America along with the scale, which found an abundant food supply in the citrus crop of southern California. It expanded rapidly through the citrus groves, unchecked by any natural predator.

People feared that the scale insect would continue to expand until it had destroyed its own food supply—and the California citrus industry in the bargain; indeed, this was already a distinct possibility by 1886.

The predaceous fly was deliberately introduced into California in 1886 and began at once to feed on the scale. But it could not keep up with the vast numbers of scale in southern California.

At the end of 1888, the vedalia beetle was introduced into the orange groves, and they consumed so many scale insects within a year that the cottony-cushion scale problem was brought under control.

From 1890 until the mid-20th century, the scale and the vedalia beetle lived together in a dynamic equilibrium. The scale insect never amounted to more than a minor nuisance, but their numbers were sufficient to ensure a constant food supply for the vedalia beetle.

Pesticides Recreate Problem

Soon after World War II, the use of pesticides (most notably DDT and organophosphorus types such as parathion and malathion) became widespread in the citrus-growing regions of southern California. The justifications for pesticide use were several, including not only the control of pests on noncitrus crops but also the final eradication of the cottony-cushion scale.

Unfortunately, the vedalia beetle is much more sensitive to these pesticides than the scale insect. A primary result of pesticide spraying was destruction of the vedalia population. This was followed by a dramatic rise in the density of cottony-cushion scale to create an economically important problem for the first time in more than 50 years.

Let us return to the two questions that introduced this chapter: What are the basic characteristics of animals, and how do we (or should we) make value judgments about them?

The key characteristics of animals can be summed up in their ecological niche. What do they eat? Who eats them? What is their overall "function" in the living system?

Most importantly, perhaps, if the animal is an economically important species such as a livestock animal or a pest, what does its niche tell us about the effects of different management techniques?

Hindsight and Foresight

For example, hindsight would have suggested that the Vedalia beetle would suffer more from application of pesticides than the cottony-cushion scale, and that the scale would expand as a result of the spraying programs designed to control it. But the point is whether this could have been predicted before the fact rather than afterward.

It is clear in hindsight that a lack of predators would lead to an unhealthy moose population on Isle Royale. But how many of us would have thought to establish wolves on the island as a way to insure the health of the moose?

On the value side, we should remember that a species has value or not as a result of its overall impact on the ecological and economic system of which it is a part. It is not adequate to assess the value of a species subjectively and without documentation.

A valuable species may appear worthless or even detrimental, or vice versa. For example, bison on the western range were once ruthlessly slaughtered. Yet research suggests they may be more efficient converters of range grasses to meat than cattle, and that hybrid "beefalo" may become a force in the market at some point.

What could be a greater scourge of the southern cotton fields than the boll weevil? Yet by forcing a diversification of the southern economy, the weevil rendered a service to the region that few would deny.

Animals fill many roles in human society, from pests to pets to sources of food to beasts of burden. Their value to us, either positive or negative, is related to their function in the living system. The best way to manage them and to optimize their contribution to people is to understand that role and to work within it.

People Change the Landscape, Pose Problems, Seek Solutions

By Thomas E. Hamilton and James N. Benson

It has been said that once a squirrel could travel from the Atlantic Ocean to the Mississippi River without touching the ground, so vast and unbroken were the North American forests. But the European colonists changed the land. They cleared the forests and planted the fields to crops. They dammed streams and built roads.

Settlement proceeded inland along rivers, which provided water supplies, transportation, and power. Over the years, the colonists moved west from the Atlantic Coast and north from Mexico. They opened untouched grasslands and forests with the plow and the axe. There were so many acres and so few people that it must have seemed as if there were no limits.

But these farmers were unfamiliar with the climate and the geography in their new land. Continuous tilling exposed the soil to intense rainfall and high winds, and reduced its fertility. Crop yields declined and soil erosion increased. After several years of use, many fields had to be abandoned. Forests were cleared, cropped, and abandoned in a repetitive cycle. Cheap land allowed the farm-out-and-move-on philosophy to become entrenched.

By 1900, farmers and ranchers had cultivated or turned livestock onto most of the fertile, well-drained soils. They began to drain, irrigate, and otherwise change the lands that had been overlooked earlier.

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James N. Benson is Writer-Editor, Public Information Staff, Soil Conservation Service.

National Forests Set Up

Forests, too, were cut, forgotten, and left to regenerate naturally. Concern over depletion of woodlands led to the creation of National Forests. These forests were placed under the management and protection of the Forest Service, which was created in 1905 to ensure the availability of wood and protection of watersheds for future generations.

Widespread exploitation of private farm and ranch lands continued until the 1930's, when the "Dust Bowl" brought home to Americans the reality that their natural resources were finite. In the late 1930's and 1940's, local conservation districts were formed in every State to link public and private actions to protect the land.

It is obvious, therefore, that people have changed our landscape—for good and for bad. And as our population continues to grow, our demands on the land will increase. The land will continue to change, if only because there will be more of us to share it. Our challenge is to use wisely what we have so that future generations can enjoy the bounty we sometimes take for granted.

Counting Noses

The 1980 Census counted more than 225 million people in the United States, an 11 percent increase over 1970. For the first time, more people live in the South and West than in the Northeast and North Central States.

Rural areas and small towns

O. K. Blake

In the 1930's, the Dust Bowl brought home to Americans the reality that their natural resources were finite.

grew faster than metropolitan areas during the 1970's, reversing the trend of the last 150 years. Despite this, we remain a nation of city dwellers. More than 70 percent of us live in metropolitan areas of 50,000 people or more.

The recent growth in rural areas does not mean we have more farmers. In fact, the proportion of farmers in our society is smaller than ever. Today, only one of every 60 U.S. residents is a farmer, compared to one of six in 1900 and one of four in 1790. There are fewer farms, too, but the ones that remain are larger. The average farm today is about 450 acres, nearly 10 percent larger than the average farm only 10 years ago.

Many demographers foresee continued growth of our population in the South and West. Still, the total U.S. population—like that of most of the industrialized world—is not expected to increase as rapidly as in recent decades.

In less developed countries, however, populations will climb so fast that total world population will be 50 percent higher in 2000 than in 1976. And in many of these countries, the old pattern prevails—clear the land, deplete the soil, and move on. But rapid population growth and soil depletion can lead to widespread and serious shortages of food and fiber.

The enormous jump in the world's population should concern us because our farmers certainly will be expected to—and most likely will—contribute a large share of the additional food needed.

Agricultural exports from the United States likely will remain high as we continue trade with both industrialized and less developed countries. In fact, our grain exports in the year 2000 are projected to be three times the 1970 level.

Competition for Land

A few years ago, at the height of the energy crisis, a major oil company asked for energy-saving ideas from the public. It used some of the unique and more appealing of these ideas in an advertising campaign.

One suggestion was to move places of work closer to places of play, thereby combining the best of the "good life" with less travel to work and recreation. The advertisement showed an "ideal" homesite on the banks of a scenic mountain lake.

The idea is appealing; practicality is another question. Obviously, there are only so many mountain lakes to go around.

Still, changes that reflect this idea are occurring across the United States. As more people move west and south—toward areas that are less crowded, have better climates, and offer more opportunities for outdoor recreation—competition for the use of our limited land base will increase.

Effects of Changes

What are the potential effects of these changes? How might they affect the resources, the environment, and ultimately the people themselves?

Food and Fiber. Long-term projections indicate we will eat more beef, pork, poultry, grains, fruits, and vegetables, and less milk, eggs, sugar, and beans. We can expect to pay more for food, and these higher prices could lead many of us to further adjust our diets.

Worldwide, per capita food production reversed its long-term upward trend in the late 1970's. This meant an even greater dependence on the United States, where production continued to grow faster than the population.

Increasing competition for food, primarily grains from the

George Clark

Housing will be affected in the years ahead as wood becomes less available and more expensive. Softwood lumber and plywood—the main products used to build houses—are expected to cost more than twice as much over the next 20 years.

United States, will likely force prices higher in other countries. The effect can be devastating, particularly on the poorer countries that most need the food.

Fiber, such as wood, is also expected to be less available and more expensive. For example, prices of softwood lumber and plywood—the main products used to build houses—are expected to more than double over the next 20 years.

Probable effects include higher housing costs, smaller houses, and lower quality of construction. Higher prices for wood will also encourage greater use of nonrenewable building materials such as steel and aluminum.

Recreation. Nearly all our inland water, nearly all our forests and rangelands, and much of our croplands are used to some degree for outdoor recreation.

Only a fraction of our land, however, is managed intensively for recreation. And future demands for some recreational uses, such as downhill skiing, are projected to triple.

Facilities, access, and maintenance must be expanded just to maintain today's levels of quality and service.

Hunting and fishing are also expected to grow in popularity. But important fish and wildlife habitat could be damaged or even destroyed as we satisfy demands for other resources. Costs of maintaining heavily used areas could rise substantially.

Despite gains already achieved through management, stricter limits on hunting and fishing are possible. If so, rural economies that depend on hunting and fishing as a major source of employment and income could be hurt.

Energy. During the 1960's and 1970's, consumption of energy in the United States rose by about 80 percent.

The Middle East oil embargo in the mid-1970's dramatized our dependence on foreign fuel sources. It emphasized that we would have to look to our own sources for future energy supplies.

However, many of our extensive coal reserves underlie forest and rangelands, where coal mining could disrupt management of large areas of renewable resources. And substantial increases in the burning of coal could lower air quality and worsen the acid rain situation.

The cost of natural gas—heretofore relatively inexpensive—is expected to climb. This could affect the cost and availability of nitrogen fertilizers, which are produced from natural gas. It could also increase the demand for wood as fuel, especially in less developed countries, and the result would be loss of forest land and probable further reduction in air quality.

In response to these and other rising demands on our resources, there has been an increase in land-use controls, environmental regulations, and systems of permits and licenses. But although such actions help improve the balance among competing demands, they are often unpopular.

Effects of Erosion

People are at the end of a complex food chain. Actions that affect the soil and the other links

USDA

Farming up and down a slope is one practice that has a lot of unintended—and undesirable—consequences. Reduced yields and increased water pollution and flooding are among them.

in the chain can have unintended consequences.

For example, if a farmer plows a sloping field and plants a crop in rows up and down a hill, the soil is more subject to erosion by water, especially if it consists of easily dislodged particles. Erosion thins the topsoil, which is generally a much better medium for plant growth than the subsoil.

As runoff water carries soil particles downslope, it also carries organic matter, nutrients, and pesticides.

Some of the soil eventually reaches a stream. For a time, the sediment clouds the water, reducing the amount of light that fish in the stream need to thrive. As the sediment settles, it reduces the depth and capacity of the channel and increases the likelihood of flooding.

Nutrients washed into the stream promote excessive growth of algae, which consume

Gene Alexander

Practices such as conservation tillage, which leaves residue of the previous crop on the surface, protect cropland from erosion.

oxygen needed by the fish and further reduce light transmission through the water. Pesticides, dissolved in the runoff or attached to soil particles, can harm the fish and other plant and animal life.

Like water erosion, wind erosion thins the surface layer. Furthermore, windblown soil particles can sandblast crops and choke the air.

A few of the long-term results of erosion? Reduced yields, water pollution, and degraded fish and wildlife habitat.

Conservation Tillage

The farmers could stop the damage by using accepted conservation methods. For example, they could plant the crop rows across the slope, at a right angle to the normal flow of runoff. Each row, like a tiny terrace, would slow the runoff and allow more water to soak into the soil.

Better yet, they could also use some form of conservation tillage to plant the crop. In conservation tillage, some or all of the residue of the previous crop is left on the surface at planting time. The residue shields the topsoil from raindrops and wind energy and also conserves soil moisture.

Of course, one cropland field is insignificant from a national perspective. But as one among thousands, it contributes to resource degradation that might take years to correct. Furthermore, cropland erosion accounts for less than a third of all soil loss caused by wind and water. Forest, range, and pasture lands and nonfarm lands also have serious potential for erosion damage through improper use and management.

And there are other problems besides soil erosion. For example, chronic water shortages and flood damages in small upstream watersheds affect millions of Americans each year. Some solutions to these problems are technological, as the development of more efficient irrigation. Others involve legal remedies, such as local laws to restrict construction on flood plains. An approach is needed that considers all these problems together.

Organized Response

We have many opportunities for expanding supplies of renewable natural resources, increasing crop production, and protecting the environment in response to greater competition for available resources.

More intensive management can increase the food and fiber production from our crop, forest, pasture, and range lands. Soil erosion can be substantially reduced, water yields and quality improved, flood damages reduced, and air pollution lessened.

Recognizing the potential for land-use conflicts and the need for an integrated look at solutions, Congress passed the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA). RPA requires the Secretary of Agriculture to prepare and transmit to Congress a renewable resources assessment and program.

The assessment, a comprehensive look at all forest and range resources in the United States, is prepared every 10 years. It analyzes resource conditions and projects supply and demand over the long term.

The program is prepared every 5 years. It guides activities of the Forest Service for at least the subsequent four decades. Under RPA, two assessments and programs have been prepared, and a third program update is scheduled to be transmitted to Congress by the end of 1984.

Related Legislation

The first RPA assessment and program proved useful enough to prompt Congress to pass related legislation. The Soil and Water Resources Conservation Act of 1977 (RCA) directs the Secretary of Agriculture to appraise condition of the soil, water, and related resources on the Nation's nonfederal lands and to develop a program to maintain or improve their condition.

The first appraisal was published in two parts in 1981, and the National Conservation Program was transmitted to Congress in December 1982.

Eight U.S. Department of Agriculture agencies administer soil and water conservation programs. The National Conservation Program, prepared under the leadership of the Soil Conservation Service, coordinates all conservation activities of the eight agencies and strengthens the role of existing local conservation agencies and organizations.

RCA and RPA activities are bringing together what had largely been the independent development and planning of conservation activities by separate USDA agencies. This coordination should lead to early identification of resource needs and opportunities, and to a logical and efficient approach to program development.

In the complex and uncertain world of natural resource management, this process provides a sound foundation for decisions about the future.

But even so, there is a limit to what the Government can do through technical and financial assistance, research, and management. People are the key. The following chapters provide striking evidence that a commonsense approach to resource issues can make all the difference.

Further Reading

Soil, Water, and Related Resources in the United States. RCA Appraisal Parts I and II. Soil Conservation Service, P.O. Box 2890, Washington, D.C. 20013. Free.

An Assessment of the Forest and Range Land Situation in the United States, 1980 and 1981 editions. Both for sale by Superintendent of Documents, Washington, D.C. 20402.

III. Managing, Natural Resource Systems

A Billion Acres of Rangeland: Our Nation's Multiple-Use Lands

By Thadis W. Box

Almost a billion acres of our country is made up of rangelands—a particular land type that is not easily defined. Almost everyone can recognize cropland. Forests have stands of trees that are managed for timber products. Rangelands, though, are those areas that are too dry, too wet, too cold, or too high for intensive agriculture or forestry. They are those lands that are grazed by animals and that produce most of our domestic livestock, while supporting deer, elk, turkey, grouse, and other wildlife.

To many people rangeland conjures up visions of vast, open, unfenced prairies, cowboys, and sheepherders. It is true that these are characteristics of rangelands, but ranges may also be fenced into pastures, closely managed, rotated, and husbanded for maximum production of livestock.

Most of our rangelands are in the western United States. States such as Wyoming and Nevada are more than three-fourths rangeland. In States west of the Great Plains, most have one-third to one-half of their land in range. Although the bulk of the rangeland is in the American West and Alaska, significant range areas occur within forested areas of the southeastern United States.

While rangelands of the United States produce most of the feeder livestock, it would be a mistake to evaluate them on this basis only. Rangelands provide habitat for wildlife, serve as a

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Erwin W. Cole

The Great Plains—the largest expanse of natural grasslands left in the United States—is used primarily for cattle production. These short grass plains are noted for high range quality.

recreational resource, produce water, enhance amenity values, and affect our lives in ways not easily evaluated from an economic standpoint.

Never before in our history have more demands been made on the ranges of this country. Not only must they support livestock, wildlife, and other animal production, but the pressure of recreational use as well. Their scant water resources must serve agriculture and industry alike. These resource values, all a part of rangelands and range products, are often in conflict, one with the other. For each product there is a separate group of backers with its own political power, pulling the land manager in several directions at once.

Climatic Extremes

Rangeland environment tends to extremes of harsh climate; it is often too cool, too wet, or too dry. The arid and semiarid rangelands, the largest portion, are characterized by low rainfall that is sporadically distributed both geographically and seasonally. Temperatures can be hot enough to cook an egg in summer, cold enough to freeze the ears off an unprotected saddle horse in winter.

These extreme conditions produce unique plant communities. In addition to the soils in which they grow, most plant types are the result of two environmental gradients: Temperature changes from cold in the North to hot in the South, and the moisture level changes from wet in the East to dry in the West.

The two most important range areas are the grasslands and savannas of the Great Plains and

Texas, and the mountains and deserts of the West. Other significant types are the annual grasslands of California, the southeastern forest, and marshes of the Gulf Coast.

America's vast midsection was once virgin grasslands. Grass covered the area from the Canadian border extending south well into Texas, and from Iowa and Illinois west to the Rocky Mountains. Throughout the Midwest, what was America's original tallgrass prairie is now mostly productive cropland. Isolated segments of the tall grass remain in the Osage Hills of Oklahoma, the Flint Hills in Kansas, and the sand hills in Nebraska.

Pioneers Overoptimistic

There has been much written . . . within the last ten years about the deterioration of the ranges. Cattlemen say that the grasses are not what they used to be; that the valuable perennial species are disappearing, and that their place is being taken by less nutritious annuals. This is true in a very marked degree in many sections of the grazing country.

This quotation could be from a bulletin recently published by any of our conservation groups. However, it was written by Jared G. Smith in the 1895 *Yearbook of Agriculture*. Yet, today, many of the same words are echoed.

There is no doubt that large areas are still producing far less than their potential. However, our ranges are in the best condition they have been in this century and I believe they are improving.

The pioneers who settled this country were overoptimistic about its carrying capacity. With the best of intentions they stocked the range, developed the wilderness, and set in action a process that led to deterioration of rangelands. In most instances, ranges were badly overgrazed within two decades after the first livestock were introduced.

The report of Smith, a U.S. Department of Agriculture grasses specialist, in 1895 was typical of many written at the time. Livestock men came into an area where grass was plentiful and free. Profits were great. Large corporations established livestock enterprises, and in a few short years livestock ranges were overgrazed.

Range 'Almost Destroyed'

A correspondent for Utah's *Deseret News* wrote from Grantsville, Utah, on Sept. 25, 1879, just a little over two decades after livestock were introduced into the area:

The crops of all kinds, including fruits, are very light in Grantsville this year. Scarcely enough were raised for home consumption which is due largely to the scarcity of water and the high winds we have had in the past summer to dry out the ground. The wells are nearly all dried up and have to be dug deeper. At present the prospect for next year is a gloomy one for the farmers, and in fact all, for *when the farmer is affected, all feel the effects.*

The stock raisers here are all preparing to drive their stock to where there is something to eat. This country which was one of the best ranges for stock in the territory, is now among the poorest; the myriads of sheep that have been herded here in the past few years have almost entirely destroyed our range.

First attempts to control grazing and improve ranges began with the work of Smith, H. L. Bentley, and others, in Texas in the 1890's. Shortly after there were experiments in the Ephraim area of Utah, and other areas throughout the West.

The Forest Service was established in 1905, and from 1905 to 1910 began the slow process of limiting numbers and control of grazing on National Forests.

Just as grazing regulations were being implemented, World War I brought a demand for increased livestock production. Numbers were allowed to rise. After the war ended, scientific range management practices and controlled grazing were once again implemented and the National Forest ranges began to improve.

However, on that portion of Federal land not included in the National Forests, the story was different. Landless livestock operators used this land to pasture the animals which could no longer be grazed on the National Forests. These lands, less productive to begin with, continued to deteriorate.

Taylor Grazing Act

The first authority to control grazing on the public domain came with passage of the Taylor Grazing Act in 1934. However, implementation of this act has been a slow process that is still continuing.

The number of animals using the public range has declined. Today the total number of animal unit months allowed is only about a third of that which occurred in 1935. Sheep have decreased significantly. However, the number of cattle has actually increased, partly because of a shift from sheep to cattle ranching.

In general, the range has improved. The amount of good and excellent range has not altered much since 1935. The great improvement has been made in poor and fair range condition. For instance, in 1935 over 58 percent of the ranges were in poor condition. By 1972, this amount had decreased to 32 percent, and today has decreased even more.

This movement from poor to fair represents a significant step in western range improvement. One would not expect those ranges that had deteriorated for half a century to move from poor to good to excellent condition within one decade. The shift from poor to fair is a reasonable and progressive step in range improvement.

The Great Plains

The largest expanse of natural grasslands left in the United States is that area generally known as the Great Plains. Sometimes called short-grass plains or mixed prairie, they begin at about the 100th Meridian and extend westward to the Rocky Mountains.

Precipitation is usually between 22 and 26 inches per year, with about two-thirds of it falling as rain between April and September. This produces the moisture supply for short- and midgrasses during the growing season.

The dominant grasses are of low stature, often sodforming, with warm-season grasses predominating in the southern part of the region and cold-season grasses in the north.

Blue grama is the most common grass. It occurs from Canada to Texas. In the central and southern portion, buffalograss is found mixed with blue grama. In the more northern parts of the area, western wheatgrass, needle-and-thread, and other cool-season grasses replace buffalograss. Blue grama often produces 50 to 95 percent of the forage on a given range and is the key species upon which range management is usually based.

The short-grass plains are noted for high range quality. The grasses cure well and maintain their nutritional value during the dormant period. Animals gain in the summer, and hold their condition well in the winter if snow cover permits grazing.

The Great Plains region is used primarily for cattle production. Livestock are grazed yearlong in the southern area. In the central area they may be grazed 8 to 10 months or, with supplemental feed, yearlong. In the more northern areas they may be able to graze only 6 or 8 months, and must be supplemented the remainder of the time.

Most of the rangelands of the Great Plains are privately owned. They are generally in fair to good condition. Although they have been grazed for over a century, their productivity has been maintained reasonably well.

These short-grass plains are marginal for crop production. During favorable moisture years of high grain demand there is a tendency to plow up grasslands and grow grain crops on them. When grain prices decline, they are converted back into grasslands for forage crops.

This shifting land use pattern causes many problems with range improvement and soil stabilization. Imprudent cultivation of these soils was the primary cause of the "dirty thirties"—wind erosion associated with America's Dust Bowl in the 1930's.

Desert Grasslands

Some grasslands occur in the arid regions. These are mostly in Texas, New Mexico, and Arizona, and extend deep into north Mexico at elevations less than 4,300 feet. They are usually rough in topography with numerous hills and broad valleys.

Most of the area receives between 10 and 20 inches of precipitation, and evaporation is high. Fifty to seventy percent of the rain falls in late summer. Due to high evaporation, vegetation must use moisture rapidly or it is lost. Annual evaporation is high. This, coupled with extremely high temperatures, makes the area one of the hottest, driest grasslands of the world.

There is no single dominant key species throughout the area. In the low spots with heavy soil and groundwater, tobosa grass dominates. On the foothills and in shallower or sandier soils, black grama may be the key species. Other desert grass species of local importance are mesquite grass, threeawn, hairy grama, buffalograss, and various dropseeds.

A number of shrubs are associated with desert grasslands. The most common are mesquite, creosote bush, and several acacias and oaks. Cacti, mainly prickly pear and cholla, occur throughout.

Desert grasslands are used primarily for cattle production. Cow-calf operations tend to predominate, although some cow-calf yearling and steer operations are well established. Sheep do well in these areas, but few ranchers concentrate on sheep production.

Some ranges support large populations of wildlife. Pronghorn antelope, javelina, and mule deer are the major large animals. Jackrabbits and other small herbivores are found locally. Scaled quail, and in some areas California quail, are found. A large variety of nongame birds is usually present.

Southwest Shrub-Steppe

The U.S. Department of Agriculture has described about 40 million acres of western rangelands as southwestern shrub-steppe. These are located primarily in Arizona, New Mexico, and Texas and may be simply an extension or close associate of the desert grassland types.

Vegetation ranges from short grass to scattered shrubs to shrub. These types typically represent a transition from the woody communities, such as desert shrub and pinyon-juniper, to the desert grassland area. Main shrubs in this type are creosote bush and mesquite. Major grasses include black grama, threeawns, tobosa grass, curly mesquite grass, and sideoats grama.

These areas contain the same grass species as the desert grasslands and are normally managed with the desert grasslands or the hot desert shrubland. This shrub stand is often singled out for range improvement projects, the major one being removal of woody vegetation.

Hot Desert Lands

Hot desert shrublands contain a mixture of creosote bush, mesquite, blackbrush and Palo Verde. They extend from Texas, New Mexico, and Arizona south into central Mexico. These deserts have the most arid climate in North America, and their vegetation illustrates many adaptations to resist drought. Most plants have evolved for survival rather than production.

Precipitation is extremely low, averaging only between 3 and 14 inches annually. There are individual years that receive less than 1 inch of rain in the true desert areas. Evaporation is high with rates of 120 to 160 inches per year common. The frost-free period is normally long. Scarcity of rainfall limits production.

The natural vegetation is shrubs interspersed with succulents and low-growing forbs and grasses. One of the most widespread shrubs is creosote bush. This vegetation type often forms almost pure stands, with few other perennial species growing within it. Associated with the creosote bush are annual grasses, such as threeawns and gramas. Some other shrubs are found, as are cacti and other succulents.

Mesquite woodlands occur on heavier soils along drainage ways throughout the desert region. Here trees and shrubs grow as a scattered savanna or strips

About 40 million acres of western rangelands—mainly in Arizona, New Mexico, and Texas—are described as southwestern shrub-steppe. The vegetation ranges from short grass to scattered shrubs.

Albert Thatcher

of dense woodland. Grasses associated with mesquite areas are the same as those found in desert grasslands.

On sandy soils almost pure stands of blackbrush occur. Perennial grasses found in this type are dropseeds and other hot season grasses.

Most hot deserts are used for yearlong livestock range, but forage production depends upon rainfall. Some lands are used only seasonally. The seasons of the desert are not those of fall and spring. Instead, wet- or dry-season grazing defines the seasonal use. Livestock water is usually scarce, development of water facilities expensive and difficult.

Most of the desert shrub ranges are publicly owned. Parts of the hot desert are in private ownership, generally managed with the more productive desert grasslands or shrub-steppe types. Most of the public land is Federal, managed by the Bureau of Land Management.

Mountain, Cool Desert

Mountain and cool desert ranges occur in a large geographic region west of the Continental Divide and east of the Sierra Nevada and Cascade Mountains. They are bounded on the north by the Canadian border and on the south by the hot deserts which occur along the Utah-Arizona border.

This area contains almost all of the States of Utah, Nevada, and Idaho; roughly the western third of Montana, Wyoming, and Colorado; and the eastern third of Washington and Oregon.

It includes all of the arid and semiarid shrublands of the Great Basin (between the Rockies and the Sierras), wooded and grassed foothills of the Rockies, and mountain vegetation of the Rockies west slope.

The east slope of the Sierra Nevadas and the Cascades and the entire vegetation of the scattered mountains of the Intermountain and Great Basin area form part of these ranges.

Almost all the land in this broad geographical area is rangeland, most of it in public ownership.

The entire intermountain area is characterized by low and erratic precipitation. The Sierra Nevadas and the Cascades on the west and the Rocky Mountains on the east form barriers to moisture movement and cause rain shadows (areas of insufficient rain on the leeward side of mountains) within the area.

Most of the precipitation comes as snow and may vary from as low as 4 inches in some of the salt deserts to as high as 40 to 48 inches at the top of the mountains. Summer rains are not dependable, and rangeland productivity occurs as a result of moisture available for a short period of time in spring. Soils are extremely variable.

Used as Winter Range

Generally, the broad valleys in the lower portion of the Central Basin are covered by low shrubs. Some are almost pure stands of shadscale. Others contain Nuttall's saltbush, winter fat, greasewood, or big sagebrush. In some areas these shrubs occur in mixed stands with half a dozen or so other desert shrubs intermixed.

Grasses and herbaceous vegetation are usually scarce. Most of the forage comes from the shrubs themselves. Much of the area is used as winter range for sheep and cattle.

The lower elevations of mountains and foothills are usually covered by big sagebrush and grass or a combination of low, shrubby, woody species. These areas receive slightly higher rainfall than the lowlands. Soils are less salty and somewhat deeper.

The foothills provide major spring and fall ranges for livestock operations. They also provide the major amount of winter forage for mule deer and elk. Spring-fall ranges are in short supply for livestock, and winter range for wildlife is usually on the same piece of land. Much of the foothill land is privately owned. Many of the ranges have been improved or have potential to be improved for livestock grazing.

Most of the grasses that have been planted are exotics, such as crested wheatgrass and Russian wildrye. These species are easier to establish and maintain themselves better over a long period than do the closely related native bunch grasses.

Water and Recreation

Mountains of the area support a number of different plant communities, varying from low shrubs in the foothills to alpine parks and forests in the higher mountains. There is some variation, but in general the plant communities at the lowest elevations are low shrubs, and at successively higher elevation change to pinyon-juniper, Ponderosa pine, aspen and lodgepole pine, spruce-fir, subalpine forest, and finally, alpine.

Lower elevations of the sagebrush, pinyon-juniper and Ponderosa pine areas may be used for spring or fall range. Higher elevation ranges are almost exclusively summer range.

It is also in these high areas that most of the water in the West is produced, and these scenic areas offer some of the Nation's prime recreational land. They are used for hunting, fishing, camping, hiking and backpacking in summer, and for skiing, snowmobiling, and other sports in winter.

In summary, ranges of the mountain and intermountain States are primarily multiple-use lands. They are mostly publicly owned and are managed for recreation, wildlife, water, timber, and livestock production.

The foothills and some of the interior basin of California are covered by annual grasslands. Here the Mediterranean climate provides for moist, cool winters and hot, dry summers. Annual plants such as bromegrass predominate. They are mixed with a number of annual clovers and forbs.

The California annual rangelands are almost all privately owned and used in farming or forestry enterprises, as well as for individual ranches. The winter period of rapid vegetative growth and the long summer dry period set up conditions of abundant winter nutrition and short forage supply in summer.

Recent Improvements

Much has been done in recent years to ensure range improvement. The Society for Range Management was established in 1948, and professional people have worked since then to improve range productivity.

There is evidence the ranges are improving. Most of the public range which improved between 1935 and 1966 is on National Forest lands. It had been under control longer and had a higher potential than the deserts. The continued improvement between 1966 and the mid-1970's represents a positive response to management on National Forest ranges and on the remainder of the public lands.

Private landowners began applying scientific range management as it developed in the mid-1930's. Today the private rangelands are in better condition than they have been in this century.

The fact that ranges are improving does not mean they are all reaching their potential. Several authorities have estimated productivity could easily be doubled.

Improvement of American rangelands has been slow, partly because of dry climate and inherent ecological conditions, but also because we as a Nation have not understood them and, as a consequence, largely continue to ignore them.

Our first mistake was to overestimate their productive ability, underestimate their fragile nature, and attempt the sort of development appropriate to a more humid area. We could make a mistake now by assuming that, because they have improved, they no longer need attention. They are an important national resource and deserve the attention of the American citizen.

The XXX Ranch: Managing Range for Ecology and Economy

By John Merrill

John Merrill is owner-operator of the XXX Ranch near Fort Worth, Tex., and Director of the Ranch Management Program at Texas Christian University, Fort Worth.

One cannot work closely with rangeland for very long without developing a deep respect and appreciation for its character and capabilities. The diversity of any given spot, much less the extent of rangeland all over the world, is mind-boggling.

True prairie consists of about 250 different plants evolved over time to be the most productive under existing conditions of soil and climate with no inputs except grazing management.

This marvelous mixture of grasses, forbs and browse, annual and perennial, cool and warm season plants provides a wide variety of nutrients for domestic animals and wildlife. It is unmatched by so-called "improved" tame pastures of one or two species which typically require purchased inputs such as fertilizer, machinery, and fuel for desired production.

Our European ancestors brought some knowledge of crop production accumulated over many generations. However, they had little regard for nor knowledge of rangelands, which were well adapted to grazing but not cultivation. To this day, range management has suffered from an agronomic input approach, as opposed to ecosystem management based on understanding and application of natural principles.

A brief review of the ecological principles which form the basis for good rangeland management may be helpful as a background for applying modern range and ranch management practices.

Aided by Wise Grazing

Grasslands were developed under grazing and are healthier and more productive with wise grazing use than with none at all. Natural grazing use was intermittent, often by relatively large numbers of animals for short periods of time before they migrated to fresh forage according to seasonal availability.

This grazing pattern provided a high level of production and reproduction in the animals by the quantity and quality of forage available and in the plants by adequate time between grazing periods for regrowth. The pattern was simulated by early herders, constantly moving their herds and flocks to desirable grazing, and also by free-roaming herds of cattle and horses escaped from domesticity.

The anomaly of continuous yearlong grazing brought on by fencing and confinement is familiar only to three generations of Americans on the face of all history, and is neither natural nor desirable in most instances.

The stocking rate—number of grazing animals per area of land—was adjusted to varying growing conditions and forage production from year to year by several natural mechanisms.

Reproduction rate is tied closely to nutrition available.

In extra good forage years, a high percentage of female deer—as an example—ovulate and give birth to one or more offspring, thus increasing the stocking rate to match the greater carrying capacity. When numbers of animals exceed carrying capacity, nutrition available above maintenance levels is inadequate to support ovulation. This results in a lower birth rate and subsequently reduced animal numbers.


Gene Alexander

Wise grazing management balances animal numbers to available forage for maximum net return.

Parasites, Diseases

Overstocking also results in the grazing of plants to shorter heights, where more internal parasite eggs are ingested and cycled through a larger number of host animals. This further decreases nutrition available to the animals, reproductive rate, and resistance to disease. With more hosts and less resistance, disease organisms that normally would be suppressed with no adverse effect now increase sickness and death loss.

Reproduction of predators follows the same pattern as their prey and acts also to reduce excessive numbers of herbivores. If overgrazing is continued too long, climax plants will be replaced with less palatable and productive plants. That further reduces nutrition available, and finally will be followed by invasion of poisonous plants, thus curtailing grazing animal numbers more dramatically.

Notice that all these factors also affect production of domestic animals. Ranchers can and have offset some adverse effects of overgrazing by additional supplemental feeding and parasite control, immunization and health treatment, and control of undesirable plants and animals.

These practices, if above normal levels, treat symptoms rather than causes. They increase costs with lowered returns compared to wise grazing management which balances animal numbers to available forage for maximum net return.

The XXX Ranch

We have tried to keep these principles clearly in mind as we developed and applied a comprehensive management plan for our own ranching operations over the past 20-plus years of my 40 years' ranching experience. With inadequate capital, adverse weather and economic conditions, I could not have survived otherwise.


James A. Glynn

I am a fourth-generation Texas ranchman and operate under the XXX brand established by my grandfather in 1872. The XXX Ranch as it presently exists was begun in the tall grass prairie near Fort Worth, Tex., in 1961.

This is an area of limestone parent material overlain by dark, inherently fertile clay loam soils of varying depths. Average annual rainfall is 31 inches. The average first and last killing freeze dates are Mar. 25 and Nov. 11 with a growing season of 231 days in between. There is occasional snow or ice in the winter that seldom lasts more than a few days.

Principal grasses are Big and Little bluestem, Indiangrass, Switchgrass, Sideoats grama,

A successful ranch depends on proper use of the range. This means grazing according to the amount of forage available for use, always leaving enough leaf area for regrowth, soil protection, and reproduction.

Texas cupgrass, Meadow dropseed, Silver bluestem, and fewer cool season grasses such as Canada wildrye and Texas wintergrass. There are many climax forbs such as Maximillian sunflower, Blacksamson, Pitcher's sage, Illinois bundleflower, and wild vetch.

With overgrazing, the same resources will produce annuals and low quality perennials such as Japanese brome, Texas grama, Windmillgrass, threeawns and other invaders such as broomweed, ragweed, prickly pear, and mesquite.

Forage production is 3,000 to 8,000 pounds of air dry forage per acre per year on deeper soils in good to excellent range condition, and 500 to 1,500 pounds in shallower sites and poor range condition.

Basic Range Practice

On this ranch and any other, proper use is the basic range practice on which all other practices depend for success. Proper use is defined as grazing according to the amount of forage available for use, always leaving enough leaf area for regrowth, soil protection, and reproduction. A standard guideline has been using half and leaving half of the annual forage production by weight.

The three principal factors in proper use are stocking rate, distribution of grazing, and species and class of livestock grazed. There are several different ways to estimate carrying capacity in order to set, monitor, and adjust stocking rates.

We principally have used the range site and condition guides developed by the U.S. Department of Agriculture's Soil Conservation Service. Then each fall we estimate the total forage available at the end of the growing season in order to calculate, by a method I devised, carrying capacity during the dormant season.

In areas where numbers of grazing wildlife are significant, sufficient forage to meet their needs should be deducted to determine the carrying capacity available for domestic livestock.

Twenty years' records by these methods on one part of the ranch indicate a 100 percent difference from high to low carrying capacity over that period of time. If we had stocked at a level rate, we would have been overstocked or understocked all the time and lost money either way.

Flexibility Needed

This record underscores the need for a flexible plan that will respond to changing conditions in a timely manner without undermining breeding programs and tax management. By making frequent (once or twice a year) adjustments in small increments, we have avoided increased costs or forced sales on down markets in bad times and taken full advantage of good forage years as they came.

Tools used in making these adjustments include early and/or deeper culling of the breeding herd to cut back. But even more important is carrying over a greater or lesser number of our own calves as replacement heifers or stocker animals, or taking in cattle from other people if that option indicated more income with less risk. We sometimes sell cattle for future delivery or hedge with commodities futures to reduce risk and lock in favorable prices when available.

There is no doubt that carrying capacity can be increased with carefully planned rotation systems, but two principles emerge fairly clearly. One is that for any given set of conditions, an optimum stocking rate should be determined and used. The other is that as carrying capacity increases, stocking rate can follow it upward with continued improvement. Conversely, there are adverse effects if stocking rate exceeds carrying capacity.

In monitoring use, we generally watch the key plant or plants that will reflect proper grazing use for that period. During the growing season, we key on 50 percent use of the best plant that makes up 10 to 15 percent of the total composition. In our case, this is Big bluestem or Indiangrass, which will increase rapidly if protected in that manner, while livestock performance is enhanced by consuming the better parts of better plants.

The method provides a gradual buildup of forage by the end of the growing season to be used during the dormant season.

After frost, we key on 50 percent use of the total forage available to have that amount remaining about Mar. 15, as the new growing season begins. In seasonal grazing areas, the operator would shoot for 50 percent use by the end of the growing and grazing season in the fall.

E. T. Jacobson

Big bluestem is one of the key plants in monitoring proper grazing use on the author's ranch near Fort Worth. During the growing season, ranch management keys on 50 percent use of the best plant or plants that make up 10 to 15 percent of the total composition.

Look Down, Not Across

One other point in monitoring rangeland is always to look down on it for accuracy, not across it. Looking across will cause one to underestimate range condition, because the lower order plants receive less use and are taller and more obvious than the better ones bearing more of the grazing burden. Looking across usually will cause overestimation of forage available because of looking at the height of seed stems rather than pounds of leaves available.

In appraising condition or kinds of plants, be sure to identify specific vegetative characteristics. Too often short grass such as curly mesquite or buffalograss is given more credit than it deserves, when blue grama, sideoats or even Big bluestem grazed short actually is bearing the burden.

Even with the proper stocking rate, uneven distribution of grazing can cause areas within a pasture to be undergrazed or overused with resulting losses in both instances. Several factors affect grazing distribution—including size of pastures, selective grazing by season, species, or stage of growth, topography and soils, prevailing winds, location of water, shade, shelter, bedgrounds and feedgrounds, density of stocking, and adequate supplemental feed.

Studies of grazing habits and activities of cattle indicate they typically graze into and away from a water facility twice each day and a bedground twice each night, causing these areas to be subject to four times as much traffic and grazing as other areas.

If developing water facilities of some sort every quarter- to half-mile by pipelines and troughs or dug tanks is economical, animals will tend to graze from water to water, rather than into one and out repeatedly.

Cattle graze to and away from salt, mineral (phosphorus and calcium supplement) and feed located away from water, subjecting them to twice as much grazing as areas between.

Placing Salt, Mineral

Contrary to popular belief, cattle do not proceed from salt to water, but graze to mineral and away before watering. Placing salt and mineral at water facilities increases the overgrazed and unproductive area, while placing mineral (or other supplemental feed) in underused areas can increase use.

We place mineral in the least used area and also feed nearby during the dormant season until more even use is achieved before moving to the next least used area.

We feed a high protein supplement during the dormant season to increase use and digestion of low quality forage. Any protein deficiency will slow digestion and passage, which reduces total intake and nutrients available for maintenance and production. The deficiency also encourages chasing green growth when it is inadequate in quantity and dry matter to meet requirements.

Supplemental protein feeding should be initiated or increased when fill is inadequate and droppings become hard and dry, indicating slow passage of ingesta, and may be reduced or ended as fill returns to normal and droppings loosen.

The source is selected on the basis of least cost per pound of digestible protein and may include three days of grazing wheat pasture, if available, with four days out. Other options include whole cottonseed or three-quarter inch cottonseed pellets purchased, delivered, and stored in bulk at a savings of $17 to $20 per ton compared with sacked feed.

By developing water facilities at frequent intervals, ranchers can encourage even distribution of grazing. Animals will tend to graze from water to water, rather than return to one repeatedly.

Donald C. Schuhart

Feeding Frequency

We feed no more often than we need to check the cattle, as little as twice per week, to reduce labor and vehicle cost without reducing production. We feed hay only in ice or deep snow. For three of the past four years, no hay was fed to any animal on pasture.

Species of livestock and proportion of each should be selected on the basis of grasses, forbs and browse available, topography, climate, available facilities and markets, and predator situation. Grazing distribution can be improved, income diversified, and total offtake increased by using more than one species of complementary livestock, but any of the above factors may limit choice of species. Predators alone have prevented many areas best suited to sheep and goats from being used by them.

Prescribed burning of rangeland under controlled conditions just before initiation of spring growth on a rotational basis can improve grazing distribution dramatically. Burning can be especially helpful on tall grass prairie where accumulation of ungrazed material is common or to encourage consumption of less palatable species such as tobosa, Alkalai saccaton or Gulf muhly. In addition to improved utilization, animal performance usually is improved by the higher quality of fresh forage available, and some reduction in competitive brush and weeds may be attained.

The next step beyond proper use in efficient grazing management is employing some method that provides intermittent grazing and rest during the growing season. A number of different methods have been devised during the past 40 years with the growing realization that continuous grazing, even at a light stocking rate, means the same preferred plants and sites will be grazed and regrazed with little or no chance for recovery as long as animals have access to them.

Since plant food is manufactured in the leaves, all plant growth—including root growth—depends upon sufficient leaf area to provide energy from photosynthesis. Research indicates that severe or continuous grazing stops root growth for a month or more before resuming at a reduced rate. For this reason, ranges that have been grazed on a continuous yearlong basis require rest periods of 90 days or more to achieve much recovery or improvement.

25% Productivity Rise

Most standard deferred-rotation or rest-rotation grazing methods, including those developed by Leo Merrill and Gus Hormay, provide extended periods of deferment or rest to meet these needs. The reliable and widely used Merrill system involves 3 herds with 4 pastures, with each pasture being grazed for 12 months followed by a 4-month rest. This system usually has resulted in a 25-percent increase in range and livestock productivity over time, with few management problems.

Universally, those who independently and persistently pursue intensive grazing management automatically evolve into a one-herd, several-pasture (seven or more work best) method with both grazing and rest periods of short duration. This is the route that many others and I followed with a considerable investment in time and money, only to find these methods and related matters addressed in interesting detail in Andre Voisin's *Grass Productivity*, published in 1959, carefully covering 300 years of application and research in grazing management.

Ideally, grazing periods should be six days or less during rapid growth periods to prevent second clipping of new regrowth in the same grazing period. Even shorter grazing periods favor maximum livestock production.

Longer stays mean regrowth will be regrazed before the plant has an opportunity to produce and store more nutrients. Extremely long stays force the animals to less total intake of lower quality forage, with reduced production.

Rest periods should be only long enough for renewed leaf and root growth. A longer period will reduce forage quality and encourage the plant to go reproductive. A shorter period will reduce plant vigor and forage available. Rest periods may be as short as 12 to 18 days in lush growing periods, and lengthen to 60 to 150 days in slow growth or dormant periods.

XXX Ranch Evolution

A high intensity-low frequency grazing system was initiated on our ranch in April of 1973, with 1 herd on 6 pastures, and has evolved into the short duration system in use at the present time. Three of the pastures had been in a 3-pasture 2-herd system for the previous 10 years. The other 4 pastures had been in 2-pasture systems with 4 months of rest followed by 4 months of grazing in each cycle for the previous 3 years.

Initial grazing and rest periods chosen for the 1-herd system were too long at 40 to 200 days respectively. This resulted in rapid range improvement but a drop of 100 pounds in weaning weight.

Changes in subsequent years to 25/125 and then 18/90 restored normal livestock production and maintained range improvement. A seventh pasture was added, and times were reduced to 10/60 and then 7/42. Grazing times for each pasture are adjusted to carrying capacity.

We have been able to run a short duration system with good results without changing or adding any fences. But it is obvious that a central cell system would greatly reduce livestock handling and labor involved in pasture rotation. The cell resembles a spoked wheel with water and corral facilities at the hub and several pastures radiating from it.

Our intensive rotation has

been used primarily during the growing season from April to October. During the dormant season we use slower moves of one herd or change to three- or four-pasture systems of two to four herds with longer grazing and rest periods to facilitate feeding, breeding, or calving and evening up underused pastures. When the principles are understood and applied, there is great flexibility to accommodate changing conditions.

Not only has there been an increase in vigor and production of all desirable plants with the short duration system, but a remarkable increase in Big bluestem and Indiangrass and the reappearance of Switchgrass, Florida paspalum, and Canada wildrye, which were almost extinct.

Carrying Capacity Boost

With proper use and short duration grazing, we were able to increase our carrying capacity by 50 percent even though 4 of the past 5 years had adverse weather and growing conditions. There is no doubt that we can increase another 50 percent over time.

Compare that kind of opportunity to the average 1 percent a year increase in livestock productivity possible through genetic selection, which receives so much attention. The keys are close observation of the condition of grass and cattle, flexibility and timely adjustment in duration of grazing and numbers of animals, and adequate, economical supplemental feeding.

Combined with intensive crossbreeding, ruthless culling for economically significant characteristics, and a sound animal health program, we have averaged weaning a 94-percent calf crop for the past 4 years, counting all losses from failure to conceive, abortion, mortality near birth, disease and predator losses.

We begin calving Mar. 1 to reduce winter feed costs and weather losses. Over 90 percent of the calves are born in the first 45 days of the calving season. Steer calves from mature cows have paid on a weight of 575 pounds at an early fall average weaning age of 6½ months.

Grass Cover Needed

We have found there is no substitute for adequate grass cover to suppress invasion of undesirable brush and weeds. Spot treatment of critical areas has maintained adequate control at very little cost. No reseeding of desirable plants has been necessary. We use plowed firelanes along public roads to reduce the fire hazard of dry forage.

The application of knowledge in a comprehensive, coordinated, communicated management plan is by far the most efficient and effective tool in ranch and range management. Knowledge minimizes the need for and maximizes the effectiveness of purchased inputs. Ranching that is both ecologically and economically sound increases productivity, profitability, and pleasure.

Texas Cattlemen and Shrubland Know-How

By Bill E. Dahl,
Henry A. Wright, and
Fred S. Guthery

Before 1850, the western three-quarters of Texas was less wooded than it is today. Shortgrass prairie in west Texas was "boundless as the ocean . . . not a tree, shrub or any other object . . ." By contrast, the Rolling Plains always had honey mesquite, but the "mesquite timber" was open enough that traveling was easy through lush grass from Big Springs to the junction of the Clear Fork of the Brazos River.

The Edwards Plateau consisted of prairies mixed with cedar brakes, oak savannas, thickets, and mesquite savannas. The Rio Grande Plain could be described in a similar manner. The Blackland Prairie on clay loam soils in east-central Texas alternated with a mixture of post and blackjack oak savanna on sandy soils. The Coastal Prairie consisted of grasslands rimmed by woodlands. The Pineywoods in east Texas had longleaf and slash pine with an excellent understory of grasses, except along river bottoms where hardwoods dominated.

Thus, historically, Texas was a land of grass, rich in beauty with a variety of landscapes and shrub mixtures. Following the control of wildfires and the introduction of heavy livestock grazing, density of shrubs and trees has multiplied, even in the relatively treeless shortgrass prairie. Some areas of the State are thickets with few understory herbs.

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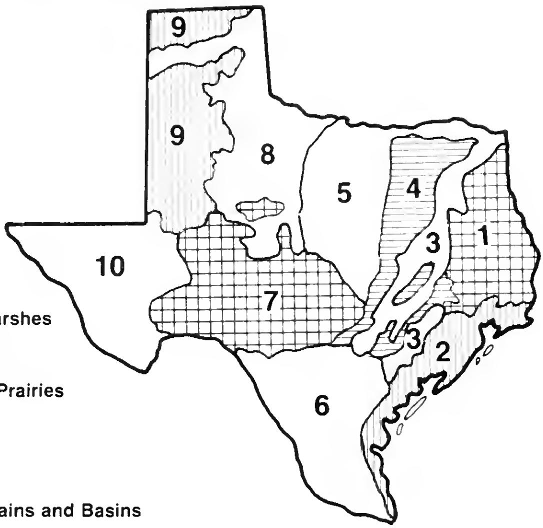
Vegetation Areas of Texas



1. Pineywoods
2. Gulf Prairies and Marshes
3. Post Oak Savannah
4. Blackland Prairies
5. Cross Timbers and Prairies
6. South Texas Plains
7. Edwards Plateau
8. Rolling Plains
9. High Plains
10. Trans-Pecos, Mountains and Basins

Of the 157 million acres of agricultural land in Texas, 95 million are rangeland, 16 million are pastureland, and 10 million are forested. These are all extensively grazed by domestic livestock. In addition, many of the cropland acres are seasonally grazed. Thus livestock is the major agricultural commodity in Texas. Also, fee hunting provides significant income to landowners with the bulk of it on the brush-infested rangelands of the State. Increasingly, enjoyment of nongame wildlife, such as bird watching and wildlife photography, make the State's rangelands valuable for nonlivestock enterprises.

Because the shrubs infesting most of the State's rangelands have value as wildlife habitat, the removal of brush to enhance livestock management must be planned to maintain a valuable wildlife and recreational resource. Thus, most managers deal in "brush management" rather than "brush eradication."

Differences in climate, soil, and topography provide 10 distinctly different vegetation groupings. The Pineywoods of east Texas has low elevations and high rainfall (35 to 50 inches). On the other extreme is the westernmost region, the Trans-Pecos Mountains and Basins, with high elevations and less than 12 inches of annual precipitation.

Major Texas Shrubs

Of the many economically important Texas shrubs, honey mesquite is the most widespread, especially in the Rolling Plains, and is regarded as a pest in all vegetation regions except the Pineywoods. It grows on all soils but is poorly adapted to deep sands. Its forage is little used by animals but all animals relish the ripening beans. Junipers, known as "cedars," occur mostly in central (Edwards Plateau) and west Texas on limestone soils and areas with rough topography. They tend to spread into the more level grasslands if fire is suppressed for long periods.

Only five of the more than 76 species of cacti in the State occur so densely that they become a problem. These are Texas, Engelmann and plains prickly pear; tasajillo; and cholla. Although they occur throughout the State except for east Texas, they become a problem primarily in the South Texas Plains and the Edwards Plateau.

Liveoak, post oak, and blackjack oak are trees that grow mostly in central and east Texas. Pygmy oaks called "shinnery" are low in stature; one form grows in the finer textured soils of the Edwards Plateau and the other grows in sandy soils of the High and Rolling Plains. Acorns provide important feed for livestock and wildlife. However, the new young leaves of all oak species are toxic to livestock, often necessitating animal removal from infested pastures during spring green-up.

Huisache, guajillo, and blackbrush are acacias that form dense thickets in the South Texas Plains and Coastal Bend areas of south Texas. Whitebrush or beebrush infests the Edwards Plateau and the South Texas Plains. Saltcedar, a water-consuming phreatophyte, forms dense thickets along streams and reservoirs in the High and Rolling Plains and in the Trans-Pecos. Sand sagebrush is a low growing shrub of sandy soils on the High Plains. Creosote bush and tarbush form dense stands in the Trans-Pecos region. In east Texas, pest shrubs are yaupon and winged elm.

While the shrubs mentioned are the most commonly encountered, many others such as the various yuccas, catclaw species, persimmon, lotebush, and ceniza become abundant enough in some regions to be the objects of control efforts.

Water Use by Vegetation

Southwesterners worry about water use by undesirable vegetation, particularly when it is reported that 10 million acre-feet of water is transpired into the air by Texas brush. This reportedly exceeds that used by all the towns, factories, farms, and people in Texas. There are many examples of springs drying up as shrub density increases.

In the Edwards Plateau, the Rocky Creek (a tributary of the Concho River) watershed had several thousand acres cleared of mesquite during the late 1950's and the early 1960's. This creek had not flowed except during floods for many years. Within five years after clearing the mesquite, it became a perennial stream which flows year-round through wet and dry years alike. Thus, judicious, well-chosen shrub control can yield extra water to landowners as well as downstream users, including municipalities.

Shrubs make gathering livestock extremely difficult as livestock soon learn they can hide in dense thickets. Shrubs compete with herbaceous plants, depressing forage yields usually in proportion to the foliage they produce. Thus, methods to control brush have been vigorously pursued in Texas. Approximately 2 million acres of brush are treated each year in Texas.

Shrub Control

Choosing the proper control technique for management of shrubs is more complex than most realize. Control of one species often releases another which could be equally detrimental; a herbicide that suppresses a species on one soil often is ineffective on another. More commonly, what controls one species will not control another. The effective rate of herbicide application also varies among species and the timing of application must be fit to the problem species. Often an effective herbicide cannot be used because it reduces yields of desirable herbaceous understory species.

Management of shrubs with chemicals requires one to choose between foliar or soil-applied herbicides. Dangers to nontarget crops, ornamentals, and water supplies are real and these are reasons why pelleted herbicides are often used instead of foliar sprays (applied to foliage). Chemical uptake by plants from pelleted herbicides is via the roots. However, as of this writing, pelleted herbicides are not

C. A. Rechenthin

Of mechanical means to control shrubs, generally only rootplowing and disking will destroy the understory herbaceous vegetation well enough to allow reseeding.

effective on all troublesome shrubs.

Foliar-applied herbicides must be translocated within the plant to the roots and site of basal buds from which resprouting occurs. Translocation from leaf to below-ground plant parts must be done within 42 to 85 days after spring leaves emerge on most shrubs. Best kills from herbicides have been obtained 72 to 80 days after budbreak. Further complicating chemical control is the fact that soil temperature must be optimum for active below-ground metabolic processes. This is usually between 75° and 85° F for Texas shrubs.

If mechanical means are to be used to control shrubs, one again has several choices. When areas to be mechanically cleared of shrubs are in poor range condition and need to be seeded, only rootplowing (which is a large blade pulled behind a crawler tractor about 12–18 inches deep to sever brush roots) and disking will destroy the understory herbaceous vegetation well enough to allow reseeding. Cost of mechanical control choices becomes another major reason to choose one technique over another. Number of plants per acre usually dictates feasibility of mechanically grubbing trees or shrubs.

Shredding or mowing effectively removes top growth of much brush, but it kills few plants and basal sprouting species resume growth with more stems per unit area.

Combinations of Tools

Increasingly, managers of shrub-infested rangelands use combinations of tools to increase degree and longevity of control. For example, mesquite infestations needing control where seeding is not desirable or feasible are mostly controlled initially with aerially applied herbicides. In two or three years some of the plants' roots will be dead and commonly 50 to 75 percent of the plants will be sprouting from the tree trunk near the ground. With moist soil, chaining (an anchor chain up to 300 feet long pulled between two crawler type tractors) two ways can topple the standing mesquite trees, pulling many of them out of the ground—sprouts and all.

Fire is a popular alternative to chaining following herbicidal control on sites having adequate fine herbaceous fuel. In west Texas, many mesquite stands have a tobosagrass understory with more than 3,000 pounds of fine fuel per acre. Using prescriptions worked out for such areas, managers can dictate the degree of burndown of herbicidally controlled mesquite trees to satisfy management goals.

Managers also use fire following a herbicide-chaining program to suppress any surviving sprouts, reduce cactus populations, reduce annual weeds, and remove the wood left from chaining. Juniper is most successfully treated by chaining with a burn three or four years later. Note that each control technique is

Edward Seidensticker

Chaining is used in combination with aerially applied herbicides to control mesquite. Several years after the herbicide application, most plants are dead or sprouting only from the trunk. An anchor chain, pulled between two tractors, topples the standing mesquite trees.

chosen for a specific purpose and to complement the action of others.

Wildlife Habitat

Rangeland shrubs provide essential habitat to game and nongame wildlife. Browse, the foliage of brush plants, is a dietary staple for white-tailed deer. Scaled quail depend on the seeds of mesquite and other woody plants. Bobwhites, the most popular gamebird in Texas, require dense brush canopy for loafing cover between morning and evening feeding periods. Cardinals, lark sparrows, mockingbirds, and other nongame birds nest, rest, and feed in brush. No brush, quite simply, means limited wildlife populations. Fortunately, wildlife management can be integrated with brush management to meet multiple objectives.

When the primary objective of brush management is to increase forage production for livestock, key brush communities and species can be preserved to maintain or improve wildlife populations. A typical approach is to control brush in strips alternated with untreated strips. For bobwhites, the treated strips can be up to 400 yards wide and the untreated strips can be about 30 yards wide. Deer and wild turkeys require more brush. At least 40 percent of a pasture should be maintained in communities of woody plants for these animals. The coverage of shrub communities has to be higher—up to 70 percent—the more level the terrain. The diversity of nongame birds can be increased by treating brush-infested areas with strip patterns, because physical and compositional diversity of the habitat will be increased.

In some cases it may not be feasible to control brush in strips, so block patterns become necessary. Block patterns—treating large acreages in square or rectangular blocks—usually should be avoided if the landowner desires maximum returns from wildlife. However, by treating areas of 200 to 500 acres (the smaller the better for wildlife) and by intermingling older treated areas with newer treated areas and untreated areas, the landowner can maintain respectable wildlife populations.

Whether strip or block patterns are used, the method of brush control influences wildlife response to brush management. Game managers like to use highly selective mechanical techniques, such as bulldozing. The cost of this approach limits its application.

Herbicides depress forbs (herbs other than grass) for one to three growing season post-

treatment, and this may depress wildlife populations for a similar period. Forbs are steak and potatoes to many species of wildlife because they are high in protein and phosphorus. If, however, the herbicide treatment suppresses a highly competitive species like mesquite, both forb and wildlife populations may bloom after the initial period of shock.

Prescribed burning has been used to manage bobwhite habitat in the Southeast since the 1930's, so it is not surprising that fire can be readily incorporated into livestock-wildlife programs. Prescribed burning generally must be considered a low-priority management tool on the arid peripheries of a species' range. Burning is most attractive where annual precipitation exceeds 30 inches, grazing is light, or brush densities are excessive.

Grazing Systems

Traditionally, Texas ranchers have grazed their shrub ranges continuously because we have been unable to consistently show that other management alternatives provide higher net returns. Consequently, most range management principles and range improvement practices have evolved to complement continuous grazing. These basic principles are:

1) Balance animal numbers with the forage resource or "don't overstock"

R. J. Nail

By controlling brush in strips alternated with untreated strips, a Texas rancher provides increased forage production for livestock while preserving key brush communities and species for wildlife populations—in this case, deer and wild turkey.

2) Graze the range with the proper kind(s) of animal (with a good mix of palatable shrubs, grasses and forbs, such as the Edwards Plateau, where cattle, sheep, goats and deer often graze in common)

3) Graze at the correct season of the year for the sake of both forage and animal health, and

4) Properly distribute livestock over the range.

Within 20 years after the expansion of cattle from south Texas into west Texas (late 1850's), observers noted that the ranges were rapidly deteriorating. Along with overstocking, blame was attributed to restraining the domestic animals year-round to a fixed area. Buffalo were free roaming and while they concentrated in large numbers on the open range, no one area had them for an extended period. Thus, the concept of providing periodic non-use or deferment was suggested.

Despite many attempts to find ways to defer ranges for improvement, no one devised a scheme that was as acceptable to ranchers as continuous grazing. Although most attempts to simulate wild animal grazing through rotation management provided range improvement, none gave individual livestock performance comparable to continuous yearlong grazing.

In the western U.S. it remained for Dr. Leo Merrill to demonstrate (around 1950) that distributing animals throughout three pastures and leaving one seasonally deferred could provide both good range improvement plus excellent livestock performance. This also proved highly desirable for wildlife management.

Probably the most common forms of deferment management have been simply to switch livestock back and forth between two pastures. These programs helped, but range improvement was slower than many desired.

Short Duration Grazing

During the last 15 years, several forms of management collectively called short duration grazing have been tested. These involve six or more pastures (often as many as 15 to 20) and usually one herd; and the animals are rotated from pasture to pasture at intervals dictated by the manager's goals.

In Texas, such programs initially provided 15 to 30 days grazing in a pasture and 3 to 6 months deferment before regrazing that same pasture. This provided excellent range improvement, ample time for browsed shrubs to recover, and increased stocking rates. However, most ranchers found livestock performance less than optimum because the animals ran out of preferred forage before movement to the next pasture, and the long deferment period allowed forage to become over mature and of little nutritional value.

More recently, Texas ranchers are rapidly adopting short duration grazing programs where animals are rotated among several pastures every 2 to 3 days and the deferment period is from 30 to 60 days, depending on the rate of forage growth. The longer deferment is used when the forage is growing slowly or is dormant. This allows animals to be selective as they are in and out of a given pasture quickly and then they return to the pasture before the forage is overmature.

This rapid movement among pastures is much easier if pastures are arranged in a cell or pie shape with water and mineral supplement usually in the cell center. Thus, animals return to the same watering facility regardless of the pasture grazed. This has also allowed plant deferment at critical times. The most important time to rest pastures is 6 to 8 weeks before frost.

Cell systems increase harvesting efficiency, because formerly large pastures were divided into 8 to 16 or more smaller ones, thus correcting many distribution problems. Several ranchers with 3,000 to 10,000 acres in a pasture have found it possible to more than double stocking rates using this approach.

The large numbers of pastures in these short duration grazing programs have made shrub management much more flexible. Pastures with severe brush problems can be skipped by grazing animals and the shrubs treated chemically, mechanically, or with fire. Thus, any given pasture can be deferred to allow range recovery or to build up fine fuel to carry fire for brush management and control. The multi-pasture single herd grazing programs have great potential for integrating grazing and game management.

Integrating Grazing, Wildlife

Wildlife species respond uniquely to grazing programs. Depending on the area, heavy yearlong grazing may result in habitat favored by killdeers and jackrabbits. Prairie chickens, on the other hand, need the high range condition promoted by a carefully designed grazing system. Requirements of most species will be met by grazing practices that fall somewhere between these two extremes.

We believe that grazing programs similar to the Merrill four-pasture, three-herd system presently represent the best complementary approach between grazing and wildlife production. On the Edwards Plateau of Texas, the Merrill system yields the best response by forbs, grasses, and browse plants for favoring diverse wildlife populations when compared to other methods of grazing.

Little is known about wildlife responses to short-duration grazing. However, concern that the concentration of livestock in smaller pastures will increase trampling losses of ground nests appears to be ill founded. Future research will have to pinpoint the role of short-duration grazing in livestock-wildlife management on the shrublands of Texas.

Livestock Predators and the Balance of Nature

By Walter E. Howard

How does the introduction of domestic livestock, especially sheep and cattle, affect the population density of wildlife? In what ways do the livestock change the balance of nature? What are the factors which sometimes cause coyotes and other natural predators to prey upon livestock?

Besides coyotes, many predators—including wolves, mountain lions, bears, bobcats, foxes, skunks, and eagles—regularly kill and eat small or large livestock. The reason it is necessary to control coyotes and other livestock predators is that they sometimes cause serious economic loss to people in the livestock and poultry industries. In this article our main interest is not the economics of livestock predation, but biological and ecological phenomena involved regarding coyotes and their control.

The goal of this chapter is to reexamine some of the biological and ecological viewpoints about the balance of nature in the hope that a clearer understanding will emerge concerning management of coyotes and other livestock predators on private and public lands. I want to stimulate you, the reader, to think more objectively about some of these environmental concepts.

First, it is important to recognize that there are no clear-cut right or wrong environmental answers concerning predator control and, in fact, with most environmental issues. The correctness of one's viewpoint, or

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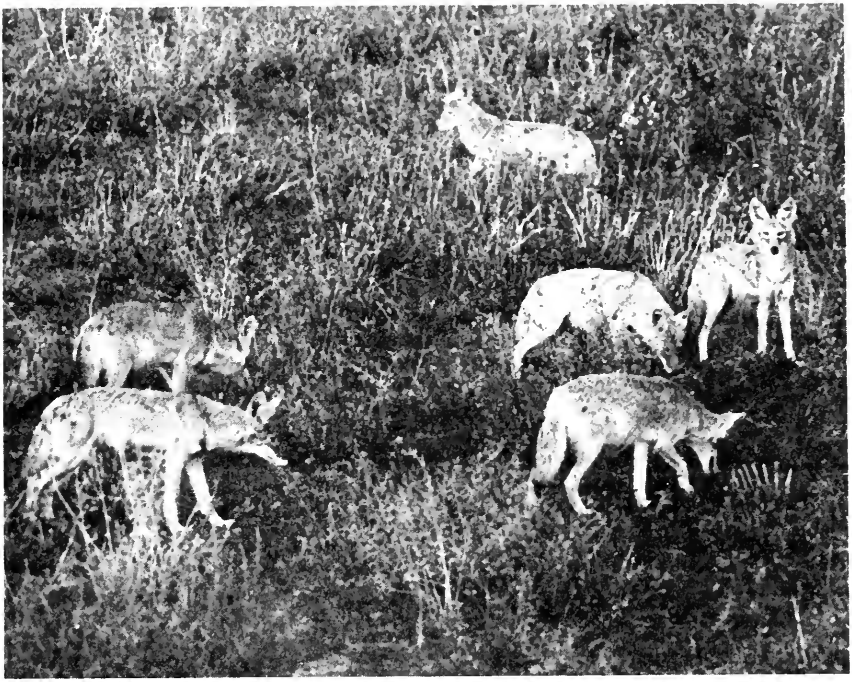

Young coyotes at the U.S. Fish & Wildlife Service predator research facility near Logan, Utah.

of a political decision on such matters, depends entirely on how such a view is defended.

All wild animals in nature, whether coyotes, eagles, rodents, or rabbits, play some environmental role. However, we seldom realize that many of these functions are not really essential for the welfare of people, or for that matter, for the benefit of most other species of wildlife.

Not Links in a Chain

Coyotes, rodents, birds, and other wildlife species are not like links in a chain where just the loss of one species will have deleterious effects on all the others. No matter what people do to the country around them, the environment is not eliminated; it is only changed. And what appears detrimental to one kind of wildlife may, at the same time, actually favor others. By practicing good wildlife management procedures, such as hunting or fur trapping, especially where natural predators have been reduced, we can then consume some of the products of our conservation practices while at the same time maintaining healthy animals.

So that we can live in our chosen environment, we usually modify the plant and animal communities, at least where we live, by eliminating troublesome animals and generally introducing nonnative plants and domestic livestock and pets. Natural animal-plant-soil relationships which have evolved together over very long periods of time are usually quite stable and can generally recover if disturbed.

On the other hand, when we put domestic livestock on rangeland, they often cannot coexist with coyotes or other predators. This same phenomenon occurs with most agricultural crops and ornamental vegetation, since these plants have not evolved the necessary resistance to cope with wild grazing and browsing mammals such as deer and rabbits, and also insects. This is because these plants and animals did not evolve together.

It is commonly thought that the web of life that permits plants and animals in an ecosystem to live together harmoniously is very delicately balanced. As far as most of our native wildlife is concerned, this is not so. When populations of coyotes, ground squirrels, and other wildlife pests are controlled to make livestock production economical, such artificial manipulation of the density of one or more species of wildlife has relatively little adverse effect on other wildlife species in those communities.

Predator control is no different than other forms of pest control. Ranchers control coyotes and other wildlife species to prevent them from taking what they want and need, whether it is livestock, ornamental plants, agricultural crops, or stored food. For clarification, when we "manage" wildlife, we are primarily concerned about that species' welfare locally, whereas animals are "controlled" either to protect other species of wildlife, to prevent damage to resources, or for other benefits to people.

It is interesting to note that one's value judgment concerning competing or pestiferous wildlife is determined principally by the manner in which the animal is affecting that person. When someone is not affected by an individual or population of animals, one's attitude usually is that such wildlife should be left alone. People generally think that what was here before modern man appeared on the scene is the best. However, to the livestock operator, coyotes become a pest when they take more livestock than the operator is willing to share with predators.

Balance of Nature

Technically, the "balance of nature" is the web of relationships among the population densities of the diverse species that make up ecological communities. But from a practical point of view, the balance of nature is the struggle for existence, that is, survival of the fittest.

Nature is harsh and cruel. Every organism is living off some other organism and in turn is itself eventually eaten. Wild animals, unlike domestic livestock, must be constantly vigilant to prevent being injured or killed.

Wildlife rarely die a nice death in nature, and nature has no life-support devices or homes for the elderly.

Since the public usually does not adequately hunt or otherwise harvest most deer herds where their natural predators have declined, barren females or does with only one fawn are a common sight. Wouldn't it be much nicer if all does had healthy twins? Due to inadequate management (hunting) of such deer herds, it is likely that many of the missing fawns suffered from malnutrition, exposure, predation or disease and died prematurely. If domestic livestock were managed this poorly, the ranchers would probably be arrested for being so inhumane.

Ecologically, the human population can exist quite independently of most species of wildlife. Nevertheless, I hope everyone will agree that we should preserve at least viable populations of all wildlife species for ethical and moral values, even if they are not essential for our survival.

People do not eliminate habitats no matter how drastically they alter an environment, and the new habitats produced will favor some species. As long as the earth has an abundance of green plants, organisms to consume the plants, and other organisms to feed on dead plants and animals to recycle the chemical elements, the survival of humankind will be largely unaffected by even drastic changes in the species composition of various birds and mammals, regardless of whether they are native or exotic species. Actually, we humans usually benefit when we substitute agricultural crops for native plants in the environment and when we use modern agricultural techniques.

New Kinds of Habitats

Despite the unfortunate extinction of many animals, such as the passenger pigeon, during historical time, today there are many more different kinds of animals than before living on all continents of the world except the two Poles. This is partly because we have created new kinds of habitats, introduced many kinds of fish, birds, mammals, other wildlife, pets, livestock, and accidentally allowed many species to escape. Some of these additional species, such as the house mouse, starling, and carp, may not be desirable to everyone, but that also applies to some native species such as a pocket gopher in your lawn or a deer browsing on your young pear tree.

Since forests provide us wood for our houses and we also utilize other types of vegetation, we may not want to see vegetated areas converted into deserts as has happened in parts of the world. But, from an ecological point of view, such newly formed desert areas are actually being managed quite well if one's goal is to help desert-adapted species.

The reason most of us do not like to see the environment changed is that we have been conditioned to distrust any human intervention in the natural world. Because of the "man must not meddle with nature" philosophy, we tend to assume that to interfere with nature is bad. Of course, we would not think of landscaping our own gardens with just native vegetation, which we call weeds.

The major world ecological crises of today are caused by the human population explosion, soil erosion, excessive deforestation, especially in the tropics, desertification, and the man-made chemical compounds (pollutants) that are not being adequately recycled. Upsetting the balance of nature in these manners is certainly not desirable.

Even though coyotes are high up on the food-web pyramid, their presence is not very significant ecologically. When wolves largely disappeared from the United States, coyotes became more abundant. Without coyotes there would probably then be more bobcats and foxes but little else would be affected.

Little Interdependence

For the most part, there is little interdependence among different species of mammals and other wildlife that live in natural situations. When the density of one species of vertebrates is artificially altered, it usually will have little or no effect on the other species of wildlife present.

For example, the effect the removal of all deer in North America would have on other vertebrate species would be negligible except for wolves, mountain lions, and coyotes. But predators always suffer when their prey is eliminated. Eventually, without deer grazing and browsing the vegetation, the resulting changes in the habitat might then affect other kinds of wildlife.

A species will generally do well if its habitat is favorable. There are interacting intrinsic (within the animal) and extrinsic (external) forces that regulate the densities of predators and other wildlife species. These include food supply (although only rarely do populations continue to grow past certain upper densities no matter how much food and cover are available), dispersal movements, predation, diseases and parasites, social factors such as defending a territory, aggression, reproduction, and other related stress factors, and environmental conditions such as weather, fire and other catastrophes.

An important regulatory factor that is very difficult to measure is an animal's ability to adapt to changed environments, which is determined by its inherited behavioral traits. Most species suffer when the environment is changed, but some—like the coyote, rat, starling, and house sparrow—seem to do better with the changes.

There is no question that natural predation can be an important mechanism for regulating some animal population densities. If coyotes or other predators were eliminated, there would be some shift in the density and species makeup of that animal community. Initially, most of the predator's prey species would temporarily increase in density. Then, depending on the species, after a generation or two they would probably decline and, even if a cyclic species, never again attain the densities they reached when they were being regularly harvested by predators.

To keep a natural population of deer or other prey healthy, once predators have been removed, we must harvest the annual surplus that is born each year by hunting, trapping, or some other means of control. Good husbandry of wildlife requires an adequate harvest just as does good livestock management. The reason most coyote populations are so healthy today is that people function as an effective predator through coyote control operations.

Predator Control Ecology

Why do natural predators become troublesome? It is simply because they have evolved as predators and humans provide them with prey species which, in the process of domestication, have lost most of their predatory defenses.

Why are coyotes a problem? They are successful, prolific, and evolved as predators. They are adapted to attack fleeing prey, like a running jackrabbit or sheep. Unlike grizzly bears, wolves, or bison, which cannot be tolerated in areas where many people live, coyotes can live close to large human populations. Coyotes can even live in cities and feed on our garbage, cats, small dogs, melons and fruits.

After settlers moved west and largely eliminated the wolves, coyotes greatly increased in numbers and also extended their geographic range from just the western United States to all of the contiguous 48 States, north through Canada to Alaska, and south through the rest of Mexico to Costa Rica in Central America.

The natural diet of coyotes is highly variable and includes rodents, rabbits, deer, berries, and melons. However, many coyotes are also very effective predators of man's possessions and often kill cats, dogs, sheep, goats, poultry, and cattle. They often eat dead things but probably produce much more carrion than they consume by leaving much of what they kill.

Like most predators, coyotes kill and eat livestock in a way which can hardly be considered humane, and they sometimes get into a killing frenzy, killing far beyond their needs (surplus killing). Coyotes prefer to attack living prey and instinctively grasp the throat of a fleeing sheep and hold on until the sheep suffocates. This behavior does not have to be learned; it is instinctive.

Verifying Sheep Kills

Research has shown that it takes coyotes an average of 13 minutes to suffocate a sheep, and they often tear open the animal and eat the entrails while the sheep is still alive. It is easy to verify most coyote kills of sheep by the characteristic canine puncture wounds and evidence of hemorrhaging found under the skin on the neck of the dead sheep.

Coyotes range widely and do not recognize property boundaries, hence the responsibility for controlling them should be under government auspices. Otherwise, individual landowners might be unable to cope with those coyotes that sneak in from adjacent properties without resorting to extreme control measures.

Even though it is very doubtful that eliminating coyotes would have any undesirable ecological consequences, no one proposes their extermination. The objective of those who suffer livestock losses from coyotes is to stop the depredations. Sometimes the eradication of all of a small number of local coyotes is the only solution to the problem. In our experiments, when we removed the killer coyote, another of the group then became the killer.

Predator control—in fact all animal damage control as now practiced in the United States—has no significant effect on the basic flow of materials and energy in the environment. Vertebrate pest control operations do not damage the welfare of wildlife communities in man-modified environments.

Early humans in the United States, however, probably exterminated some of their prey species, just as the first humans to reach New Zealand did to the giant flightless moas. Also, human beings have eliminated many predators, of which the European lion is probably the first such extinction to be recorded in historical times.

Need Different Methods

Many different control methods are needed to protect livestock because of the great variety of behavior exhibited by coyotes, the diversity of physical environments where they are found, and the different livestock management practices that exist. The ecology of coyote depredations to livestock is highly variable in different situations, and sometimes coyotes and sheep exist together quite peacefully.

Control methods that offer varying degrees of protection from coyotes include use of herders, shed lambing, guard dogs, coyote-proof electric fences, fumigation of pups in dens, traps, shooting from the ground or aircraft, hunting with dogs, snares, and M-44s that eject cyanide into the mouth of coyotes that bite and pull on the device. Some protection has been claimed by using llamas as guard animals, various odor repellents, sound-producing devices like portable radios and acetylene exploders, and aversive conditioning with lithium chloride or other agents.

So far, however, at least in many parts of the West, no single method or combination of these methods has adequately protected livestock from coyotes. Hence the need for additional toxic chemicals such as Compound 1080 and strychnine.

Conclusion

With reference to coyotes and many other wildlife species, it is a fallacy to claim that the balance of nature is delicate and easily disrupted. Natural communities containing wildlife wouldn't exist if they were not highly stable and quite resistant to most external forces. To design a management scheme for livestock predators such as coyotes, that does not sometimes require the use of poisons and traps, is beyond the expertise and inventiveness of current science.

Humans are highly territorial and claim absolute dominion over other organisms around their homesteads. For example, average homeowners will not tolerate snakes, rodents, birds and other wildlife species that conflict with their interest or well-being; at least they do not tolerate them with equanimity. What is right or wrong about most environmental decisions, including coyote control, is a personal value judgment.

Modern animal-damage control methods usually treat animals more humanely than nature does. Biologically, the control of coyotes is similar to good livestock husbandry practices in that the removal of surplus individuals allows more of the young to survive and live healthier lives. In modified environments the human race manages or controls problem wildlife species under far better husbandry and animal welfare conditions than does nature.

Instead of a zealous but biologically unsound "protectionist" ethic, what is needed is a better "conservation" or "wildlife control and management" ethic. Those with genuine compassion for wildlife will not let nature take its course in environments that humans have altered; instead, they will attempt to manage and control the various species of wildlife and their habitats in order to establish the best possible harmony between people and nature.

If you want animal communities to function harmoniously (although not humanely), it is necessary to either have a variety of different kinds of natural predators to remove the surplus wildlife born each year, or people must act as the predator. To let the balance of nature create new balances in environments we have modified may not be very rational nor ethical because of nature's brutality and cruelty. Therefore, once people disrupt a natural environment, they have a moral obligation to manage and control the various wildlife species present, including coyotes and other livestock predators.

Eagles Saved From Electrocution

By Allan R. Ansell

Allan R. Ansell is Environmental Studies Coordinator, Idaho Power Company, Boise.

Simple survival isn't all that simple anymore for birds of prey which claim as home the skies over the Nation's rangelands.

Raptors have been starved out as agriculture converted ranges to farms, wiping out the habitat of the jackrabbits, ground squirrels, mice and reptiles on which the birds feed.

And in the past, under the guise of predator control, thousands of eagles and hawks in Western States were shot from aircraft.

But all this has not gone without notice, and someone is doing something about it.

The eagle slaughter of the 1960's resulted in a public mandate for legal protection of both the bald and golden eagle. National concern spurred the passage of Federal protection for both species.

At the same time, public concern prompted field work to identify other human-related causes of raptor mortality. One cause pinpointed was accidental electrocution by electrical distribution lines which crisscross the range.

Release of this information, and the accompanying public concern about the eagles, gave rise to an investigation of the electrocution problem by a western electrical utility and a raptor expert. This research led to an extensive program to eradicate the offending features of distribution lines and a highly successful raptor conservation program.

Wildlife Film Man

The association between conservationist and utilities began in March 1972, when the Idaho Power Company, headquartered in Boise, asked birds-of-prey authority Morlan W. Nelson to assist with an investigation of the electrocution problem.

Nelson, also of Boise, has spent most of his life studying and working with raptors. He has been a consultant and photographer on Walt Disney wildlife films and has traveled internationally as a falconry consultant. Nelson was a natural for the job.

Intent of the studies was to identify causes of electrocution and develop corrective measures.

Falconers and others knowledgeable about eagles know the birds are extemely selective in their choice of landing sites. And, in order to identify preferred landing sites, one must have an intimate knowledge of eagles' behavior, of prevailing winds, and topography.

Poles as Perches

In areas of the West barren of cliffs or trees, raptors favor specific power poles as hunting and feeding perches. They usually prefer poles having crossarms crossways with the prevailing wind and in a commanding topographic position. By examining poles fitting this description, it is possible to pinpoint those preferred by eagles.

Eagles' selectivity was pointed up when it was discovered a single pole might have several dead birds, either shot or electrocuted, beneath it. Often other poles along the same line did not indicate eagle activity.

Obviously, this selectivity simplifies corrective efforts by reducing the number of poles requiring modifications.

Initial field investigations by Nelson and Idaho Power personnel revealed most eagle electrocutions occurred on relatively small lines of between 20,000 and 69,000 kilovolts. Two types of poles were found to be involved.

Many electrocutions occurred on single-phase lines with a conductor mounted on top of a pole and a ground wire extending to within a short distance of the conductor.

Single-phase current is carried to homes, businesses, factories and farms by a two-wire circuit. It is a common mode of electrical service delivery to locations not requiring high power.

The second hazardous design was found to be a three-phase, single-pole line with crossarms 6 to 8 feet wide. Conductor spacing was too close to allow a large bird to land safely and without touching wires on either side simultaneously, thus forming an electrical pathway through its wings.

It also was noted poles with additional electrical equipment—such as transformers and jumpers—and corner poles sometimes could present special safety problems to raptors.

Trained Eagles Used

In order to examine exactly how power lines interfered with eagles' activities, a mockup of the offending power poles and lines was built. Nelson's trained golden eagles would fly to these mockups, their flights documented on 16mm film.

Studies of slow-motion photography taken during these test flights demonstrated electrocution could occur if an eagle with a 6- to 8-foot wingspan made contact simultaneously with two phase conductors or a single phase conductor and a ground wire.

A practical solution appeared to be placing conductors and ground wires at sufficient distance from each other to prevent simultaneous contact. This suggestion was made to utility engineers, who redesigned poles accordingly.

'Streamlined' Design

A mockup of the new design was built and tested, again using trained eagles. The new design featured conductors and ground wires supported by short sidearms projecting from the poles rather than by crossarms.

This configuration, known as the "armless" or "streamlined" design, now is used by many companies as a standard for construction in areas inhabited by raptors.

Having developed a fairly accurate idea of the how and why of eagles' problems with power

lines, utility personnel and Nelson proceeded with studies of existing lines to determine corrective steps to prevent electrocution.

Using similar study techniques, they came up with several methods of modifying existing poles that appeared to be hazardous.

Together they decided poles with crossarms could be rendered safe by lowering the arms holding the two outside conduc-

Morlan W. Nelson

tors and installing the center conductor on a pole-top pin. This would increase the distance between conductors.

To gain a safety margin, a distribution arm must be lowered enough to provide about 60 inches of separation.

Another method of obtaining the required separation is to install a pole-top extension supporting the center phase. This extension must be a minimum of 60 inches above the crossarm.

This eagle is courting death. If it happens to touch the wires on each side it could be electrocuted. Idaho Power Company engineers worked out modifications to prevent injury and death to these birds.

Morlan W. Nelson

Sturdy perches built above the power lines give eagles a safe landing site from which they can hunt and feed. It was found that eagles are selective in their choice of landing sites and not all utility poles have to be modified.

Wooden Perch Installation

An alternative to modifying the pole is to install a wooden perch a safe distance above the electrical equipment. The perch, generally made of sturdy two-by-four construction, must be high enough to allow the birds to clear the dangerous equipment, but not so high that they can continue to land in the danger zone. A maximum distance of two feet generally is recommended.

Installing insulation over conductors is another reliable and inexpensive way of making hazardous lines safe. Conductors may be covered with material such as pvc pipe extending about 6 feet on either side of the pole. Jumper cables also should be covered when this method is used.

Although several methods of pole modification are available to correct problem lines, utility engineers need leeway in selecting methods. This allows the utility to design the most reliable, economical line to serve customers and still protect raptors.

Following are some suggested priorities in selecting the type of modification to be used:

1) When new line construction is being considered, the preferred technique for reducing the likelihood of raptor electrocution is streamlined or "armless" pole configuration. Although this technique may require more poles per mile of line than stand-

ard crossarm construction, actual cost of the new line may be lower because of the availability and market conditions of construction materials.

2) On existing crossarm structures, raising the center phase may prove to be the most effective method of modification and serves to properly isolate electrical parts

3) Gapping ground wires, when consistent with design needs of the utility, has proven to be an inexpensive and effective way of modifying poles. It is recommended highly in appropriate situations

4) The addition of insulation to conductors is effective, but it has the disadvantage of needing periodic inspection and maintenance. This is because insulating materials may decompose over time

5) Use of pole-top perches is beneficial in some instances. Spacing of the perch above the conductor is extremely important in this technique. Perches are particularly useful when a large amount of hardware is located at or near the top of the pole or when transformer banks, switches and other equipment are so situated.

Ironically, Nelson's research also served to exonerate utilities of raptor deaths in some cases.

There has been a long-standing tendency to assume a bird found dead beneath a power pole died of electrocution. However, close examination of the carcass is required to positively identify the cause of death—not always electrocution, but sometimes gunshot wounds, diseases, malnutrition or poisoning.

In electrocution cases, birds often will exhibit severe burns and evidence of trauma. The feet, beak or wings are most likely to show burns; however, this is not always the case. Lethal electrical currents can pass through an animal without leaving visible signs.

Careful Check Needed

Careful examination of a bird—including skinning or X-raying the carcass—is essential to avoid erroneous diagnosis of cause of death. Many birds reported killed by electricity later were found to have died from other causes.

A case in point occurred in the Camas Prairie region of Idaho. A conscientious person reported to the local electrical utility that he had found 18 supposedly electrocuted birds under various distribution lines located in the vicinity.

Utility personnel inspected the lines, and most turned out to be telephone circuits, which do not carry sufficient electrical charge to cause electrocution. Other lines carried electricity, but had phase spacing too wide to allow electrocution.

In this case, pesticides and shooting became the prime suspects. Only one of 18 reported fatalities turned out to be electrocution. Corrective action was taken on the suspect poles and no further incidents were reported.

'Double Whammy'

In other cases, birds having physical marks indicating electrocution also had other injuries likely to have been the actual cause of death.

One such incident involved a bald eagle. A sportsman was watching the bird, perched on a distribution line, when another person, some distance away, fired a rifle. The bullet struck the eagle. As the bird fell to the ground, it spread its wings and came into contact with phases on the power lines. It naturally received a jolt of electricity, burning several wing feathers.

The offending hunter escaped without punishment. However, the witness found, upon inspection, that the bird was alive and took it to Nelson. The bird succumbed after three days to the double whammy of the shooting and electrical shock.

While the Idaho research was being conducted, the Edison Electric Institute—through the efforts of Richard Thorsell, environmental program manager—coordinated a workshop to study problems of raptor electrocution on power lines. Participants included western utilities, various state and Federal agencies, and other interested groups.

As other utilities became aware of the research being carried on in Idaho, they began cooperative work on specific problems within their own organizations. Most notable is work done by the Utah Power and Light Company, Salt Lake City, and the Pacific Power and Light Company, Portland, Oreg. Cooperative studies among these utilities and Idaho Power continued through 1982.

Films Tell the Story

Several films have told the story of utility efforts to save raptors from electrocution. The first, *Powerlines, A Place in Nature*, was produced in 1974 by Idaho Power Company.

A second motion picture, *Silver Wires, Golden Wings*, was produced in a joint effort of several utilities and the Edison Electric Institute. It was circulated widely and received awards from cinematic associations and wildlife groups.

Among other efforts to disseminate the newly found knowledge, education programs have been incorporated in several land management training programs and in schools across the Nation.

It's worth noting the study of electrocution problems has led to other unexpected benefits for birds of prey. For example, nesting platforms were designed and installed on transmission towers, giving eagles safer, more permanent places to raise their young. And changes were made in utilities' treatment of eagles' nests.

Sticky Problem

Eagles often use very long sticks, up to 6 or 7 feet long, in nest building. If the sticks dangle down too far from the nest, they can make contact with an electrical conductor, allowing current to flow back to the tower. This can cause a line outage or, occasionally, a nest to catch fire.

Utility linemen customarily destroyed nests they found, only to learn later they were compounding the problem. Eagles are persistent when it comes to nest building, and will attempt to replace a destroyed nest.

Instead of dismantling nests, linemen now trim longer sticks hanging from them. With the nest left intact, each year the eagles add sticks to the top. If undisturbed, birds will use the same site year after year.

Advantages of Platforms

Nesting platforms have a number of advantages over wild nests. Chances are good that if they are placed on certain towers, the birds will use them over other areas on the tower. This allows the utility to control nest placement, and thus limits the likelihood that nest building will interfere with line operation.

Platforms also offer advantages for the birds. When properly constructed and placed, they provide protection from wind and sun to the young birds, increasing their chances of survival.

By providing a missing element—nesting sites—to otherwise suitable habitat, transmission structures may provide a much more positive impact on some wildlife species than ever imagined.

Wise use of nesting platforms as a management tool may result in benefits to species believed to be threatened or endangered. Bald eagles, ferruginous hawks and peregrine falcons are a few of the species that may reap this benefit.

The first test of nesting platforms was conducted in the fall of 1975 by Idaho Power, which erected six experimental platforms. By the following spring, five of them were being used and produced young birds. The future looks bright for use of this knowledge.

Further Reading

Prevention of Golden Eagle Electrocution is available through the Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, Calif. 94304. EA 2680, $11.50 per copy.

Protection of Bald and Golden Eagles From Power Lines, Bulletin 61-10, Rural Electrification Administration, Washington, D.C. 20505. Free.

Suggested Practices for Raptor Protection on Power Lines—The State of the Art in 1981 is available at the Raptor Research Foundation, Dr. Gary Duke, Department of Veterinary Medicine, University of Minnesota, St. Paul, Minn. 55108. $6.50 per copy.

Comeback of Grasses and Forbs

By Warren C. Whitman and Harold Goetz

The herbaceous portion of native range vegetation is made up of the grasses and grasslike plants (sedges and rushes) and the forbs, with the forbs considered to be all herbaceous plants other than those in the grass, sedge and rush families. In general, forbs are the broadleaved plants with showy flowers which add color and visual diversity to the range landscape. For a long time they were referred to—and to some extent they still are—as range "weeds." On range grasslands, the grasses and forbs constitute the major apparent vegetation.

If the range vegetation type includes abundant woody plants, shrubs and trees, as many do, the herbaceous plants exist as an understory to the woody plants. In most cases, unless the type is largely dominated by shrubs, the herbaceous plants provide the bulk of the forage for the grazing of domestic animals. Associated with the herbaceous layer may be plants of lower life form such as the algae, lichens, horsetails (*Equisetum*), clubmosses, and mosses.

Forbs deserve special mention. A great deal of attention has been focused on how to get rid of them, or at least control them. In the heyday of the chemical control fervor, nearly every common range forb had a specific treatment assigned to it for control or attempted eradication. But until recently little attention has been paid to their value in the diet of the grazing animal, their soil conservation potential,

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C. A. Rechenthin

Heavy grazing by domestic livestock is the major cause of today's seriously deteriorated rangeland. Wind erosion takes a heavy toll on range in this condition.

their singular significance to wildlife, and their general esthetic value.

It is thought that before the beginning of extensive grazing by domestic livestock, range ecosystems in the Western States were at a nearly stable natural equilibrium—with relative proportions of the grasses, forbs, and other plants varying somewhat in response to climatic and other environmental influences, but generally fluctuating moderately around the normal, or so-called "dynamic climax," condition.

Such a viewpoint is generally accepted, but the idea that this meant "grass up to the horse's belly" wherever you went in the range country must be viewed with some skepticism. No doubt all portions of the range were subject at various times to serious overgrazing by native animals, to extensive severe drought, to widespread wind and water erosion, and a host of other disturbances, somewhat similar to those experienced today.

Damage from Livestock

There is no question but that grazing by domestic livestock on semiarid and arid ranges of the West in the last 100-150 years resulted in extensive and severe range deterioration. Most of the deterioration apparently took place in the late 1800's and early 1900's under largely unrestricted grazing.

There was great alteration in relative proportions of plant species, in density of cover, and in vigor and productivity of the forage-producing components of the vegetation, mainly the grasses and forbs. In some areas greatly accelerated soil erosion took place; and probably throughout the range area as a whole scarcely detectable, subtle erosion effects resulted in less favorable growing conditions for the range plants.

The deterioration effects of continued heavy grazing on range vegetation are well documented. Grazing animals are selective in their diets as long as there is a variety of forage plants to choose from. They first graze those that they prefer. Nearly always the preferred plants are high in the successional scale, being the major plants in the vegetation when the plant communities are near their ecological potential.

In herbaceous vegetation the grasses are generally abundant and preferred, although a few forbs are grazed with relish. Sheep and some of the wild grazers show a preference for forbs, and depending on season, a direct choice of woody material. However, most forbs are utilized by grazing livestock to a lesser degree than are the grasses.

Effects of Heavy Grazing

The net result of continued heavy grazing of the preferred species is that they are weakened, their vigor declines, and their competitive ability relative to other species in the cover is greatly reduced.

Shifts in relative proportions of species in the cover begin to occur. The less desirable grasses increase, while the more desirable perennial grasses decrease. The less palatable forb component of the herbaceous vegetation increases. The way for the invasion of undesirable alien species is opened up, and they may begin to replace the original species in the vegetation. The effect of all these changes is that the plant cover on the range has moved down in the successional scale and the range has deteriorated.

Heavy grazing use by domestic livestock should not be interpreted as the sole cause for the widespread range deterioration on the semiarid and arid ranges. But certainly it has been the major cause. The suppression of range fires is thought to have had much to do with the remarkable spread of shrubs and small trees on the Southwestern ranges. The dissemination of seeds of undesirable plants associated with movement and transportation of domestic livestock and shipment of hay, the introduction of weed seeds with spreading crop production, and climatic effects—particularly those associated with drought—all have contributed.

Changes in Vegetation

In the last 50 years or so the catastrophic results of the weakened condition of the herbaceous components of the range ecosystems have become all too apparent. Both native and alien plant species have been involved in massive replacements of the desirable species by plants of significantly less forage value.

One of the best known examples of range deterioration is seen in the great increase in woody species, particularly mesquite (*Prosopis* spp.), in the ranges of the Southwest, where 70 million acres or more are considered to be infested by this species. Junipers (*Juniperus* spp.) too, have increased substantially in the Southwest and in the Intermountain region.

Sagebrush (*Artemisia tridentata*) stands in the Great Basin and adjacent areas have thickened greatly, reducing the perennial grass component in the sagebrush grass ecosystem and lowering the grazing value of the type. To a lesser extent, the increase of other woody plants such as creosote bush (*Larrea*), rabbit brush (*Chrysothamnus*), oaks (*Quercus*), shrubs of the chaparral, and introduced species such as the McCartney rose have contributed to lowered grazing values in a number of range ecosystems.

The increase of water-consuming phreatophytes in stream channels in the semiarid and arid Western States has been spectacular, with the saltcedar (*Tamarix*)—an introduced salt-tolerant tree species—becoming an especially vexing problem in these habitats.

Growth of native range vegetation is hampered by the increase of introduced water-consuming phreatophytes like saltcedar on streambanks in the Western States.

Spread of Cheatgrass

The annual grass, cheatgrass (*Bromus tectorum*), has spread over millions of acres of rangeland in the Great Basin and Pacific Northwest. It is definitely a species of lower grazing value than the perennial bunchgrasses of the native vegetation. What to do about cheatgrass remains an unresolved problem. Medusahead (*Taeniatherum asperum*), another introduced annual grass, poses a threat to ranges in the same general area.

Conversion of the California bunchgrass vegetation of the Central Valley and foothills to an annual grass and forb range took place long before 1900, and any attempt to convert the range back to an approximation of its original condition by controlled grazing and progressive succession has long since been abandoned.

It is impossible to devote space to adequately discuss the status of other species and what can be done about them. Prickly pear species and cholla cacti (*Opuntia* spp.), along with musk thistle (*Carduus*), *Halogeton*, and a host of poisonous plants, all of which can and do increase on deteriorated ranges, deserve mention. And now Northern Plains grassland ranges are being invaded by a relatively new intruder, leafy spurge (*Euphorbia esula*), which already infests over 2 million acres in the Dakotas, Montana, and Wyoming. A major cooperative research effort has recently been launched toward control of this intruder.

The temptation is strong to speak only of the threatening species, but it must be remembered that a host of desirable species remain in the vegetation of every range ecosystem. The legumes, some of which are poisonous, but many of which are palatable to livestock, especially the clovers, peavines, and trefoils, fix atmospheric nitrogen, and contribute substantially to the value of the range forage. Even the lowly dandelion, some of the sunflowers, balsamroot (*Balsamorhiza*), groundsels (*Senecio* spp.), and many others are utilized by domestic livestock and wildlife.

Grasses, Forbs Coming Back

Despite slow progress, and seemingly disastrous setbacks—such as the great drought of the 1930's—grasses and forbs of the range ecosystems have begun a comeback. Recent estimates place 28 percent of western and Great Plains rangelands in good or better condition (that is, producing near potential), 48 percent in fair condition, and 24 percent in poor condition. Unsatisfactory as these figures are, they indicate appreciable improvement from earlier situations.

It must be remembered that grazing has been a natural influence on range vegetation from long before historic times. Most range plant communities are highly resilient, and most of the original grasses and forbs are still there in the communities, although in many cases greatly reduced in abundance, vigor, and competitive ability.

Recognition of the need to apply ecological principles to management of range ecosystems has been and still is essential to restoring grasses and forbs of the plant communities. Natural successional processes must be controlled to initiate and maintain progressive successional trends; all this while some reasonable degree of forage utilization by livestock is taking place.

Obviously there are complications in a situation like this.

Site Status of Vegetation

By the end of the first quarter of the 1900's, it was generally accepted that there were recognizable plant successional stages in the deterioration and the regeneration of range plant communities. However, it was not until the early 1940's that a usable system for the quantification of the ecological status of the vegetation of range plant communities was developed and put into general usage.

Under this system, within relatively broad climatic, vegetational, and geographic areas, specific sites were identified—based on soil, topography, and relative proportions and productivity of plant species when in the climax or near-climax stage. Ecological status of the vegetation on the same type of site where grazing had altered the plant cover could then be established by comparison of the relative proportions of plant species on the grazed site as related to the species proportions for the site in the near climax condition.

Simple verbal expressions of the degree of departure of the vegetation from site potential such as excellent, good, fair, and poor have been used to express relative grazing value of the existing vegetation on any given site.

This system is not without flaws in both its theory and application, but the philosphy of the system represents the cornerstone on which the implementation of grazing management systems designed to initiate and maintain progressive successional trends toward site potential is based.

Environmental Limitations

Limitations to the ecological approach must be recognized. Environmental limitations are real and restrictive. The more arid the region the slower will be progressive succession under any type of grazing system.

Even under no grazing at all, environmental conditions on some sites may be so harsh that progressive succession can be so slow as to be barely detectable in a generation. Under favorable conditions progression from a lower condition class to the next higher class could well take from 5 to 20 years, if no treatment other than controlled grazing is applied. If serious soil erosion has damaged the system, further complications are introduced.

In extremely favorable conditions, where adequate precipitation and soil moisture are not problems, as in the ranges of the Southern and Southeastern States, the application of ecological principles to management becomes less important. Here the management may center on complete conversion of the vegetation to a seeded cover designed to provide maximum livestock production. This type of cover can be completely replaced if serious deterioration takes place under grazing.

Challenges Ahead

The challenge of the future is not to attempt to reestablish pristine conditions in the range ecosystems. This would probably be possible only in extremely local situations, and most likely would not be desirable. Grazing values for domestic livestock and wildlife are probably greatest at some stage in the ecological progression scale below that of full site potential.

The real challenge is to provide a vigorous, productive cover of vegetation, with a desirable mixture of grasses and forbs, or other forage-producing plants, which can be maintained indefinitely under an economically feasible grazing system, and which will successfully suppress invasions of undesirable alien species or unbalanced increases in native species.

Obviously this is a big order. In the long run, it may well involve more than an attempt to promote a known, definable, progressive succession. New and unfamiliar successional courses to new end products may have to be sought, or may take place whether consciously sought or not.

Under prehistoric conditions, range ecosystems were not required to produce a sustained output of livestock products, and there is no real evidence that they did. Present expectations are that these systems should yield a sustained output of livestock products under the existing economic and political system. The challenge to agricultural technology is to make a reality out of these expectations, while the resource itself is maintained and protected.

Challenges

Major areas of challenge at this time appear to be:

1) Continued development of improved grazing management systems for more efficient livestock production consistent with the maintenance of a desirable balance of range forage plants

2) Improvement of ways of controlling undesirable plants in range ecosystems, including development of more environmentally acceptable herbicides and more effective ways of applying them plus the increased applica-

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tion of biological control techniques

3) Broader application of the use of combinations of supplementary pastures and feedstuffs to supplement native vegetation in semiarid and arid range ecosystems

4) Development of systems and practices to speed up revegetation on both unfavorable and favorable sites, including increasing the certainty of success and reducing the risk in reseeding operations

5) Improvements in conservation and management of water for use in more efficient plant production by range vegetation.

Lastly, economic and political means must be found to provide for the integration of multiple uses of rangelands including grazing by livestock and wildlife, energy production, mining, timber production, recreation, and—where feasible—on and offsite water production. In many cases procedures which provide for comeback of grasses and forbs in range ecosystems may not be cost effective in our economic system. Ultimately, protection and maintenance of the basic range vegetation and soil resource may well become the major factor in its use.

The real challenge on the range is to provide a vigorous, productive cover of vegetation with a desirable mixture of grasses and forbs or other forage-producing plants that can be maintained indefinitely.

Forest Lands of the Continental United States

By Fred C. Hall

The United States is blessed with a rich mixture of tree species on its 494 million acres of productive forest land. About 50 conifers and 90 hardwoods grow throughout the country.

Productive forest land, which makes up 22 percent of the land area, are those lands which can produce 20 cubic feet of wood or more per acre per year. This is equivalent to about 100 board feet per acre per year.

These forests have other uses beside wood production. Fall colors can be beautiful with the yellows of western larch and quaking aspen silhouetted against rich green conifers of the West, or the brilliant red leaves of maple and the yellow of birch contrasted against pines in the New England States. The forests furnish a home for wildlife, protect watersheds from erosion, and may contribute gum for turpentine, sap for maple sirup, and forage for livestock.

Six major forest types are found in the United States. The Eastern United States is divided into northern forest, central oak-hickory, southern forest, and bottomlands. Western forest land is divided into the highly productive west coast and less productive interior forest.

Wilderness, Park Areas

Not all these lands are available for commercial wood production. Twenty million acres are reserved for uses such as Wilderness and National Parks, or have been deferred for possible inclusion in these kinds of

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dedicated areas. About 234 million acres, or 10 percent of the land area of the United States, is classed as unproductive forest land, land not capable of growing 20 cubic feet of wood per acre per year.

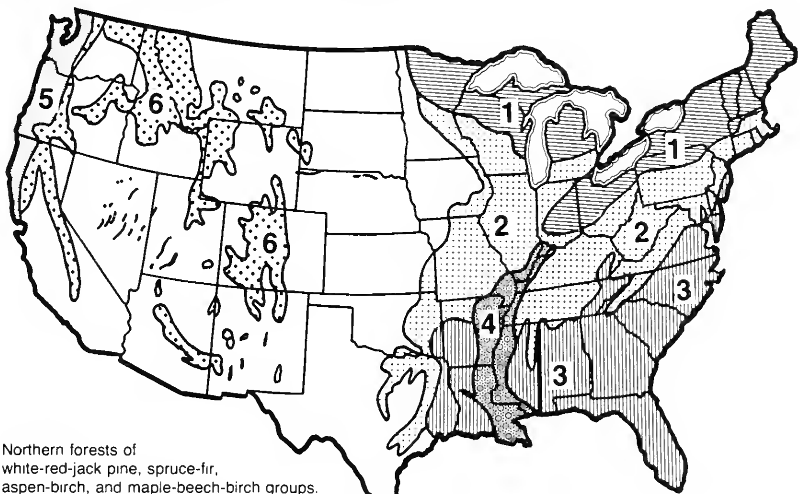
Climate and soil are primary, natural factors influencing distribution of the 19 forest groups that make up the six types of forests. Climate changes from cold in the North to warm in the South, while precipitation is too low in the Great Plains and in many parts of the West to support forests.

But precipitation and temperature are not the only climatic factors influencing forests. Storms affect them too. Hurricanes along the southeast coast influence the kind of tree species growing there and often disturb the forests. In the west, southeast and northern forests dry lightning storms start natural fires which tend to create or maintain some forest groups.

Soil is the other major natural factor influencing forests. In many cases, soils are poorly suited to agriculture due to low fertility, stoniness, or steep slopes.

Where topography permits, the better forest land soils have remained in cropland. Many farms occurring on poorer soils have been abandoned and have reverted or have been planted back to forest. These soils often pro-

Major Forest Types of the United States



1. Northern forests of white-red-jack pine, spruce-fir, aspen-birch, and maple-beech-birch groups.
2. Central forests of oak-hickory.
3. Southern forests of: Oak-pine, loblolly-shortleaf pine, and longleaf-slash pine groups.
4. Bottom land forests of oak-gum-cypress.
5. West coast forests of: Douglas-fir, hemlock-sitka spruce, redwood, and some western hardwood groups.
6. Western interior forests of: Ponderosa pine, lodgepole pine, Douglas-fir, white pine, western larch, fir-spruce, and some western hardwood groups.

duce a limited amount of wood and tend to grow only certain tree species.

Each combination of climate and soil produces unique environments in which only a few tree species can compete and grow. The same is true for shrubs and herbs growing under a tree canopy. It is the entire plant community—trees, shrubs and herbs—that produces habitat for wild animals, esthetic pleasure for people, and which protects our watersheds.

The People Factor

Climate and soil are natural environmental factors over which we have little control. However, people have been and will continue to be the major factor influencing vegetation. People have influenced forest land vegetation by logging, clearing for farming, and controlling fire.

Natural fire produced some of our most magnificent coniferous forests, such as red and white pine in the Lake States, Douglas-fir on the West Coast, ponderosa pine in western interior forests, and the productive southern pine forests.

When fires are stopped, trees that can grow in the shade will eventually dominate these forest groups. Hardwoods invading under pine often grow more slowly and produce a different quality of wood, wood that is of less value in the marketplace. Planned burning under forest stands is being used to maintain desired species in many parts of the country.

Forests have been converted to other uses ever since the days of colonization. Forests were cleared for farms, many of which were scratched out on poor, infertile soil.

Eighty years ago New England was about 60 percent forested, whereas today it is 80 percent forested. On 20 to 30 percent of the present forest area the original forest was destroyed, the land plowed and tilled, then abandoned, and now a new forest has developed. The same thing has happened in many areas in the South. This is a rather striking influence by people.

Top Quality for Kings

But disturbances to the forest such as fire and farming have affected less area than timber harvesting. During colonial days, highest quality white pine stands were reserved for the kings of England and France to supply masts for their sailing ships of war. Black walnut was selectively harvested for furniture and weapon stocks. Chestnut, at one time extensively used, was eliminated when people introduced chestnut blight from Europe.

The greatest impact on forest lands probably occurred during the industrial revolution, between 1860 and 1900.

During this time, clearcutting of red and white pine progressed from New England through the Lake States where, in 1900, the "inexhaustible stands of timber" suddenly disappeared in western Minnesota. Alarm over the devastation of timber caused the Federal Government to create Forest Preserves in the West, initiate fire suppression, and protect scenic areas as National Parks.

Since 1900, increased attention has been focused on sound management of forest lands. Low productivity farmland has been replanted to trees, and areas clearcut during the late 1800's have been reforested.

The concept of sustained yield forestry has gained nationwide acceptance. The forest industry has found it necessary to use sustained yield management to stay in business. This concept, of course, is required by law for management of National Forests and many other Federal and public lands.

Eastern Forests

The four eastern forest types are composed of 10 groups. They occupy about 80 percent of New England, 50 percent of the Atlantic Coast States, and 15 percent of the Central States where forestland soils are often amenable to farming.

The northern forest consists of four groups: white-red-jack pine, spruce-fir, aspen-birch, and maple-beech-birch. Maple-beech-birch occurs mainly on upland sites in the New England, Middle Atlantic, and Lake States Regions. In the Lake States, some sites are dominated by the aspen-birch group, composed of relatively short-lived species, that have occupied large areas following logging and fires.

Spruce-fir forests grow from New England and the Lake States north into Canada. They occur after long periods without fire.

Oak-hickory is the largest of the eastern forest groups. Much of this group is found either on abandoned farmlands or in mountainous areas. Since better soils have been selected for farming, this group is often of relatively low productivity.

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Oak-hickory is the largest of the eastern forest groups. Much of it is on abandoned farmlands or in mountainous areas. Since the better soils have been used for farming, much of this forest group is of relatively low productivity.

Pines and the South

Southern forests consist of the oak-pine, longleaf-slash pine, and loblolly-shortleaf pine groups. Oak-pine includes residual hardwoods left after merchantable pine has been selectively cut. On many timber industry lands, oak-pine is being converted back to nearly pure stands of pine.

Longleaf-slash pine occurs in the Southern States and along the Atlantic Coast, while loblolly-shortleaf pine tends to grow at higher elevations and further north. Both of these groups have been maintained in the past by planned burning under the pine canopy. They change to hardwood forests if steps are not taken to regenerate pine.

Southern bottomland forests of oak-gum-cypress are found primarily along the Mississippi River drainage. They include such valuable species as sweetgum, cherrybark oak, tupelo and bald cyprus. Productivity is often high.

Forests of the West

Western forests have been separated into the highly productive west coast area and the less productive western interior forests.

West coast forests consist of the Douglas-fir, hemlock-Sitka spruce, redwood and some western hardwood groups. They include some of the most productive forest areas in the United States. However, lack of prompt reforestation following clearcutting has converted some highly productive Douglas-fir and hemlock-Sitka spruce groups to red alder, one of the more productive western hardwood types.

Western interior forests consist of the ponderosa pine, lodgepole pine, interior Douglas-fir, white pine, western larch, fir-Englemann spruce, and some western hardwood groups.

Lodgepole pine, white pine, and western larch generally resulted when crownfire destroyed the previous stand and permitted these shade-intolerant species

This Douglas-fir forest on the West Coast produces 120 cubic feet of wood or more per acre per year. It requires only 16 years for one acre to grow enough wood for a three-bedroom house.

to dominate. Selective cutting tends to convert these stands to true firs and Douglas-fir. Ponderosa pine was maintained by natural burning under the forest canopy. Many stands are now changing to fir because of fire suppression.

Ownership, Productivity

Management of productive forest land is significantly influenced by objectives of the landowner. Ownership may be summarized according to: National Forest, other publicly owned land such as state and municipal governments, industrial-owned by timber companies, and farm ownership.

Farmers and other individuals who own forests generally do not produce a sustained profit from forest products because tracts are small and because the owners are interested in other endeavors, such as farming or recreation.

National Forests account for 18 percent of the productive forest land, other public 9 percent, forest industry 14 percent, and farm ownership 59 percent. Over half the western forest land is in National Forests. In the East, three-fourths is in farm and individual ownership.

Productivity of forest land varies dramatically from less than 20 cubic feet of wood to greater than 120 cubic feet of wood per acre per year. For example, an acre of forest producing 20–50 cubic feet per year requires 63 years to grow enough wood for an average three-bedroom home. An acre of forest producing 140 cubic feet per year takes only 16 years to produce the same amount of wood.

Average wood productivity for eastern forests is 74 cubic feet per acre per year. The West Coast averages 102 cubic feet compared to 62 cubic feet per acre per year for western interior forests.

Overall, 10 percent of the productive forest land produces 120 cubic feet or more of wood per acre per year. Twenty-five percent falls in the 20–50 cubic foot class. Much of this low productivity occurs in the western interior forest which also contributes significant forage for livestock grazing, wildlife habitat, and recreation.

A relatively large proportion of the better sites, above 85 cubic feet, are in forest industry ownership. National Forests and other public owners have a relatively high proportion of the poorer sites.

Forest Productivity

One cubic foot of wood equals 5 board feet of lumber. About 11,000 board feet of lumber are required to build an average three-bedroom home (1,600 square feet).

	Cubic Feet of Wood per Acre			
Conversions	*20–50*	*50–85*	*85–120*	*120+*
Average cubic feet	35	67	102	140
Board feet	175	335	510	700
Acres required to build one home	63	33	21	16
Years required for one acre to grow wood for one home	63	33	21	16

Forest Succession

The 19 forest groups are identified by trees that dominate the overstory. In many cases, these trees became established following a disturbance such as logging, fire, or farming. They require full sunlight for best growth and tend to be replaced by more shade-tolerant species.

The change from sun-loving to shade-tolerant species is called succession. Shade-tolerant groups include spruce-fir, oak-hickory, and maple-beech in eastern forests, and fir-Engelmann spruce, and hemlock-Sitka spruce in western forests. Most of the other groups are successional to more shade-tolerant species.

Take, as an example, oak regenerating under 40-year-old slash pine planted on abandoned farmland. After the final harvest of slash pine, oak will dominate the site and it will become an oak-hickory forest.

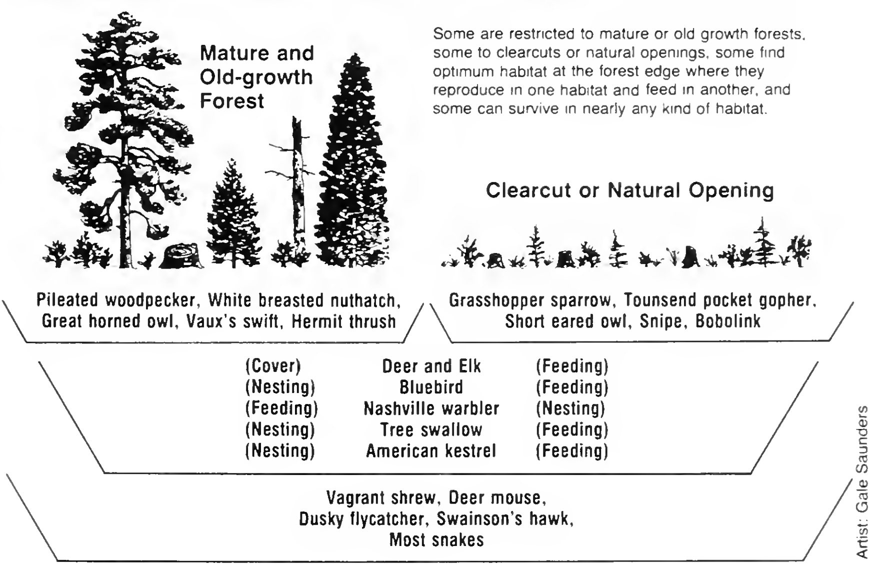
Western larch, white pine, and lodgepole pine generally reproduce poorly in shade and will be replaced by firs. Many ponderosa pine stands maintained in the past by natural fires are now, with fire suppression, being colonized by fir. A similar situation occurs in the West Coast Douglas-fir group, where western hemlock tends to replace it.

Timber harvesting methods greatly influence which species will dominate a forest stand. Selective cutting of southern pine encourages succession to slow-growing oak. The same treatment applied to ponderosa pine may convert it to fir. If successional forests are to be maintained, cutting and regeneration techniques such as clearcutting or shelterwood must be used.

Wildlife Relationships

Different wildlife species tend to be associated with each of the 19 forest groups. Species found in the northern forest of white-red-jack pine tend to be different from those found in the loblolly-slash pine of southern forests. Within southern forests, wildlife species found in loblolly-slash pine are different from those found in oak-hickory. As forest succession changes from pines to hardwoods, the wildlife communities change.

Preference of 20 Wildlife Species for Different Forest Habitats



Not only do wildlife species change with forest succession, but there also are different species within a forest stand and an adjacent opening.

Wildlife may be placed into four general categories: Those that reproduce and feed in mature- to old-growth forests, those that prefer openings or clearcuts, those that find optimum habitat at the forest edge, and those that survive in both forested and nonforested areas.

In the Blue Mountains of eastern Oregon, for example, the pileated woodpecker must excavate a nest hole every year in a tree larger than 22 inches in diameter measured at 4½ feet above the ground. Since this bird is a year-round resident, it also requires a supply of snags that house carpenter ants, its staple winter food supply. It clearly needs large diameter, mature, or old growth forests.

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A clearcut or open area is a preferred habitat for many animals. In the Blue Mountains of Oregon, for instance, about 40 percent of the wildlife species depend on natural openings or clearcuts for optimum habitat.

Gopher, Bluebird Needs

In contrast, the Townsend pocket gopher lives exclusively on clearcut sites or old burns. It leaves a burned or clearcut area when tree crowns merge.

The western bluebird lives at the forest edge. It nests in a cavity excavated by a woodpecker, yet prefers to feed in the open, not within the forest. Therefore, it needs a combination of trees near an open area.

Many wildlife species use both forest and open space for reproduction and feeding. The deermouse is a classic example. It can be found in moderate numbers within the closed forest. After clearcutting, however, the number of deer mice commonly doubles or triples because they can find more food.

In the Blue Mountains of eastern Oregon, about 40 percent of the wildlife reproduce and feed primarily in natural openings or clearcuts, 40 percent live primarily in mature- and old-growth forests, and about 20 percent can survive in both. The distribution of natural openings, or clearcut areas, has an important influence on the kinds and distribution of wildlife species.

Outlook for Timber

The land area in forests has been changing. For a while after 1900, abandoned farms were returned to timber production. This offset the conversion of forest land to residential areas, highways, and industrial sites. At the present time, however, there seems to be a gradual, steady but slow decrease in forest land area. While a gradually shrinking forest land base is a problem, the real concern is increased growth of wood and demand by the American people for wood products. Our increasing population demands more housing and other wood products such as paper, firewood and furniture.

The demand on U.S. forests can probably be met with improved timber management despite a shrinking land base. This does not mean, however, that we can supply all our wood needs. The United States has been consuming more wood than it produces since about 1945. In 1952, wood imports supplied 13 percent of our demand. By 1976 it had risen to 21 percent. Projections to 2030 suggest imports will be about 15 percent.

Demand, exports, imports, and supply of timber products from U.S. Forests with projections to 2030

Billion Cubic Feet

Item	*1952*	*1962*	*1970*	*1976*	*1990*	*Projected** *2010*	*2030*
Total U.S. Demand	11.9	11.6	12.5	13.4	18.8	22.8	25.5
Exports	.1	.5	1.5	1.8	1.5	1.5	1.3
Imports	1.5	1.9	2.4	2.8	3.8	4.2	3.8
Demand on U.S. Forests	10.8	10.2	11.6	12.4	16.5	20.1	23.0
Supply from U.S. Forests	10.8	10.2	11.6	12.4	16.5	20.1	23.0

*Projected based on relative prices rising from their 1970 level (inflation).

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Building a Family Along With a Family Forest

By Leonard A. Kilian, Jr.

Many American families hold the ideals of living close to nature and the privilege of land ownership in high regard. Much old-fashioned satisfaction can flow from a family forest.

Managing such a forest can be rewarding emotionally, spiritually and financially. As the forest-owning family develops ties to their forest, growth occurs in the family unit and its members as well as among the trees.

People have many reasons for owning forest land. Some inherit land, but an increasing number of previously unlanded Americans are purchasing family forests. Near or at the top of their lists of reasons for ownership are love of nature and speculation for financial gain.

Whatever the reason, it often is not easy to make the land productive and improve the natural beauty or wildlife habitat. However, difficult tasks can be eased by involving all or part of the family and developing a positive attitude for the hard work—an attitude that will serve family members through other challenges in the years ahead.

One of a new forest landowner's first tasks is to compare the deed and the land itself to make sure they match throughout the tract. The property corner markers should be in place and boundaries clearly marked or easily recognized.

Neighborly Attitude

Establishing good relations with adjoining landowners and neighbors is desirable and bene-

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Technical forestry assistance is available to new landowners through public forestry agencies, private or industrial consultants, and Extension Service forestry specialists.

fits all parties. Many possible disputes, perhaps even lawsuits, can be avoided by careful and continuous consideration of the rights and needs of neighbors and community residents.

Time spent getting to know these folks may even lead to more profits, besides reducing misunderstanding or possible hostility. Knowing them, their land, and personal situations may provide opportunities to help solve their problems and solidify friendships.

Involving younger members of the family in these neighborly activities can teach a lesson in cooperation without a boring lecture on the value of positive human relationships. The example of neighborliness is set and the lesson is more lasting than most adults realize.

Newly acquired land comes in almost as many varied conditions as the personalities of the landowners. Many forest tracts have been harvested either completely or partially. Other properties have excellent stands of beautiful and valuable trees. Regardless of original condition, a carefully thought out plan for the future is a must.

Public, Private Help

Few family forest owners have extensive expertise in forestry. Most need technical and professional advice. There are many sources.

Public forestry agencies, private forestry consultants, and a growing number of industrial forestry companies provide free advice or charge reasonable fees for assessing forest conditions and recommending improvements.

There is a State forestry agency in all 50 States and in Puerto Rico, Guam, and the U.S. Virgin Islands. They employ foresters to help landowners. The Extension Service in many

States employs forestry specialists to provide information and publications, and conducts periodic demonstrations of desirable forest practices. These agencies can also provide names of private forestry consultants.

A number of industrial forestry manufacturing firms provide assistance either free or at cost. Some companies will enter into long-term agreements to manage the forest if this is the landowner's wish. The point is, though, that a plan is mandatory.

However the forest management plan is developed, it can be a valuable reference in managing the long-term investment to improve a forest property. Most successful family forests have such a written plan based on the family's objectives.

From time to time the basic plan can, and in most cases should, be modified. Occasionally circumstances dictate a complete rewrite or revision. Considering all the family's needs and objectives contributes to the forest's success and keeps everyone involved, interested, and growing along with the forest.

Raising Capital

One critical factor influencing plan decisions is the availability of sufficient money or capital resources to support desired forestry improvements. Some families may have adequate financial resources to underwrite forest management activities. Or partial harvest cuts from the land itself may provide needed funds.

Financial incentives have been authorized by both the Federal Government and several States—including capital gains tax benefits, amortization of reforestation expenses, and cost-sharing payments such as the Forest Incentives Program. In Texas the forest industry and the Texas Forest Service are jointly sponsoring a reforestation program financed by the industry. All of these programs are designed to encourage landowners to regenerate forests and increase growth. Local foresters can provide up-to-date details.

Obviously, labor of the landowner and other family members including children can substitute for part of these monetary needs. Working together on a family forest project can knit the group into a tighter family and help children understand parental objectives.

Gradual commitment to the objectives—and even productive suggestions from family members to get the job done better and easier—will probably lead to more continuity in the plans in the future. Long-term involvement is more desirable than having unknowing heirs learn as a will is read that there are several or even hundreds of forest acres with only vague directions to guide the new owners.

Harvesting Products

Usually one of the objectives in managing a family forest is to obtain income at regular intervals. With most small ownerships, annual income is not practical except with special products such as hunting and fishing permits or Christmas trees. But funds for college or similar objectives are wonderful benefits to be returned from a family forest, and harvesting some products is the way.

Scheduling cutting operations requires thought to take advantage of better price situations, permit successful reforestation, and take into account many other personal needs and biological factors.

Estimating the volume and quality of wood to be cut can be an interesting family project. Determining the value of sizable areas or extremely high value tree species such as black walnut is beyond the ability of average woodland owners, but the volume of smaller sales of trees can be estimated by family members using relatively inexpensive tools.

Even with small sales it is always wise to have a professional forester advise how to make these estimates, and review the results before trees are put on the market. Services of professional foresters are well worth the fee charged when forest product sales are made.

Sales contracts are in many forms—from simple verbal agreements to very specific written documents of many pages with numerous conditions and limitations described in detail. When a sale involves large timber volumes and significant sums of money, it is wise to have a written sales contract.

Deeds May Be Required

Many States and timber-buying firms require a timber deed that is recorded in the local courthouse or similar repository of legal records. Professional advice from the legal, financial, and forestry fields should be obtained before the potential sale is offered to those who might be interested in buying the trees. Participating in the contracting process is educational for most family members.

After selecting the most advantageous offer for the wood to be sold, the cutting operation must be supervised by either the landowner, a family member, or a representative such as a consulting forester.

Even reputable timber harvesting crews occasionally will make honest mistakes and vary from the sale conditions. In most cases, frequent visits to the cutting area can prevent possible problems from becoming uncorrectable. These trips to the woods prove interesting and informative for the owner and others involved in the family operation.

Everyone who goes into the forest must be careful and alert for possible injury. A cutting operation with a number of workers moving about rapidly and dropping tall trees to the ground is probably the most dangerous woods activity, and all in the vicinity must know their safety lessons well.

Roads or Trails

An adequate road system is a capital investment in the family forest. If the land is to be managed for salable products, today's mechanized world requires access to forest land. This is also true throughout the cycle of other forest operations—from planting or natural seeding through preharvest improvement cuts, to final harvest either by individual tree harvest or cutting all the trees on selected areas.

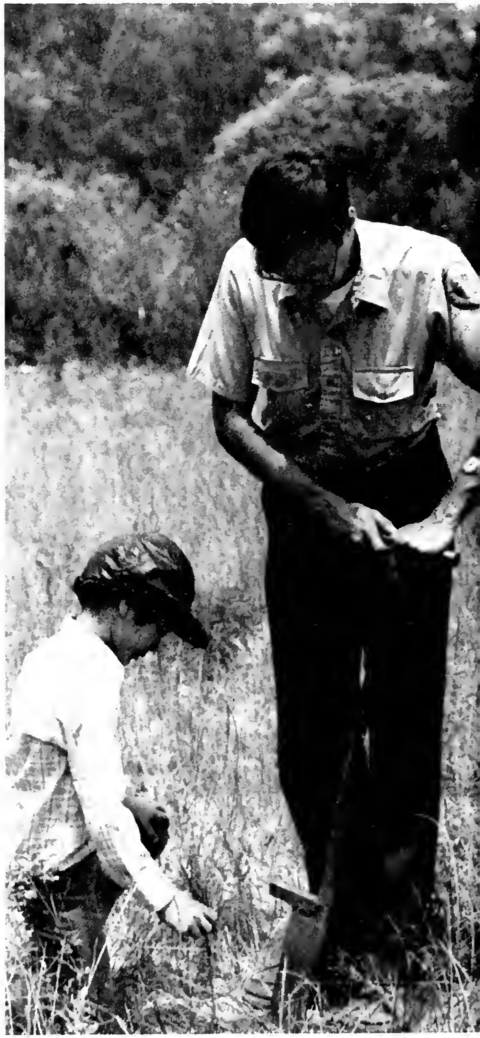
And the roads or trails are always there for family access for wildlife viewing, a few moments of solitude, enjoying the wildflowers, or perhaps a familly picnic.

Often a newly acquired tract of land will have open fields or other areas that should be planted with trees. Some acreages may have been harvest cut without replacement by desirable trees. Establishing a desirable stand often becomes one of the first actual forest management objectives to be achieved.

Selecting tree species to be managed is the initial step in a forestation project. Once again a local forester can give sound advice. The forester will usually be able to recommend a primary species choice and a secondary one depending on whether the family's goal is sawtimber or production of hardwood veneer or dimension stock, or if the family emphasizes the presence of wildlife or some other goal.

Planting Operations

Tree planting of open areas which require little or no site preparation can be an enjoyable family project even for relatively



Rhett Bickley

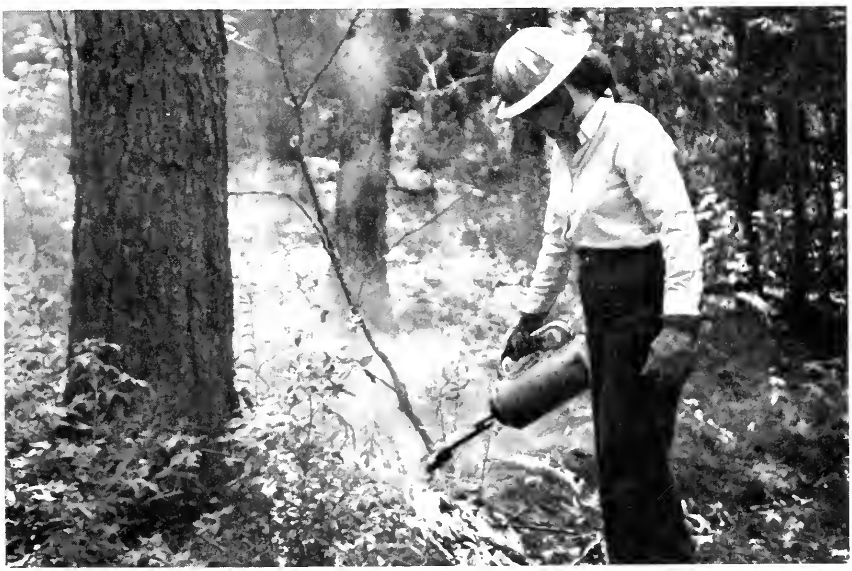
Tree planting in open areas can be an enjoyable project even for relatively young children.

young girls and boys. Areas where harvesting operations have left heavy vegetation, cull logs, and unmerchantable standing trees are of course more difficult to plant. Still, such areas may offer the family a chance to work together for the benefit of the forest and the family team.

Selecting the kinds of trees and the types of products the family forest is to produce is both an exciting family challenge and a significant decision that will have important impact on the activities needed to complete the growing cycle. Tree species and product objectives influence the amount and frequency of return besides the time the family must wait until the first harvest.

State forestry agencies operate tree nurseries that provide seedlings at or near production costs for landowners. In addition, some forest industries provide seedlings either free or at cost to individuals. State or industrial foresters will gladly give advice on how, when, and what species to plant for best advantage in the local area.

In some parts of the country a prescribed burn can eliminate much unwanted vegetation and not only make the planting job easier but reduce undesirable competition for sunlight, nutrients, and water needed by the desired tree species. Prescribed burning requires a high degree of knowledge of weather, forest



Rhett Bickley

Prescribed burning makes planting easier and reduces competition for the desired species. Because a burn requires expertise, it should be directed by a professional.

fuels, and fire behavior. Thus, a professional should direct prescribed burning operations. This is definitely *not* a do-it-yourself family activity!

Christmas Trees

Christmas is a family holiday, and growing Christmas trees a satisfying experience for a family too. If Christmas tree production is possible, practical, and desired by the forest landowners, an earlier financial return—compared to most timber crops—can be obtained. In most areas, Christmas trees require more sustained attention than trees grown for timber.

Many individuals who own forest land become interested in growing the trees while shopping at Yule tree lots in early December and comparing prices of various trees for sale.

Members of the local Christmas Tree Growers Association, who are already growing trees, and forestry agency personnel can explain the many cultural operations needed to bring a tree to the point of sale.

After planting, Christmas trees must be pruned or sheared to gain a higher percentage of shapely trees. Grass and other vegetation should be mowed at least annually to hold down competition and prevent the lower tree limbs from being misshapen. Insect and disease problems must be prevented, or controlled when detected. These operations lend themselves to involving the whole family.

The size of Christmas tree undertakings must be held within capabilities of the landowners and their families or the readily available labor supply. It is easy to become too ambitious when beginning. The most successful growers start small.

Fuelwood, Hunting

The forest may contain areas of trees that are both desirable and merchantable alongside undesirable and unmerchantable species. Condition of these stands can be improved by removing the unwanted trees. Careful consideration should be given to possible wildlife food production and cover benefits.

After these evaluations, some trees may be removed for fuelwood either for use by the landowner or for sale to others to offset part or all of the expenses of the timber stand improvement operation.

In some areas, fuelwood production is a primary reason for land ownership and these harvests bring comfortable profits. And what family wouldn't enjoy the warmth of a wood fire stoked with the products of their own forest?

Whether for fuel or not, removing competing vegetation by hand, chemical, or mechanical means can increase the volume produced by the crop trees and is another possibility for involving the family in improving the forest for their own future benefit.

In most areas hunting rights can be either allowed at no charge, leased seasonally to a group, or rented daily for individuals for a fee. This recreational use can contribute to the pleasure of ownership. If a fee is charged, the income can be used to improve wildlife habitat or other land use benefits.

Landowning families usually enjoy the outdoors, and fishing and hunting trips with friends and their families enhance the ownership experience.

Challenges Faced

It would be naive to overlook the possible problems of owning a family forest. At times they seem overwhelming.

Joint ownership with relatives or business associates dictates that a wider range of opinions and objectives must be considered when planning management. Differences in age, financial condition and need, reason for ownership, and changes in any or all of these over the time of ownership can make continuity of land management decisions difficult.

Attitudes of neighbors and area residents can also have both positive and negative effects on land management decisions.

Natural disasters such as floods, extended drought, ice storms, hurricanes, and forest insect or disease epidemics can change a favorable condition to a problem requiring immediate solution. In a short afternoon a forest fire can turn a beautiful growing stand of trees into a blackened liability that must be liquidated quickly.

Alert owners, with the help of forestry professionals, can adjust to these problems and often turn a bad situation into an opportunity with prompt attention.

Transfer of Property

Each owner must face the reality of eventual transfer of property. Some of the questions that must be faced are: Is continuity of family ownership a goal? Should a plan be developed to dispose of all or part of the forest property? What if economic conditions force a sale of the forest?

Involvement of the whole family will help in answering these questions. A predetermined outline for the future is an important part of forest land ownership for private individuals.

Owners of forest land have both rights of ownership and responsibility to others and society in general as a result of land being entrusted to their care. Many families believe the stewardship concept regarding land ownership requires that land be passed to the next owner in a condition at least as good as it was received. More desirable is for the new owner to receive an improved property.

Good stewardship should not be difficult. Many landowners readily combine personal profit with pleasure for the family while improving soil fertility, forest tree conditions, wildlife carrying capacity of the land, and last but not least the beauty of the landscape.

Super Trees for the South's Pine Forests

By Steve McDonald, Clark Lantz, and Pieter Hoekstra

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Pieter Hoekstra is retired from the Forest Service and is living in Alexandria, Va. He worked for many years as a forest genetics researcher in the South and in State and Private Forestry in Washington, D.C.

For over 30 years a quiet revolution has been taking place in the vast pine forests of the South. Foresters have been producing a new breed of "super" pine trees. These trees grow 10 or 20 percent faster than the average "wild" tree in the forest. They are also straighter, more disease-resistant, and produce more wood of higher quality.

These "super" trees perform better because they have been selected and bred to be genetically superior. All this work is part of the southern pine tree improvement program. The program has developed to the point that nearly half of all pine seedlings planted today are genetically improved.

By about 1995 all pine seedlings planted in the South will be genetically improved. Then the average improved seedling will grow about 25 percent faster than the wild trees and, as more time passes, the growth rate may go as high as 35 to 45 percent above average "wild" trees.

Genetic improvement of southern pines is important because southern forests comprise the largest timber resource in the United States, about 193 million acres of commercial forest. This resource is being strained by the demands of our increasing population, just as other forest resources are worldwide. Substantial amounts of land are being converted to nonforest uses.

Nation's Wood Basket

The South will have to provide a greater share of the Nation's

Cellulose bag prevents unwanted pollen from fertilizing a test tree. Pollen from the selected male parent tree is injected into the bag with a hypodermic syringe. Results from these tests determine which trees are retained in seed orchards.

timber needs in the future. In 1962 the South provided 37 percent of our softwood requirements. In 1976 it was 45 percent and the Forest Service projects it will be 47 percent by 1990. More and more the South is becoming the "wood basket" of the Nation.

The dramatic story behind development of "super" southern pines is one of professional dedication and intense cooperation by Federal, state, university and industry scientists, foresters and technicians. Phillip C. Wakeley of the Southern Forest Experiment Station of the U.S. Forest Service started a Southwide Seed Source Study in 1951.

Hundreds of foresters planted and measured performance of tens of thousands of seedlings on dozens of sites in all Southern States. The Station's Gulf Coast Research Center at Gulfport, Miss., became the Southern Institute of Forest Genetics. Development of superior gum-yielding longleaf and slash pine started by Keith Dorman in 1942 continued at the Lake City (Fla.) Research Center. The Station, in cooperation with the State of Georgia, also concentrated on seed orchard establishment at Macon and started various tree improvement studies from 1954 to 1959.

The first Southern Conference on Forest Tree Improvement was held in 1951. The Conference appointed a standing committee to coordinate forest tree improvement research in the South. This Southern Forest Tree Improvement Committee is still the principal coordinating committee for southern tree improvement activities.

Much of the credit for the success of tree improvement in the South is due to the cooperative spirit engendered by the pioneers of the 1950's and 1960's. In Texas in 1951 Bruce Zobel started the first university-industry tree improvement program in the South. Tom Perry started the University of Florida Cooperative Forest Genetic Research Program in 1954. In 1956 Zobel moved to North Carolina State University and organized what has become the largest of the university-industry cooperative tree improvement programs.

Grafting Material Supplied

The cooperative spirit seemed to be contagious from the very beginning of these programs. Timber companies, State forestry organizations, and universities all helped one another. Grafting material was freely exchanged as were pollen supplies, and on occasion personnel were loaned from one organization to another when an important job had to be done. New techniques were quickly passed around with no thought of proprietary information.

The 3 southern tree improvement cooperatives now in existence include 36 forest industries, 1 forest seed company, and 9 State forestry organizations. Both the Forest Service and the Tennessee Valley Authority have had longstanding tree improvement programs. The Southern Region of the Forest Service currently has seed orchards located in Arkansas, Florida, Louisiana, Mississippi, North Carolina, and South Carolina.

All of the southern state forestry organizations have active tree improvement programs regardless of membership in the cooperatives. Several of these have the benefit of technical advice from local forestry schools; others rely on Forest Service research stations for technical support.

Forest tree improvement is the use of genetic principles to produce trees with faster growth, better form, improved insect and disease resistance, and higher quality wood. Many of the same breeding techniques for corn, wheat, cattle and poultry are used with forest trees. But while corn and wheat can complete one generation per year, southern pines take 16 years to complete a generation.

Breeding techniques in use in the South normally involve selecting individual trees in natural stands and/or plantations followed by establishment of grafted seed orchards for producing genetically improved seeds. Factors that led to this methodology were:

1) Critical need for a reliable source of improved seed

2) Natural stands of southern pines contained large populations of extremely variable trees

3) Selection of outstanding individuals in a highly variable population is a well-established technique in plant and animal breeding

4) Grafted seed orchards produce good seed crops much

The tall, clear trunk and narrow crown of this slash pine tree in Louisiana identify it as good potential breeding material. Selecting such superior trees is the essence of tree breeding.

faster than other tree breeding techniques.

A typical southern pine tree improvement program contains these steps: Selection of outstanding trees; grafting and seed orchard establishment; progeny testing; and seed production.

The essence of tree breeding is selecting trees from natural stands or plantations that have superior growth, form, and disease resistance with desirable wood characteristics. The more critical the selection, the greater the potential genetic gain.

Outstanding trees are chosen on the basis of how they look (their "phenotype"). The phenotype is the result of interaction of the genetic codes in the cells of the tree (its genotype) with the environment in which it has grown. Since the genotype cannot be seen, it is impossible to tell how much of the tree's superiority is due to environmental influences—the soil, water, and competition where it is growing—and how much is due to its hidden internal genetic constitution.

Pine seed orchards in the South are based on many tree selections, well in excess of 14,000. Foremost reason for all these selections is that the eventual genetic gain—degree of improvement—is limited by the size of the base (selected) population. Secondly, a large base minimizes mating of related trees (inbreeding) and its associated depression of vigor or fertility (inbreeding depression).

Finally, maintenance of a large selection base incorporates a wide variety of genetic diversity so the trees produced can cope with unanticipated pests and extreme sites or weather. This last element is particularly important in long-lived organisms like trees. Corn wiped out by an unexpected blight can be resown the following year, but a lost forest takes years to replace.

Making "Carbon Copies"

The purpose of grafting is to make "carbon copies" of the selected trees. In the grafting process, scions (branch tips) are collected from these trees. The scions are grafted to rootstock seedlings that were planted earlier. Rootstocks provide the scions with nutrients, moisture and support.

Grafts from 25 to 50 selected trees are planted in "orchards" in patterns designed to encourage maximum cross-pollination upon flowering. These orchards are managed for seed production using methods very similar to those used in fruit and nut orchards. The difference is that the end product is improved seeds—not edible products like apples, peaches or pears.

The selected trees are evaluated for their breeding value by a procedure called progeny testing. Selected trees are bred with one another and the offspring planted at a variety of locations in specially designed plantations called "progeny tests." Performance of the progeny—regarding growth rate, straightness or other traits—is then compared.

Grafted seed orchards produce good seed crops much faster than other tree-breeding techniques. The orchards are managed using methods very similar to those used in fruit and nut orchards. Note the original graft on the tree trunk just below the sign.

Those that express the superior characteristics their parents had, even when reared in a variety of different environments, prove their parents had a high breeding value. Poor performing progeny are discarded from the program at this point.

Below average trees are removed from seed orchards on the basis of progeny test results. Seed production of the remaining trees is stimulated by fertilization, cone and seed insect control, and sometimes irrigation. Seed orchards normally produce crops of high quality seed much more reliably than wild stands do.

Pine cones may be picked from bucket trucks, ladders, or platforms, or brought to the ground by tree shaker machines. The seed is then extracted from the cones in special processing plants or "seed extractories." These seeds are then used to grow nursery seedlings that are planted to regenerate pine forests.

The Big Payoff

Even with all the work started in the 1950's, no genetically improved southern pine seed was available as recently as 1960. Forestry agencies bought pine cones on the open market.

The resulting seedlings were often of poorer quality, genetically, than the average wild population they replaced. But seed orchards started in the 1950's were producing enough seed by 1973 so that 11 Southern States were using large volumes of certified seed. This allowed production of hundreds of millions of seedlings that grew notably faster than wild stock.

By 1970, 127 pine seed orchards covered 6,500 acres in

A mechanical tree shaker comes in handy when it's time to harvest ripe cones from a superior pine tree in a seed orchard.

the South. The number of genetically improved seedlings grown steadily increased. In 1975, 27 percent of seedlings were "improved"; in 1978, 41 percent. By 1981 there were 10,300 acres of seed orchards in the South, 76 percent of all tree seed orchards in the Nation.

Southern pines from tree improvement programs now grow 10 to 20 percent faster than average wild trees. These gains are the result, largely, of "first generation" improvement. In other words, the first round of selection and testing. But what about "advanced generation" testing? This is where things really begin to become exciting! What if we take the best of the best trees from the first tests and breed them?

Bruce Zobel, professor of forest genetics at North Carolina State University, and for years Director of the North Carolina State Industry Tree Improvement Cooperative, projected the following gross gains in volume growth and quality for southern pines as the result of tree improvement work:

Type of Seed Orchard	*Genetic Gain (% volume increase)*
First generation seed orchard	10–20
Specialty orchard: (disease resistance or high gum yield)	30 +
Second generation orchard	30–45

Currently there are about 700 acres of second generation seed orchards in the South. Most do not yet produce seed but they soon will, and the acreage of such orchards is increasing. The advanced generation program in southern pine tree improvement is not speculative or projected. It is real and it is here now.

In the early 21st century most of the planted seedlings will be coming from seed from advanced generation seed orchards. So, while the southern pine "super" trees are here today, even more "SUPER" ones are on the way.

Safeguards Provided

The question of maintaining natural genetic diversity while pursuing a vigorous program of tree improvement has been of deep concern among forest geneticists and forest managers. In the South no gene complexes will be lost because of a number of safeguards. Thousands of selections from thoughout the species ranges are collected in special areas and continually are being expanded.

Many areas, large and small, are excluded from harvest and kept in a natural state. Finally, despite large-scale planting programs, there are and will be large areas that are managed under a system of natural regeneration.

Money was a key factor that made tree improvement in the South succeed. Initial financial commitment by the forest industries in the South was the spark that ignited the program.

Tree breeding is not cheap by any means. Crossing two select trees and all the testing, measurements and associated data analysis are very expensive. In the South there have been hundreds of thousands of such crosses. These costs, added to the costs of developing and operating seed orchards to produce the improved seed, can amount to as much as $6,000 per acre of orchard.

Yet tree improvement was and is an extremely good investment. Rates of return from 17 to 21 percent are entirely feasible. Hans van Buijtenen, professor of forest genetics at Texas A&M University, estimates that after 30 years of planting all improved seedlings in the South, enough additional wood will be produced to support two new pulp mills each year.

Looking to the future, exciting new techniques such as tissue culture and genetic engineering hold much promise. Tissue culture would permit quick mass production of plants with exceptional gene combinations. Genetic engineering would allow us to manipulate these gene combinations in exciting new ways.

In the southern pine tree improvement program we all have received a heritage of more productive forest lands in the South.

Grizzlies, Elk, Eagles: Wildlife Diversity and the National Forests

By Hal Salwasser

You know about the diversity of this country's National Forests if . . . you've heard the haunting call of the arctic loon pierce a morning fog on the Chippewa; warmed to a campfire while jays and chickarees compete for attention on the Sierra; thrilled to the sight of moose and elk on the Kootenai or eagles and bears on the Targhee; discovered a myriad of salamanders and butterflies of the Siuslaw; added brilliant, feisty trout to a frypan on the Medicine Bow; hunted turkeys on the Nantahala; fought Chinook off the Tongass; or captured pileated woodpecker with film on the Santa Fe.

We come from factory, farm, and town to reaffirm our role as guardian and steward of our forests' resources, and partake of their richness. Our contribution to the next generation is to leave them a little richer and more productive than when they passed into our trust.

This is a story about how the U.S. Forest Service, with your help, continues to provide forest wildlife and fish resources to serve the American people.

The 191 million acres of National Forests and Grasslands in the United States are home for over 3,000 species of fish and wildlife. They are the major remaining pieces of suitable habitat for species like the California condor, gray wolf, and grizzly bear. For others, like moose, elk, cougars, mountain goats, and spotted owls, the National Forests provide as much as three-quarters of their entire habitat.

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Donald C. Schuhart

The National Forests provide as much as three-fourths of the entire habitat for a number of species, including elk.

Many of these wild creatures ranged throughout the original forests of this country. Over the past 200 years they have been increasingly confined to National Forests by land development and conversion of forest land to other uses.

Today, increasing pressures for development of National Forest resources portend additional constriction of the habitats for some species. At the same time these developments allow other species' populations to expand. The developments are certain to occur in response to economic and recreational demands. What role will wildlife and fish play in the future National Forests?

Reservation of forests from the public domain began in 1891. Norman Wengert in analyzing the original "purposes" of the National Forests, stated that ". . . what Congress and the Nation sought was comprehensive forest management involving two flexible elements: A) increases in scientific knowledge and improvement in the technology of management and B) adjustment of management to meet the growing and changing needs of the American people . . .". These elements remain primary today.

From its inception the Forest Service has employed the concepts of multiple-use sustained-yield, and the greatest good for the greatest number of people in the long run. The multiple-use concept was championed by wildlife advocate George Bird Grinnell in the 1880's and 1890's. Beginning in the early 1900's it was applied to National Forest management by Chief Forester Gifford Pinchot and all subsequent chiefs. Adjusting Forest management to meet the changing needs of Americans and provide the "greatest good" has been the cornerstone of Forest Service multiple-use policy.

Emerging Land Ethic

One of the changing needs of the American people is for environmental quality, wildlife and fish diversity, and wildlife-oriented recreation. Conservation of big game populations and rare species was an original purpose of the National Forests. It remains important. But over the past eight decades the nature and relative importance of demands for wildlife and fish have changed. Early Forest Supervisor Aldo Leopold captured the essence of this change in his essay on a land ethic.

Leopold's land ethic proposed that people are members and stewards of a land community of interdependent parts. Conservation is a state of harmony between people and that land community.

Leopold was a hunter, fisherman, forester, and conservationist. He believed in the management and wise use of natural resources, but not to the extent that the productivity and diversity of the land community became permanently impaired.

Expressed in Legislation

His thoughts, and society's concerns for environmental quality, were eventually expressed in Federal legislation on air, water, and environmental quality. Earth Day and the National Environmental Policy Act of 1969 marked a turning point in the emergence of biotic variety and land health as social concerns.

When Senator Hubert Humphrey introduced what was to become the National Forest Management Act of 1976, he captured the land ethic in stating that the basic purpose of the bill was ". . . to assure that the multiple uses are realized and their yields are sustained. This bill seeks to strengthen resource management so that it is ecologically effective. The days have ended when the forest may be viewed only as trees and trees viewed only as timber. The soil and the water, the grasses and the shrubs, the fish and the wildlife, and the beauty that is the forest must become integral parts of resource manager's thinking and actions."

The National Forest Management Act now requires that a National Forest "provide for diversity of plant and animal communities . . . ." The National Forest goal for wildlife and fish is to manage habitats to maintain viable populations of fish and wildlife and to maintain and improve habitats for the featured species.

Tinker, But Save the Parts

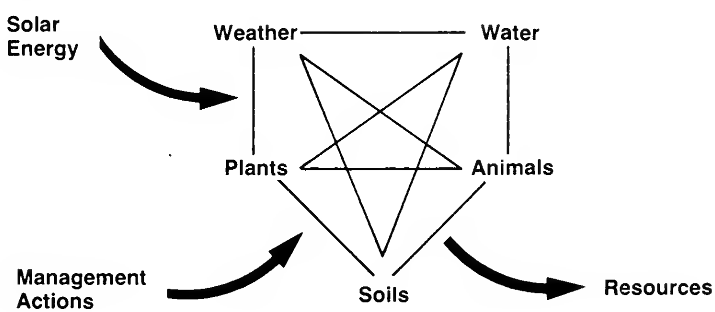
The requirement to maintain viable populations harks back to Leopold's admonition that the first rule of intelligent tinkering is to save all the parts. Beyond this diversity foundation, locally established objectives for a Forest's wildlife and fish set the direction for producing wildlife and fish resources for human enjoyment.

Maintenance of the Nation's forest wildlife diversity and productivity are clearly one of the purposes, and challenges, of National Forest management. The land ethic is becoming the foundation of multiple-use and providing the greatest good for the greatest number over the long term.

Legal and ethical mandates for wildlife diversity are clear. But so are the increasing demands for other uses of National Forest resources. These demands—for softwood and hardwood timber, minerals, water, forage, and recreation—must be met on a static to shrinking forest land base. As Will Rogers once said, the good Lord isn't making any more forest land.

Conflicts between incompatible uses will intensify and tradeoffs between valued resources will occur. This offers unprecedented opportunities to apply scientific knowledge and improve forest management tech-

The Forest Ecosystem



nology to capitalize on the many compatible uses and minimize the necessary tradeoffs (remember the first element). These opportunities lie chiefly in an ecosystem approach to resource management.

Forest Ecosystem

All forest resources come from the same production center, the forest ecosystem. The word "forest" connotes a kind of land, composed of characteristic climates, soils, vegetation, and associated wild animals. Interconnections of these components makes the forest an integrated, whole ecological system: a forest ecosystem.

When nature, or humankind, changes the forest—as through fire, tree harvest, pest epidemics, or windstorm—the ecosystem adjusts from its original condition to a new condition. In the new condition there may be large, standing or down, dead trees (snags and logs), small live trees and shrubs, and quail where once there were large live trees, no understory shrubs, and nuthatches.

The forest is dynamic; it is constantly changing. Over time the new condition described above can return to the original state and its set of resources. Each forest condition has different capabilities for producing each of the forest's resources.

Forest management is man's purposeful augmentation of nature to maintain the mix of forest states that best produces desired resources and environmental conditions. Applying the ecosystem concept to forest management means recognizing the full consequences of each management action.

Every action, because it changes the condition of the ecosystem on a site, affects the flow of all resources from that site. Tree harvest at the same time produces timber and sets the course of soil conditions, wildlife habitats, livestock forage, water yields, and esthetic values on a site for decades.

Architect of Ecosystems

Another way of putting this is that the forest manager is not just a grower of trees, but the architect of future forest ecosystems. The forester becomes the resource manager Senator Humphrey called for.

Getting the desired mix of high quality forest benefits to serve the American people at low costs is the challenge of forest management. Integrated, multiple-use planning guides that management.

Planning each management action as if it only produced one desired resource—be it timber, forage, water, or deer—is inefficient. It fails to capitalize on the ecosystem concept of forest management.

The National Forest Management Act, therefore, mandated an integrated and interdisciplinary forest planning process. In this process all resource specialists work as a team to evaluate the productive potential of the ecosystems on the National Forest and develop a management plan. The public has significant input to the plan.

Goals and concerns for resource production and forest conditions drive the planning process. They come from national, regional, and local needs as expressed by Federal, State, and local governments and interested citizens or groups.

The minimum socially or legally acceptable forest conditions (for example, viable wildlife populations) are the foundation for integrated forest management. The specified conditions ensure that no one resource or use will be favored to the extent that other forest values, including land health, fall below certain levels. Above these management standards the forest plan balances objectives for the multiple-uses against the economic feasibility of providing the greatest good and reconciling conflicts.

Management and Monitoring

A forest plan is a best effort to lay out an effective course of actions to produce a variety of resources for many uses. It is not, and never can be, a perfect prediction of the future.

Forest ecosystems are far too complicated for us to ever fully understand and precisely predict future conditions. Inventories of current conditons, and technologies for analyzing resource potentials and conducting management actions, are often incomplete or less than desired. And, society's perceptions of acceptable forest conditions and its priorities for different uses and resources change over as short a time as one to two decades. None of these are excuses for lack of action. They are simply the circumstances under which resource managers operate.

Uncertainties about future forest conditions, society's changing demands for different resources, and emerging technologies argue strongly for a management concept that stresses continual adaptation to change (remember the second element).

Managers must monitor changing social concerns and demands and the effects of their past actions, and assess changing technologies. Knowledge gained from these measurements feeds back to decisionmakers so they can adapt goals, strategies, and actions to new circumstances. Thus monitoring, the measurement and feedback process, is a crucial part of adaptive resource management.

Recognition of the forest ecosystem as a multiple benefits production center, the use of integrated and interdisciplinary planning methods, and monitoring to support adaptive resource management are three important new aspects of multiple-use forest management. We now turn to a vital new technology being used to plan for forest wildlife and fish diversity and productivity. General term for the technology is wildlife and fish habitat relationships.

Quantitative Models

During the 1970's, pioneering efforts to integrate wildlife and fish in forest resource management appeared in all regions of the country. Biologists and scientists developed management guides for featured wildlife, and for diversity in general. Some focused on groups of animals, others on special habitats like snags and riparian areas.

Computerized data bases and predictive models were built. Research generally shifted attention to quantify the nature of species relationships with their habitats, most notably how those relationships change as managed forests age and develop. Today these efforts have coalesced in each Forest Service Region as the Wildlife and Fish Habitat Relationships (WFHR) System.

The heart of each Regional Wildlife and Fish Habitat Relationships System consists of quantitative models of the species-habitat relationships. The models allow for planning and predicting the effects of habitat change on selected wildlife and fish.

Using these models, biologists can quantitatively evaluate the effects of sediment on salmon production, of a clear-cut timber harvest on elk habitat, of prescribed fire on quail production, or of hardwood growth on turkey populations. In some Regions

The effects of habitat change on wildlife—such as hardwood growth on turkey populations—can be predicted by use of models.

the effects of habitat change on all species can be analyzed with these models.

Coping With Complexity

A typical National Forest has over 300 different fish and wildlife species in 20 or more kinds of habitats. Such complexity cannot be handled with any detail in a Forest plan. Therefore, biologists select certain of the species, groups of species, or habitats as management indicators.

The management indicators serve a variety of purposes by collectively representing the major issues, concerns, and goals for fish and wildlife production and diversity. Commonly, threatened or endangered species or species sensitive to anticipated management actions are selected to ensure that habitats are provided to maintain viable populations of all the fish and wildlife. Goshawks, spotted owls, and red-cockaded woodpeckers are examples.

Major game animals like deer, turkey, and trout—along with species of local special interest, like colorful songbirds—are selected as the featured species.

Jack Stevens

Wildlife and Fish Management Indicators

- *Species*
  - Recovery/Viability
    - Threatened or endangered species
      - e.g., grizzly bear, red-cockaded woodpecker
    - Sensitive species
      - e.g., spotted owl, pine marten
  - Production/Featured
    - Game species
      - e.g., elk, deer, squirrel, trout
    - Commercial species
      - e.g., fox, salmon
    - Special interest species
      - e.g., pileated woodpecker
  - Ecosystem Indicator
    - Key members of ecosystems
      - e.g., beaver, tree vole
- *Groups of Species*
  - Groups Related to Sensitive Habitats
    - e.g., cavity nesting birds
  - Groups Related to Productive Habitats
    - e.g., waterfowl
- *Special Habitats*
  - Sensitive Habitats
    - e.g., snags, logs, old growth
  - Productive Habitats
    - e.g., wetlands, riparian, mast bearing

Often a special habitat, like snags or a group of species such as cavity nesting birds, are selected to ensure the maintenance of critical diversity elements. Some habitats, such as large downed logs in old growth forests, aid in nutrient cycling and productivity of the trees on a site. They are also habitat for many animals. The log might be selected for its key role in land health.

Forest diversity and fish and wildlife resource production are guided by the planned standards and objectives for the full set of management indicators.

Habitat Capability

Production of fish and wildlife resources rests on the health and diversity of habitats provided. These are controlled chiefly through the spatial distribution of stages of forest development. The stages begin with grasses and herbs on a newly disturbed site and culminate in the fully mature forest stand with its large trees and characteristic understory.

Ability of an area to support a management indicator species or group of species is known as the area's habitat capability for that indicator. Habitat capability results from the kinds, amounts, and arrangement of the different forest stages. It is expressed as the number of animals or pounds of fish the area's habitat can accommodate.

A habitat capability model quantifies the relationship between a species and its habitat. The models are used to translate population goals into habitat objectives that can be worked into the forest management strategy. They are also used to assess existing and predicted future habitat conditions as to their capability for indicator species.

Since each forest management strategy shapes the size, arrangement, amount, and kinds of all forest stands it also shapes habitat capability for the fish and wildlife indicators. Integrated, multiple-use management means coordinating the strategies to get the optimum conditions for fish, wildlife, and the other forest resources.

Summary

As forest management adapts to meet the changing needs of the American people, purposes of the National Forests are served by new philosophies and technologies. In the case of fish and wildlife, the land ethic philosophy and the Wildlife and Fish Habitat Relationships technology for diversity and productivity are intertwined.

New laws and regulations call for greater attention to a land ethic in public forest land management. Integrating that with the increasing need to produce other resources requires a sound, habitat-based approach.

Management indicators, and species-habitat relationship models (for example, habitat capability models), are the new tools in the WFHR System. They are helping fish and wildlife biologists work actively with other

USDA

The rich diversity of wildlife in National Forests will be part of the natural heritage we give to future generations.

managers to more effectively produce all desired resources.

Through continued WFHR system development, the cadre of professionals trained in the land ethic and quantitative habitat evaluation are putting behind us the days when wildlife and fish were an afterthought in forest management. The rich diversity of National Forest fish and wildlife will be part of the natural heritage we give to future generations.

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Return of a Native: The Wild Turkey Flourishes Again

By James E. Miller and Herman L. Holbrook

Transform yourself to some isolated, forested swamp or mountain ridge in the eastern United States just before the break of the first light of day on a still, chilly April morning. The woodland sounds heard include: the call of whippoorwills, followed by an awakening eastern wood pewee, ovenbird, cardinal, or cooing mourning dove; then there is the hooting of one or more barred owls, followed almost immediately by the sound not heard for almost a year—the challenging gobble of a male wild turkey. . .

Restoration of the wild turkey, although not the only native wildlife species to make a comeback in modern times, is certainly one of the greatest success stories of scientific wildlife management.

This story, in conjunction with progressively improving natural resources management in forestry, range and on private agricultural forestland ownerships, describes an example of wise resource stewardship that we can be proud of.

The wild turkey is our largest American game bird with adult males of some of the subspecies in the wild reaching weights approaching 30 pounds, although commonly having an average weight of 20 pounds or less. The female is much smaller, generally averaging around 10 pounds in adults.

During the breeding season the adult gobbler is one of the most colorful birds we have—exhibiting not only vivid red, white

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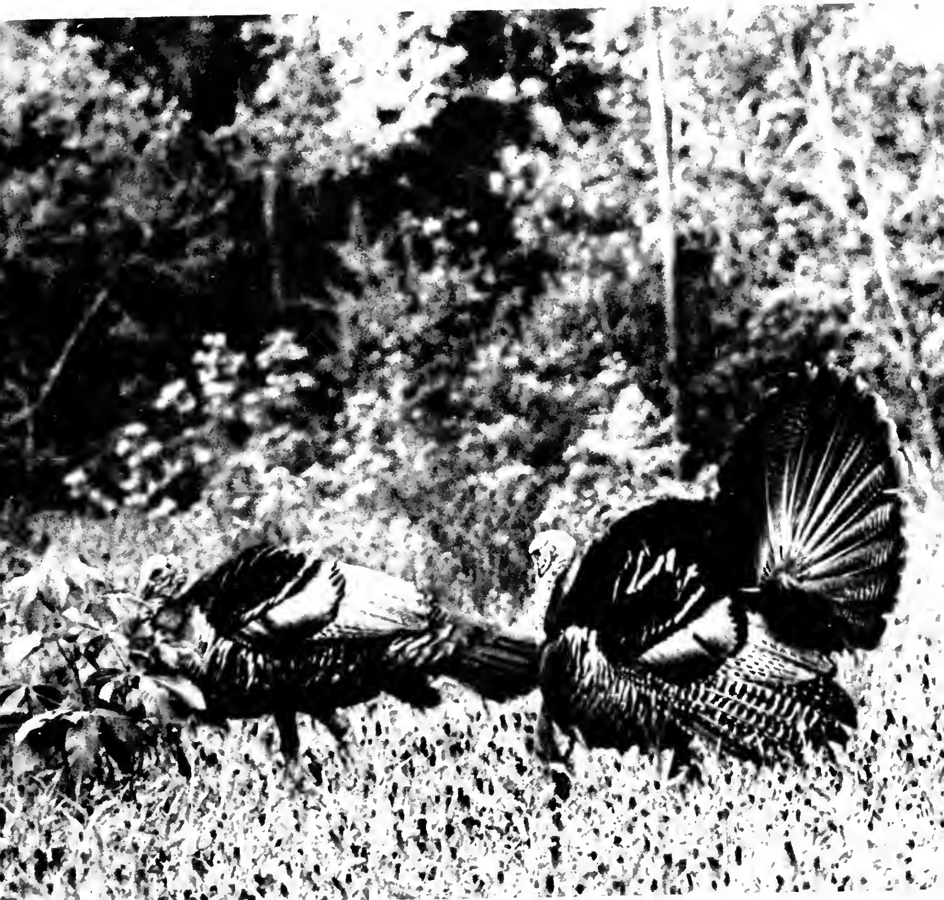


Herman L. Holbrook

and blue skin colors on the head and upper neck, with reddish-pink legs, but a plumage of brilliant metallic hues of black, bronze, purple, green, copper, brown, buff, and black and white feathers.

The comeback of the wild turkey is one of the greatest successes in wildlife management. The population had dwindled in the United States to 30,000 by the 1930's; today, it is 2,500,000.

Can Fly 55 MPH

Capable of flying up to 55 miles per hour and running at speeds approaching 20 miles per hour, the wild turkey is well adapted to its environment. With remarkable eyesight and hearing, it can readily distinguish color, movement, and alarming sounds.

Wild turkeys live in a variety of habitats from dense swamps to mixed prairies to rugged mountains. However, the availability of some mature, open and mast-producing timbered land is vital to their existence. (Mast is forest food such as nuts and fruit.)

Management for the wild turkey must consider the need for diversity. A side benefit of management directed toward the wild turkey is that such management is beneficial for many other wildlife species. These include other game birds, deer, squirrels, endangered species, furbearers, raptors, and songbirds.

To provide some idea of the diverse needs of the wild turkey, early research in Virginia identified 354 different plant species and 267 different species of insects eaten by the eastern subspecies.

Like all game species, the wild turkey prospers with proper management and regulated sport hunting, and populations reach carrying capacity in a given area of habitat whether hunted or not. It has many natural predators, particularly while young,

Bill Stuart

Wild turkeys can fly up to 55 miles per hour and run at speeds approaching 20 miles an hour.

but even adults are killed by coyotes, bobcats, foxes, owls, and feral dogs.

Hunting Is Challenge

Hunting the wild turkey is a very challenging, demanding and difficult activity, whether with camera or gun, and many people never see a wild turkey even though they may hear one or more gobblers on a spring morning. Not only is it one of our most valuable wildlife species, it is also one of the most difficult to bag with gun or camera.

The wild turkey in body structure, behavior, recent genetic background, or survival capability has very little in common with the domestic turkey we buy in the supermarket.

Historical records indicate the wild turkey existed in large numbers throughout what is now the contiguous United States, Mexico, and the Canadian Province of Ontario. These records indicate it was found in an area covering all or parts of 39 States at the time of European settlement.

Fossil remains examined from earlier times apparently belonged to the same five subspecies of the wild turkey we have in the United States today. These five subspecies include the Eastern, Florida, Merriam, Rio Grande and the Goulds, each of which is adapted to certain geographic and climatic regions.

Used by the Indians

There are records of extensive use of the wild turkey by the American Indians. Aside from domestication of one Mexican subspecies, and use of wild birds for food, they also used parts of the turkey for ornamentation, tools, arrowheads, art, and for various religious ceremonies.

Early settlers recognized not only the availability of the wild turkey but its importance along with other wildlife as staple food items. Indications are that the settlers found the wild turkey in great flocks and of apparently less wariness than is found in the wild turkey of today. The bird was extensively hunted and trapped by these settlers, and no other wild bird was as important to them as the wild turkey.

Population of the wild turkey fell sharply from the 1600's to the 1800's as a result of the bird's availability and harvestability, dependence on diverse forest habitats, and need for relatively large undisturbed areas. Exploration, industrialization, and destruction of forest habitat was widespread during this period with little regard for the impact on wildlife.

This habitat destruction—along with market hunting and subsistence hunting—paved the way for almost complete elimination of the wild turkey in much of its range.

The wild turkey disappeared from some States as early as 1813 and continued to be reduced throughout the mid-1800's on into the early 1900's. By 1907 the turkey had been eliminated from at least 12 States, with populations low to marginal in many others. However, by the mid-1930's to late 1940's some early wildlife and natural resource managers were beginning restoration and management directed toward the wild turkey.

Population Cut to 30,000

With the population reduced by the 1930's to less than 30,000 birds nationwide, most of those remaining were found in dense swamplands in the South and rugged mountain ranges with poor soils in other States. Reports from the early 1940's indicated about three States with viable wild turkey populations, only sparse populations in 21 States, and the bird eliminated completely from 15 others.

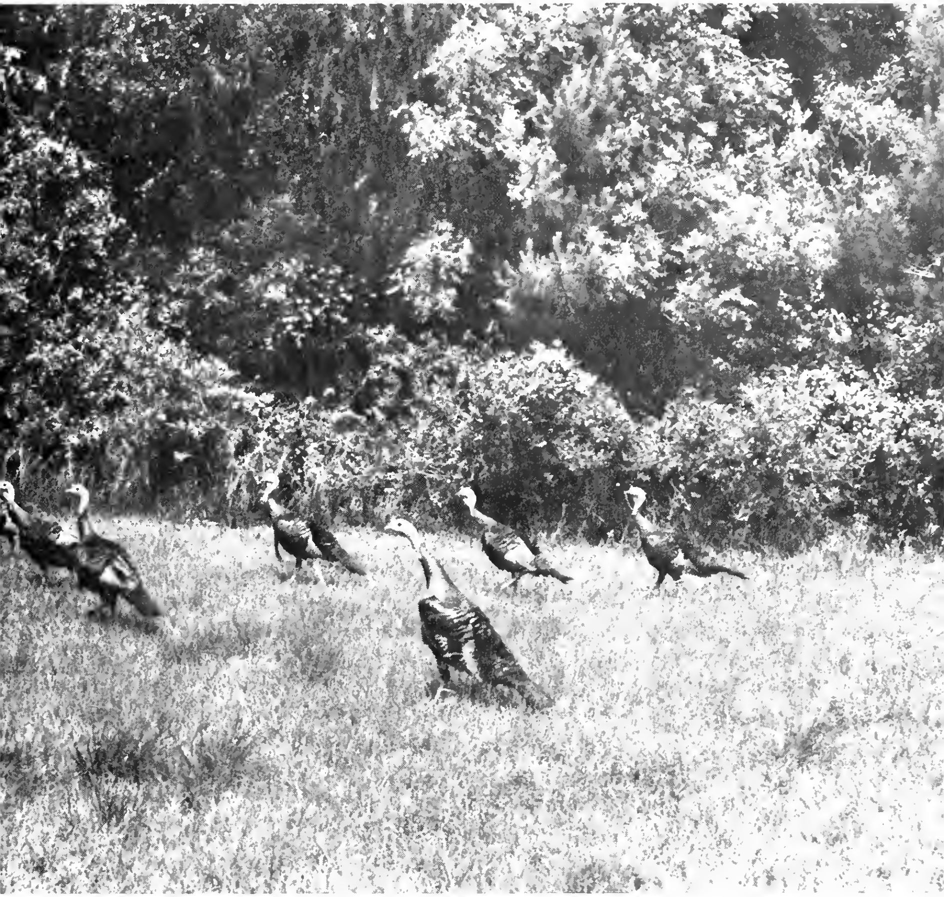
Following the cut and run philosophy of many small sawmill operations during the early 1900's, land management gradually improved. At the same time, the forestry and wildlife management professions were advancing. The impacts of these professional advancements were important to restoring wildlife populations, particularly those species dependent on forest habitats.

The Forest Service, established in 1905 under the U.S. Department of Agriculture, was continuing its growth and management as were National Refuges and other public land acquisitions. Establishment and development of public lands by States—such as State Forests and State Wildlife Management Areas—also contributed to improved management for wildlife.

Wildlife Restoration Act

The Pittman-Robertson Act of 1937 or Wildlife Restoration Act provided Federal funds for State Fish and Wildlife Agencies. This was followed closely by establishment of the Wildlife Society and similar organizations, providing significant impetus for improved wildlife management.

Management efforts for the wild turkey intensified within the next two decades on both public and private lands, and by



R Clayton Graham

Wild turkeys can now be found in all 48 contiguous States. Forty years ago, they had only sparse populations—or had been eliminated—in 36 States.

the late 1950's its populations had significantly increased.

From the mid-1930's to late 1950's, some State agencies with remaining stocks of wild turkeys were doing what they could to sustain these populations, including difficult but successful trapping and restocking. Others tried expensive but futile pen-raised "wild" and domestic hybridized turkey stocking efforts. Not only were these pen-raised stocking attempts costly and generally unsuccessful, but they also posed a potential disease hazard to existing wild birds.

State Fish and Wildlife Agencies across the Nation have made dramatic improvements in management for the wild turkey through:

1) Establishing seasons and bag limits, people management, and public education,

2) Protecting and enhancing wildlife habitat through improved management,

3) Vastly improved wildlife management techniques through research, including better methods of capturing wild turkeys from one area for restocking in another area of suitable habitat, and

4) Continued research and management to reduce losses caused by parasites and diseases, competition and predation.

80 Times as Many Today

Wild turkeys within the United States currently are estimated at about 2.5 million birds. Turkeys are found in all 48 contiguous States, and have even become established in Hawaii. The present population represents an increase of over 80 times that in 1940, a phenomenal comeback.

Equally important is the fact that more than 312,000 wild turkeys were legally harvested during 1982 by hunters from the 45 States that have huntable populations. One of the principal reasons for recovery of the wild turkey is that the public has supported wildlife managers' efforts.

Some unsung heroes in this restoration story are the early developers of the cannon net and other capture techniques. Others are the savvy trappers and biologists who spend long hours catching and determining where to stock wild turkeys for successful establishment.

In 1973 an organization was established dedicated to conservation of the wild turkey. Named the National Wild Turkey Federatin (NWTF), it presently has more than 35,000 members and financial supporters who maintain the organization's goals and objectives. It strives not only to support and/or assist all State, Federal, and private management efforts to benefit the turkey, but also to better educate the public about the value of this bird and its management needs.

As a nonprofit organization, the NWTF provides bimonthly a high quality and informative publication. Each year it also supports needed wild turkey research with funding to agencies, universities and individuals for restoration and management efforts.

30 Species Traded

An important economic factor in restoring wildlife species in the United States has been the exchanges of wildlife and fish species between States. Costs of such trades have been significantly less than alternatives available for species restoration.

Some 30 different species of fish or wildlife have been traded one way or another for wild turkeys for restoration. This cooperation among State Fish and Wildlife agencies has greatly assisted establishment of viable and huntable populations in only a few years.

Even though the hunter success rate of wild turkeys harvested is among the lowest for all hunted species, the dramatic increase in populations has been accompanied by a significant rise in turkey hunters. More hunters are buying licenses, thus returning additional dollars to the State and Federal agencies for management.

The scramble for high quality turkey hunting on public and private lands has also had an economic impact. Leases of private and industry lands for hunting wild turkey and associated species vary from 50 cents an acre per year to $15 an acre per year.

Wide-Ranging Bird

Because of the wide-ranging nature of wild turkeys (up to 1,000 acres and over 2–5 miles of range daily), one does not lease just a few acres for hunting them. This has contributed to retention of many acres of bottomland hardwoods in parts of the South to take advantage of the income potential, as well as modifications in timber management practices on other private and industrial forest lands which are more conducive to wild turkey needs.

What then are the limitations to the future population gains of the wild turkey? Habitat loss is without question the most important factor that will prevent population increases across the Nation. Not only is it the most important limiting factor but also the factor that wildlife managers have least control over.

Converting suitable turkey habitat into any type of permanent or semipermanent use is significantly reducing quality wildlife habitats. Effects are felt from suburban housing developments, large reservoirs, highways, airports, mining and/or industrial sites, and urban expansion. Nonetheless, the economics of habitat loss is being turned around in some areas and landowners, aside from a stewardship ethic, are finding that growing timber and wildlife on the land may be their best alternative.

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Endangered Bird of Fire—the Kirtland's Warbler

By Robert E. Radtke, John Byelich, and George Irvine

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George Irvine is Forest Biologist, Huron-Manistee National Forest, Cadillac, Mich.

The Kirtland's Warbler is a "bird of fire." It depends upon forest fires that create the unique habitat required by this songbird. Ounce for ounce, the Kirtland's Warbler has drawn more interest, and created more controversy, than any songbird. Yet the entire population of this warbler weighs less than 13 pounds.

The Kirtland's Warbler is an endangered species. Like the California Condor, Ivory-billed Woodpecker, and many other endangered species, the Kirtland's requires a unique habitat. This warbler nests only in young jack pine stands in one small area of Michigan's Lower Peninsula.

In this one corner of the world on the Huron National Forest and adjacent State Forest lands, the Michigan Department of Natural Resources, U.S. Forest Service, the U.S. Fish and Wildlife Service, and others with a will to work for life, work together to save a species.

Out of the fire, and from the ashes, comes new life for the jack pine—and life for the Kirtland's Warbler.

The story of the endangered Kirtland's Warbler provides an example of a species whose numbers have been dramatically reduced through the indirect influence of man. Suitable nesting habitat for this warbler declined sharply because of man's successful endeavor to control wildfire.

Dow Chemical Co

The Kirtland's is one of the most attractive wood warblers. The male has a striking lemon-yellow breast with bold black streaks. This species is an endangered songbird. Only 415 of the birds remain.

246 Species Imperiled

Our changing environment has brought a number of species to the brink of extinction. Congress, in passing the Endangered Species Act in 1973, established as a national goal the conservation of endangered and threatened wildlife. Currently, some 246 species are classified as endangered or threatened within the United States. The Endangered Species Act provides a national commitment to protect and perpetuate these species.

Lands managed by the Forest Service, a part of the U.S. Department of Agriculture, contain habitat for some endangered and threatened species. Programs are underway to help meet the needs of these species.

The Kirtland's is a colorful bird, and one of the most attractive wood warblers, which ornithologist Roger Tory Peterson calls "the butterflies of the bird world." About the size of a house sparrow, the male has a striking lemon-yellow breast, with bold black streaks. It wears a black "mask."

The song is loud and somewhat like the familiar house wren. Its song is the bird's best identification guide and can be heard more than a quarter-mile away on a windless day. This trademark permits a complete census of the Kirtland's, which has been underway since 1951, when Harold Mayfield, author of the definitive monograph, *The Kirtland's Warbler*, organized the first census with the help of the Michigan Audubon Society.

Alarming Drop

The 1951 census, of about 500 pairs, remained unchanged by a second count in 1961. In 1971, however, the count dropped to 201 singing males. This sharp decline alarmed conservationists.

An annual census has been made since 1971, with a low of 167 singing males recorded in 1974. Since then, populations have slowly responded to management. The 1982 levels stood at 207 singing males or about 414 birds. This is still a very low number considering the life span of the warbler, which is only 5–7 years.

The annual census involves more than 50 individuals in a cooperative effort by the Michigan Department of Natural Resources, Forest Service, Fish and Wildlife Service, Michigan Audubon Society, and a number of independent cooperators.

The Kirtland's Warbler was first discovered only a little over 100 years ago, when one was taken in 1851 near Dr. Kirtland's farm in Ohio. The winter range of the Kirtland's was found when a specimen was collected on Andros Island in the Bahamas in 1879.

Nests in 60-Mile Area

The nesting habitat of the Kirtland's remained undiscovered until 1903, when a pair of trout fishermen, on Michigan's famous Ausable River, heard a strange bird singing in the jack pine. A bird was collected and taken to the University of Michigan's curator of birds, Norman A. Wood, who rushed north via train, rowboat, horse and buggy, and foot.

Wood heard a Kirtland's singing, but it took five more days to find the nest, located in a large tract of jack pine swept by fire a few years before. Every nest found since has been within 60 miles of that spot.

Today, nesting birds are found only in seven counties in north-central Michigan, near the town of Mio. A few lone males have occasionally been seen in Minnesota, Wisconsin, and Ontario, but no nest or mated pairs have ever been found. A few birds have been observed during their southward migration to the Bahamas.

The nesting range of the Kirtland's Warbler is found only in the jack pine stands that occur on the dry Grayling sand outwash plains of the northern part of Michigan's Lower Peninsula. Here, the soil and climate combine to produce jack pine forest with a sparse ground cover of grasses, sedges, blueberry, and low shrubs that provides conditions that meet the requirements of the warbler.

Fire is Essential

A factor essential to maintaining this jack pine ecosystem is fire. Many of the jack pine trees have cones that are tightly closed and require the heat of fire to open and release their seed.

Almost without exception, the Kirtland's has nested in jack pine stands of Christmas tree size which have become established following fire. Burning also prepares the ground for seed germination, and maintains the grasses, blueberry, and other plants required for nesting.

Wildfires, historically, maintained the jack pine "plains." Wildfires may have created suitable habitat, but left uncontrolled they destroyed extensive areas following the lumbering era of the late 1890's.

As late as 1911, the sawmill towns of Ausable and Oscoda on Lake Huron's shore were wiped out, with loss of life. In 1925, nearly 4,000 forest fires blackened 733,000 acres in Michigan.

Michigan's firefighting efforts began in 1912, with the purchase of ". . . 18 long-handled shovels . . .". The State Auditor General questioned necessity of the purchase, delaying payment of the bill 6 months.

Today, airplanes have made lookout towers outdated, and a "bad" fire year in Michigan is one that blackens more than 5,000 acres. Thus fire was tamed, but in doing so man's efficiency threatened to push the Kirtland's over the brink of extinction.

Recognizing that modern forest management and fire protection would eliminate the Kirtland's, the State of Michigan, the Forest Service and others developed plans to maintain suitable jack pine areas.

Efforts taken in the 1960's are paying off. Almost 93 percent of the total warbler population is now located on public land—lands managed for this songbird.

The Kirtland's would probably not exist in viable numbers today, if this program had not been undertaken.

Prescribed Burns

Setting fire to the woods is a bit drastic and contrary to fire control efforts preached by "Smokey Bear" for many years. "Prescribed burning," as the forester calls it, can be an effective tool when properly controlled. It is necessary if this species is to be saved from extinction.

In 1964, the Forest Service burned almost a square mile in operation "Pop-Cone." Its purpose was to create future habitat. Today this area contains a number of warblers. Some 30 successful prescribed burns have been undertaken by the State and the Forest Service since 1964.

The Michigan Department of Conservation (now Department of Natural Resources) formally established three warbler management areas in 1957. Each area was four square miles in size and dedicated to warbler management. In 1962, the 4,010-acre Kirtland's Warbler Management Area was established on the Huron National Forest.

The combined 11,670 acres of State and Federal lands were established, not as a preserve or sanctuary, but as a working forest. Each area was large enough to maintain jack pine in various sizes ranging from young trees to trees ready for cutting. This is the basis for all warbler management. Unless there was opportunity for commercial harvest, a succession of ages could not be maintained without considerable expense.

These management efforts preceded the Endangered Species Act, and were one of the first extensive habitat improvement efforts designed to save a songbird.

Recovery Plan

The Endangered Species Act called for establishing Recovery

Kirtland's Warblers nest only in dense jack pine which springs up naturally following fire. Prescribed burning is conducted in Michigan to maintain nesting habitat for the endangered species.

Teams to assist the Fish and Wildlife Service in carrying out provisions of the act. In 1975, a Kirtland's Warbler Recovery Team was appointed by the Secretary of Interior to guide efforts at aiding the warbler.

A Recovery Plan was developed in 1976, which outlined steps designed to "Reestablish a self-sustaining wild Kirtland's Warbler population throughout its known former range at a minimum level of 1,000 pairs."

To achieve this will require:

1) Managing 135,000 acres of suitable habitat,

2) Protecting the Kirtland's on its wintering range,

3) Reducing factors which adversely affect reproduction,

4) Monitoring populations, and

5) Possible introduction of Kirtland's Warblers to other areas.

The Forest Service and the State of Michigan developed a comprehensive habitat management plan designed to meet the Recovery Plan objective of 135,000 acres of suitable habitat. The intent is to maintain the jack pine ecosystem using commercial timber harvest, prescribed fire and planting of jack pine.

It is difficult to be optimistic with current population levels, and a gloomy habitat forecast. Projections of breeding habitat indicate a critical low will occur about 1986. It will take 7 to 10 years before new habitat created during the late 1970's and early 1980's is suitable. After 1987, a large increase in habitat will result from current management.

Cowbirds Cut In

The Kirtland's Warbler nests in a special ecological "niche" of sun-scorched, fire-scarred, sandy plain called the "barrens." Few other birds use this same type of habitat; therefore it may be that the warbler exists because of little competition from other birds.

The Brown-headed Cowbird moved into the warbler's habitat with the farmer, who followed on the heels of the lumberman. The cowbird lays its eggs in the nest of other birds, leaving the foster parents with the chore of hatching and raising the young. If you have ever seen a sparrow feeding a chick twice its size, chances are the chick is a cowbird. They eat like teenagers—always, and a lot!

The young Kirtland's hatch a day or two later, with little chance of survival. If the cowbird lays two eggs in the warbler's nest, none of the warbler chicks will survive, as they cannot compete for food with their larger "brothers."

In the late 1960's, studies showed that up to 78 percent of the warbler eggs in parasitized nests failed to produce young. The seriousness of this threat was not realized, however, until a 1971 census revealed that the Kirtland's Warbler population had dropped from 1,000 to 400, a 60 percent reduction. The cowbird is believed to have been a major factor in the decline of the warbler population.

Control Project

To reverse this decline, the Fish and Wildlife Service, Forest Service and Michigan Department of Conservation, in cooperation with the Michigan Audubon Society, launched a cowbird control project in 1972. Kirtland's Warbler reproductive success has improved dramatically since cowbird trapping began. Average number of young warblers fledged per nest has increased from 0.81 to 2.76.

Few nests are parasitized now by cowbirds. But despite the increased reproductive success, the Kirtland's breeding population has remained stable since 1972.

Kirtland's Warbler management is a good example of multiple use of public lands. These areas are for wildlife—not only the warbler, but deer, upland sandpiper and several other species use the area.

Timber (pulpwood for paper) is cut according to a prescribed plan. Hunting, berry-picking (blueberries follow prescribed burning), and other forms of outdoor recreation are permitted when the warbler is not present.

People from all 50 States and 17 nations visited the area in 1980-81 to add this bird to their life list.

Tiny Transmitter

Nesting habitat is believed to be the major limiting factor for the Kirtland's. Another factor is the Brown-headed Cowbird. A third may be a yet unidentified factor on the wintering grounds. Efforts are now being taken to examine the bird and its winter range.

A tiny (1 gram) transmitter has been developed by the Fish and Wildlife Service to track small birds, including the Kirtland's. This will permit better understanding of migration and winter habitat. The bird is seldom observed in its winter range, because it does not sing.

The Recovery Team monitors all research on the Kirtland's Warbler to prevent disturbance of the nesting birds. The State and Forest Service's North Central Forest Experiment Station is evaluating vegetation requirements of the Kirtland's. It is hoped that this will provide better and more economical ways of developing suitable habitat.

The "home" of the Kirtland's is Mio, Mich. In 1963 the local people built a four-foot-high replica of the Kirtland's, which was dedicated by Roger Tory Peterson. Kirtland's College is located nearby and contains a research library on this species.

Tour Information

Kirtland's Warbler nesting areas on State and National Forests are closed to public entry between May 1 and Aug. 15, except by authorized permit. Free guided tours are available from mid-May to mid-July.

Information on tours that are conducted by the Fish and Wildlife Service and Forest Service can be obtained from the Forest Service, Mio, Mich. 48647 and the Michigan DNR Field Office, Grayling, Mich. 49738.

Human populations and development have increased within the range of the warbler, resulting in conflicts between development and warbler management. Competition for land, and the management of habitat using prescribed fire, often result in conflicts.

About a fourth of the warbler population nests within Camp Grayling, a military reservation. National Guard Units, as well as Regular Army units, use the area for training with tanks, aircraft, and artillery. About 7,500 acres of the total 121,000-acre reservation are warbler habitat.

An agreement has been worked out with the National Guard to restrict use of the occupied habitat. The Michigan National Guard has been very cooperative. In a "battle" between a half-ounce warbler and a 50-ton tank, the tank has given way!

The Spectrum of Forest Settings for Recreation

By Charles McConnell and
Warren R. Bacon

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The alpine lake shimmers with the reflection of aspen trees shining from the jagged rock towers so characteristic of Colorado's San Juan Range. Nearby, three people relax after a meal cooked over a small backpack stove. In quiet tones they reminisce about the day's seven-mile hike up to tree line.

There is a gradual awareness of leaving behind the crowds and noise of the modern, hustling world as they immerse themselves in the vastness of the high mountains and listen to the breeze whispering in the forest below and the mesmerizing low roar of a cascading stream.

After their discussion, each backpacker mentally anticipates tomorrow's activities; one a climb to the peak, another the quiet solitude of fishing the lake, the third an exploratory trip over the 12,000-foot pass to view the expanse of the river basin beyond. . .

Two families relax around a campfire whose light flickers across the sides of their pickup campers and makes shadows dance among the grove of Douglas fir sheltering the campsite. The rush of the nearby river brings to mind the thrill and satisfaction earlier in the day of having their hand-tied flies taken by flashing rainbow trout inhabiting the many pools and eddies.

The adults talk of their plans to return in fall to hunt elk along the edges of openings in the forest created by past timber harvest. The children chatter about tomorrow's plans to ex-

James Hughes

plore with their trail bikes the logging roads leading to the next valley. . .

Inside the large recreation travel vehicle occupying site #23 in the developed campground in Florida, the couple from Ohio exchange travel stories with their new-found friends from North Dakota.

"Have you been to Kiabab in Arizona? No? You should go, the ponderosa pine forests are so pungent, and the Indian history of the area is fascinating."

"Have you been to Oregon? We so enjoyed the forested coastline! Maybe we can meet there next year and do some salmon fishing.". . .

Most people visit National Forests for specific reasons such as whitewater boating or mountain climbing. Yet others may want privacy, solitude, and tranquility in a natural setting.

Menu Of Opportunities

Success of these families in finding the outdoor recreation sites that appealed to them so much may have resulted from a new forest management system which offers visitors a "menu" of recreational opportunities to meet their desires.

The accelerating increase in use of our forest lands for outdoor recreation by such varied user groups over the past two decades lends support to findings of the President's Outdoor Recreation Policy Review Group. This group noted that with American society in the midst of dramatic change, recreation has assumed a prominent role in our physical, mental and spiritual health, contributing to individual identity, well-being, and cohesion of family and community.

The Nation's forests provide an unusual range of opportunities for outdoor recreational activities and experiences—unusual because the breadth of the spectrum is no longer available in most developed nations.

The notion that outdoor recreation use of forest lands is somehow incompatible with other forest uses is ill conceived. Today's environmentally aware, professional forest managers are developing ideas and techniques that recognize the role a healthy forest setting plays in providing high quality recreational opportunities.

The People Spectrum

One exciting technique being used on the National Forests throughout this country is the Recreation Opportunity Spectrum, or ROS. With this concept, forest managers and planners now have a tool which allows total integration of outdoor recreation resource requirements into overall forest land and resource planning and management.

ROS describes a variety of recreational opportunities to meet the needs of people who, while pursuing satisfying recreation, engage in diverse activities through a broad range of environmental settings.

The settings—like the ones described at the start of this chapter in which people enjoy these activities—are critical to obtaining a desired recreational experience.

For example, it is difficult to get a feeling of solitude in the middle of a fully occupied campground. For that reason, many people seek undeveloped sites along the backroads or trails in the forest. Others enjoy the social interaction at a developed site or ski area.

The concept of a spectrum of recreational settings which radiate out from highly developed urban areas to the most remote parts of the Nation's wildlands is not new. Aldo Leopold, Arthur Carhart, Bob Marshall, J.V.K. Wagar and other recreation management pioneers often spoke of a spectrum of experiences and advocated such a management concept in one form or another in their writings.

But the necessary understanding and testing of recreation behavior theories had to wait until the decade of the 1970's to evolve.

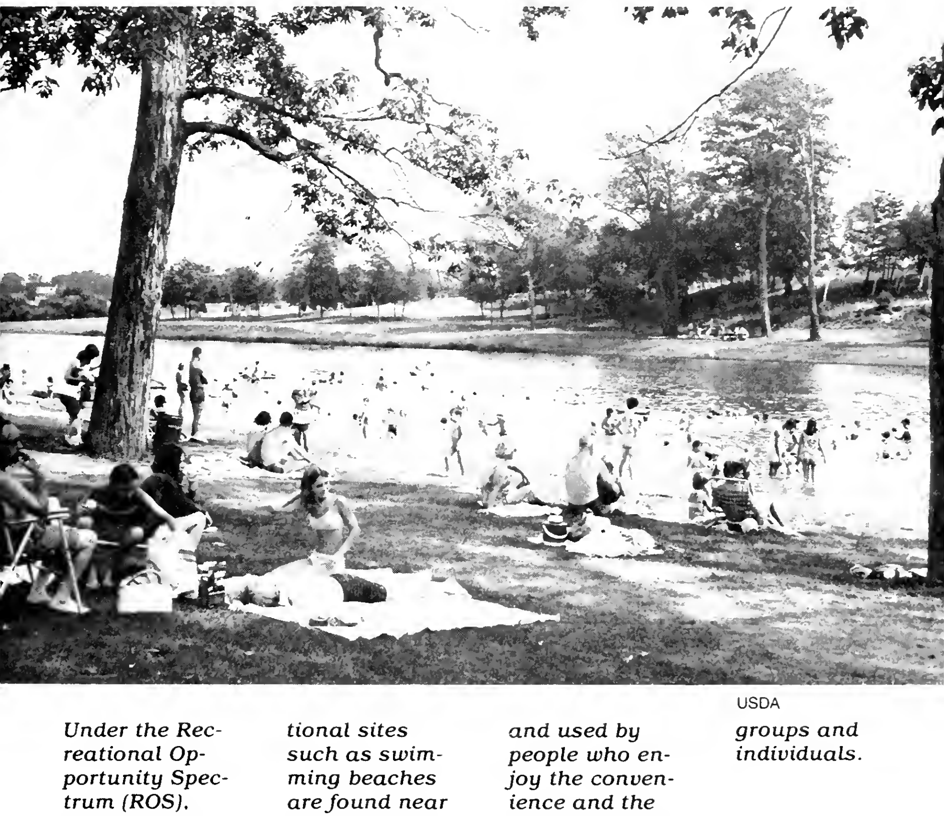
Research and Recreation

Outdoor recreation research became a principal endeavor at each of the U.S. Forest Service's Forest and Range Experiment Stations throughout the country. Researchers, working with universities, have recently been able to identify important relationships among the selected activities, preferred environmental settings, and expected recreational experiences sought by recreationists.

Armed with this insight, planners have been able to develop the ROS into a functional framework consisting of a coordinated resource inventory, planning, and management system previously unavailable.

The spectrum provides a framework to stratify and define classes of outdoor recreational environments. Its use on National Forest lands by planners has facilitated enfolding recreation into overall multiple use management.

While there often is a range of conditions within each ROS class—and some overlap be-



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Under the Recreational Opportunity Spectrum (ROS), urban recreational sites such as swimming beaches are found near communities and used by people who enjoy the convenience and the affiliation with groups and individuals.

tween classes—the following description of the physical, social and management characteristics of each class generally applies.

Urban: The urban settings are often where people live and work. Buildings dominate as do powerlines, traffic controls, and paved roads. Large numbers of users can be expected. Recreation places are often city or county parks with exotic plantings and mowed lawns.

Few urban recreation places occur on National Forests, and those are like small cities with all the comforts of home. Examples may be very large sophisticated resorts or winter sports complexes.

Rural: These are often the settings between the cities and the forests, such as pastoral farmlands and small communities. Affiliation with people and convenience of facilities are prevalent. Recreation places are often county and State parks.

Rural settings may include large winter sports areas and large campgrounds on National Forest lands. Facilities often include cooking grills, and flush toilets with electric lights. Occasionally, electric and sewer hookups for trailers are provided. Fees are charged on nearly every site. The visitor is restricted to designated roads and campsites.

A campground host may be on duty to help the visitor. Outdoor living skills are not important and seldom needed.

Roaded Natural: These are the settings seen from the many highways and scenic roads through the forest. The vegetation is often managed through timber harvest to maintain a healthy, natural-appearing forest. Recreation places are smaller campgrounds or winter sports facilities, with moderate evidences of people.

Roads and parking are often gravel; some may be paved. Facilities include toilets with sealed pits, fireplaces, tables, and level places for tents. Water may be provided by handpumps. There are no hookups for trailers, but parking spurs will often accommodate self-contained units.

Fees are charged at many campgrounds. The user is restricted to camping and picnicking in designated sites by roadside barriers and is subject to periodic visits by a compliance checker.

Roaded Modified: This ROS subclass is seen in many Western States, away from main public travel routes. Timber harvest or mining activities may dominate. The forest visitor may explore miles of roads with a highway vehicle, but must be cautious of fast-moving trucks. Few recreation facilities are provided.

Visitors usually bring everything themselves in the form of self-contained vehicles, and may find secluded spots along a back-country logging or mining road to make their own camp away from others. They are generally free to do as they please.

Semiprimitive Motorized: These settings are more remote, away from main traveled highways or roads, where nature predominates. The visitor often must have a 4-wheel drive vehicle or trail bike to travel the primitive roads and trails. Visitors may also travel by foot or horseback expecting to see the motorized user, but concentration of users is low.

There may be logging or mining, but it is limited. The forest appears predominantly natural. Recreation facilities are few, if any. At some campspots there may be sealed-pit toilets and spring boxes for water. There are only limited onsite controls over users, such as road closure signs and limits on where they may camp to protect lake and streamside areas.

Semiprimitive Nonmotorized: These settings are similar to the above except they are designed for the hiker, backpacker, and horse user. Sights and sounds of motorized users are not found on the trails. Distant sounds of highway and logging road traffic may sometimes be heard.

Hiking and equestrian trails offer varying degrees of travel difficulty and provide challenges to users. The visitors usually display higher degrees of outdoor skills and must bring all their own equipment for activities like camping, hiking, and river running. Few facilities are provided.

Timber harvest activities may occur but are limited, and any motorized access is closed to public recreational use. The forest appears natural. Some onsite controls over users occur, such as trailhead registration and restrictions on camping areas to protect lakeshores and streamside areas.

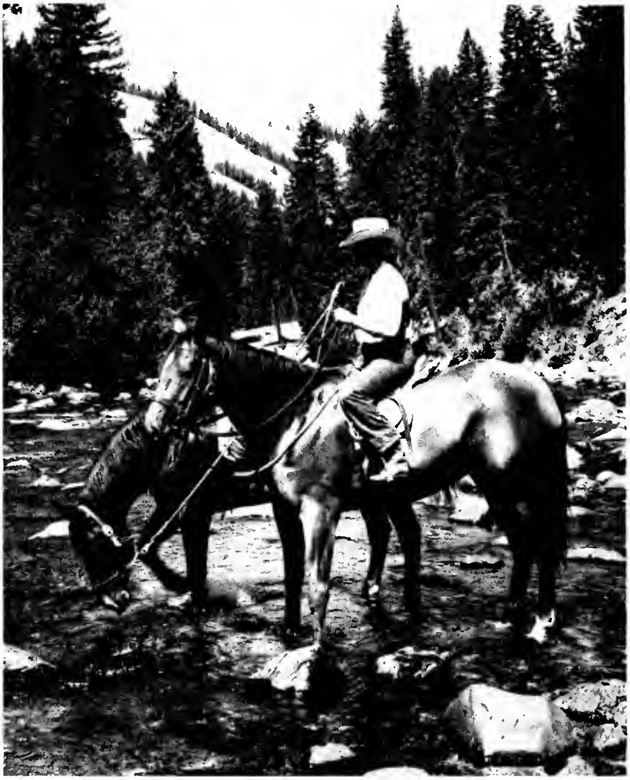
Primitive: These are large in size and the most remote areas of all, where both interaction and evidence of other humans are slight. Often the settings are the central core of wilderness areas, completely away from the sights and sounds of people.

The areas are for foot and horse traffic only. No facilities are provided. Visitors should have adequate outdoor skills to cope with a multitude of natural wildland conditions. They bring all their own equipment for camping, hiking, mountain climbing, and the like.

There is no timber harvest. Other resource activity such as grazing may occur, but is usually limited. Trails offer varying degrees of travel difficulty; sometimes large areas have no trails at all.

There are no onsite controls over visitors, but they may see a back-country ranger occasionally. Users generally are free to travel and camp where they want, although there may be restrictions on camping near lakeshores and streambanks to help protect those areas.

Primitive recreational areas are the most remote with access only by foot or horse. Often they are the core of large wilderness areas.



Don Baldwin

Photo Posters

These descriptions of the different classes of the spectrum are often summarized pictorially so the forest visitor can gain a clearer feeling of the settings and facilities in each class and make a comparison between classes.

Such a photo poster can be used along with a forest map to give the visitor a palette of recreational opportunities to choose from. Recreational activities locally available in each area can also be listed, along with mapped trail and road locations which may show levels of difficulty.

For management and conceptual convenience, the ROS has been divided into six classes. However, one advantage is that the classes can be combined when advantageous for management purposes.

For example, rural and roaded natural may be combined when there is little or no difference in resource management activities such as grazing or water development.

On the other hand—when there is a need to display more intensive, and somewhat different, management direction to certain areas—an ROS class can be broken into subclasses. Special management direction can be provided for each subclass, such as allowing motorized use of one area but closing other areas to that use. This also allows for more specific descriptions of setting characteristics which may aid in letting users know what to expect in a given area or to allow managers to deal with unique situations.

'Primitive' and 'Pristine'

Wilderness managers often subdivide the primitive class into "primitive" and "pristine". The latter provides for more intensive management direction designed to maintain particular wilderness areas where there is little or no past evidence of human use, or to provide needed isolation for some wildlife species.

Managers have found it desirable to subdivide the roaded natural class into "roaded natural" and "roaded modified." Thus they can define and describe forest areas which have been or will be more heavily modified or roaded than others.

These areas offer opportunities for a roaded, dispersed type recreation in a setting that features relatively high degrees of isolation from concentrated recreation areas. But it is easily accessible to motorized road and trail users who shun developed sites and find substantial evidence of other resource activity acceptable.

As demand on forest lands for all resource uses including recreation grows, each setting along the spectrum must be expected to provide a multitude of different forest products. For maximum social and economic benefit, this must be done without losing the biophysical and social attributes needed for certain recreational experience opportunities.

When settings are modified from one class to another, they tend to attract different sets of users with different recreational needs. Previous users tend to move on to other areas which will continue to meet their needs. However, it is becoming more difficult for displaced users to find satisfactory places to go.

The other important factor in setting management is that vegetation is not a static element in the landscape. Natural changes may sometimes take place that are not always desirable from a recreation standpoint.

Take a Douglas-fir stand nearing the end of its normal life cycle. Regeneration of new trees underneath is limited due to sunlight requirements of this species.

Wildlife or insect and disease epidemics may historically have been the natural forms of regeneration (and the appropriate forms of renewal in areas such as wilderness). However, careful and subtle management by timber harvest of small groups of mature trees can often be done in sensitive areas to forestall the more devastating impact of natural processes.

Blending Scenic and Other Values in Our Forests

By Robert F. Scheele and Robert W. Ross, Jr.

One of America's great pleasures is the view of the National Forests from travel routes, waterways, and other highly used areas. People's visual expectations of publicly and privately managed landscapes are beginning to affect land-use decisions in many places, with special emphasis placed on the federally managed lands of the Forest Service.

The demands on these lands are many and diverse. Sometimes they are complementary but often they seem to conflict. Demands can range from providing "hard" natural resource values such as wood, forage, and clean water to less tangible or "softer" resource-based values such as the sense of wilderness, the exhilaration of a mountain climb, or the beauty of natural appearing scenery. In combination, these disparate demands may be thought of as satisfying the needs of both the body and the spirit.

The challenge for natural resource managers is to find the appropriate mix of resource uses and to know the resource base's ability to sustain various uses over time. This challenge is especially tricky when considering multiple-use proposals which cut across the hard and soft resource values.

For example, a hunter might be quite dependent on a National Forest for a productive deer-hunting experience, while a hiker in the same autumn forest might feel put out by the hunter's presence. In such a case,

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In timber harvesting, achieving a natural-appearing edge is an important key to attain a desired landscape character. Here, harvest boundaries are at existing biological edges. This also has advantages for wildlife.

the clash of unfilled hopes and expectations may be predictable.

This clash can be equally loud when scenic expectations are not met because resource development activities such as wood harvesting or road building sometimes create dramatically obvious changes in the view.

Scenery, a Natural Resource

Congressional cession of Yosemite Valley to the State of California for use as a State park in 1864 and creation of Yellowstone National Park in 1872 are two of the earliest examples of scenic values being given natural resource status.

But is scenery really a natural resource? It is generally accepted that a material or area qualifies as a resource if it satisfies human needs or otherwise has value for human populations. To be natural, the material or area must be basic or primary, in other words not manufactured. So where valued scenery consists of mountains and virgin forests, it can be defined as natural.

When the forests or mountains are affected by timber harvesting, road construction, mine development, or a powerline corridor, the resultant scene might be more correctly thought of as a renewed resource. The idea of the renewability of resources suggests the need for wise stewardship and management in order to sustain visual quality while simultaneously providing for use of other forest resources.

While National Park managers have usually had legislated authority to maintain visual quality, expansion of this concern to other large areas of the public landscape—National Forests and public domain lands—is a development more recently mandated through Congressional actions.

These two categories of public lands are managed under principles of multiple use and sustained yield and the many resources controlled to insure their renewability. Scenery is no exception. But managing the visual resource goes beyond merely protecting areas of outstanding scenery.

Developing Standards

So it is not unusual to have portions of a National Forest, for example, being used primarily as a source of wood products. Another part of the forest might be managed mainly for recreational experiences in the form of campgrounds, trails, or scenic drives. In each situation, the result of management decisions and actions usually has visual consequences.

Working to insure that these consequences jibe with management objectives involves paying conscious attention to scenic attributes of the landscape under study, and developing recommendations or performance standards.

These recommendations may, for some critically important places, suggest that no visually perceptible change take place. Most often, however, the recommendations focus on ways to minimize negative visual consequences of a resource development activity without hindering that activity. In both cases, the multiple resource and sustained yield management principles are achieved and the general public benefits.

Visual System

Since passage of the 1891 Creative Act which brought the National Forest System into being, more than 20 pieces of legislation have been enacted that have major effect upon managing Forest Service lands. Of these laws, eight have either a strongly inferred or direct mandate regarding scenic resources.

Although the laws may not be as strongly worded as many might prefer, they identify scenery as a resource to quantify and consider in assessing environmental quality.

In response to this expressed concern and increasing awareness about scenic resources, a National Forest Visual Management System was developed and instituted during the late 1960's and early 1970's. This system provides for inventorying all National Forests and a procedure by which to develop measurable standards for managing visual quality.

Today any activity that occurs on these lands—for example, timber harvesting, oil and gas exploration, or recreation development—can no longer take place without due regard for the visual ramifications.

During the past two decades, as more land has been visibly affected by management activities, much public concern has been expressed about the forest environment. Often cited are harsh and incongruous visual effects that can result from timber harvest activities.

Stands Left Unmanaged

That has led, in some cases, to decisions which have left many of the more visually sensitive timber stands unmanaged because of the lack of acceptable harvesting methods. However, a number of such stands are beginning to reach the end of their normal life cycle, resulting in equally undesirable visual conditions due to such natural processes as disease, windthrow, and fire.

Forest managers have recognized this as a serious dilemma, and have provided for developing vegetation management tech-

By tying several clearcuts together over time, fewer harsh edges are created. Shown here are several areas that have been clearcut over a period of time.

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niques to perpetuate desirable visual conditions while at the same time meeting timber production goals.

With a basic understanding of landscape design methods for timber harvesting and the principles of corridor viewshed planning, one can gain insight into this facet of National Forest management.

Manipulating edge, shape, and scale of harvest units and distribution of activities over time and space are some of the techniques of landscape design for timber harvesting. They can be used to produce desired landscape character by accentuating positive elements and minimizing or mitigating negative elements of timber management activities.

Natural Edge a Key

Achieving a natural-appearing edge in timber harvests is an important key to attain a desired landscape character. A natural-appearing edge is perceived mainly in terms of texture.

Harvest unit edges which are also biological edges have advantages for wildlife. In general, the greater the edge diversity, the greater the number and variety of animals which will use the area.

Often tying several clearcuts together over time can result in fewer harsh edges. In addition, a desirable edge effect can sometimes be achieved by leaving the existing understory just inside the harvest unit boundary, or by progressively increasing the height of uncut vegetation away from the harvest unit.

The shapes of clearcuts that resemble or repeat natural openings in the existing landscape are, for the most part, more pleasing. Generally speaking, the shape of a timber harvest activity is more evident the farther away the observer is.

Scale refers to the relative size of activities in relation to the surrounding landscape. It is an important variable to consider so that activities do not appear too large or too small for a particular site. The same size clearcuts can be in scale in one landscape and too large in another.

The landscape design technique of distribution spreads out impacts of timber harvests over time and space to reduce negative impacts and create variety in natural-appearing forms, color, and textures.

Corridor Viewshed Plans

A viewshed is the total landscape seen or potentially seen from a travel route, use area, or water body. As we strive to get more timber into a managed state, while at the same time maintain or enhance visual quality, progressive and intensive approaches like corridor viewshed planning have become mandatory tools for managers.

Purpose of this type of planning is to provide the management direction for retaining or creating the desired forest character in an attractive sequential arrangement over time. Although they may differ slightly from one area to the next, most viewshed plans are developed within a framework of similar assumptions:

1) Vegetative composition of the landscape will gradually change over long periods of time

2) Sound timber management principles need not be sacrificed to meet desirable visual goals, and

3) Many combinations of landscape management principles and techniques and silvicultural practices can be used to simultaneously assure timber production and visual quality.

Achieving a specific long-term desired visual character for a viewshed is a challenging task that requires input from an interdisciplinary team. In the case of many Forest Service plans, makeup of this group includes a landscape architect, silviculturist, fire management specialist, and often a wildlife biologist and logging systems engineer.

Design Awareness

Team members have some, even if only limited, awareness of basic landscape design principles. These are often relayed through a general training session covering such issues as design vocabulary, discussion of achieving desired character, and review of various design techniques.

Possible planning processes to establish management direction for corridor viewsheds are, of necessity, quite varied in both character and intensity.

Currently, several viewshed plans are in various stages of completion in the Forest Service. As our landscape architects become more familiar with the procedures, silvicultural concepts, and terminology, we will see further refinements and adjustments.

In addition, completion of more research in environmental psychology will give valuable insight into the forest visitor's visual preferences. And as we move into interactive computer graphic systems, we can also expect major advancements in ability to simulate visual consequences of proposed viewshed plans before the plans are put in effect. These obviously will become useful tools for the Forest Service land manager.

Further Reading

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The Multi-Faceted Control of Pests That Damage Our Forests

By William M. Ciesla

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Look out over a mountain vista just about anywhere in the Rockies and the panorama may include large groups of dying trees. The cause? Mountain pine beetle.

This tiny insect bores into lodgepole, ponderosa, and other western pines and lays its eggs just under the bark. In a single year, 1981, nearly 14 million trees were attacked and killed. Over 116 million cubic feet of timber was destroyed.

But mountain pine beetle is just one of the many insects and diseases that damage our Nation's forests. Each year about 2.4 billion cubic feet of timber is killed. As a group, insects and diseases are the greatest cause of tree mortality.

Insects and diseases may do more than just kill timber. Dwarf mistletoes, for example, can also deform a tree or slow its growth. This group of parasitic plants infects many species of western pines, Douglas-fir, larch, and true fir. Estimated annual loss to the Nation's commercial forests from dwarf mistletoes is 418 million cubic feet per year.

Insects and diseases damage commercial forests, reducing both the amount of timber harvested and the quality of the products. That's not all they do. Pests also can alter water yields, increase fire hazard, and reduce property values. And most people do not like to drive through, hike, or camp in a forest of dead or dying trees.

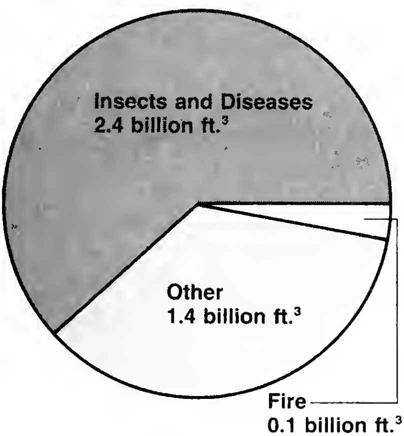
Managing pests must be considered in all phases of forest management. If they are disregarded, pests can seriously reduce the flow of goods and services from our forests.

When Not to Act

Nearly two decades ago, a new term was coined to describe the task of dealing with pests. That term was integrated pest management (IPM). The term, and its practice today, applies to both agriculture and forestry. It is regarded by many as the most effective way to deal with pests.

IPM is defined in various ways, but most definitions include two basic elements. The first is a decision process that considers the dynamics of the pest, its impact on the resource, and possible effects of treatment on the environment. The second involves use of one or more treatment methods to reduce pest impacts.

Average Annual Mortality on Commercial Timberland in the United States



Total = 3.9 Billion Cubic Feet

In IPM, the mere presence of a pest does not automatically justify treatment. When land managers decide whether or not to control a pest, they consider several factors. How numerous is the pest? How much damage will it do? How much will it cost to treat?

If treatment costs exceed losses, land managers would most likely opt to accept the loss. They may also decide to acccept the loss if treatments might damage other resource values, such as wildlife or fisheries.

The role of natural enemies—parasites, predators, and disease—on the pest is also considered. If natural controls will take over within a short time, artificial control may not be necessary.

IPM programs consist of one or more control methods used alone or in combination. Cultural, mechanical, biological, or genetic approaches may be used.

Chemical pesticides are also very much a part of IPM. However, when combined with other methods, they can often be used less frequently, in lower dosages, and applied with greater precision.

Predicting Pest Risk

In the past, outbreaks of insects and diseases have often appeared without warning in our Nation's forests. Widespread damage occurred before action could be taken. Today at least some of the reasons why outbreaks occur are understood, and can be used to predict susceptibility of a forest stand to attack.

Several risk-rating methods are available to rate susceptibility of a stand to pest damage. These methods take into account species composition, age, number of trees per acre, topographic position, and whatever other combination of factors are known to make a stand susceptible.

Pest managers use risk-rating methods to identify areas susceptible to such pests as the Douglas-fir tussock moth, mountain pine beetle, gypsy moth, and fusiform rust. Once high-risk areas are identified, land managers can plan for the necessary harvesting, thinning, or other appropriate treatment to reduce damage or prevent outbreaks.

Genetic Resistance

Reforestation with trees genetically resistant to certain diseases is another way to prevent pest damage. For example, pines have now been developed that are resistant to white pine blister rust.

This fungus, a native of Asia, was introduced to North America during the early 1900's. The fungus causes a lethal stem and branch canker of five-needle pines in several commercially important trees, such as eastern and western white pines and sugar pine. White pine blister rust became so severe in some areas that white pine could no longer be grown commercially.

Through selective breeding, geneticists have developed white pine varieties resistant to attack. By planting resistant seedlings, foresters can once again grow white pines in areas that were previously devastated by this disease.

Fusiform rust, a native fungus that invades the stems of young southern pines, is a major tree killer in the Southeast. Several years ago, the Forest Service established a screening center in Asheville, N.C., to evaluate natural resistance of pine seedlings to fusiform rust.

Here, scientists expose seedlings from different seed sources to doses of fusiform rust spores several times higher than can be expected to occur under natural conditions. Thus, seedlings that show high rust resistance are identified.

This service is available to forest managers—Federal, State, or private—throughout the South, who are replanting areas with pine seedlings already improved through selective breeding to grow faster and straighter.

Messages From Pests

In managing forest pests, one key is to keep the forest in a healthy condition. To do this, foresters must understand the role of insects and diseases.

The forest is a diverse, interacting community of plants and animals. Insects and diseases, like fire, often function as agents of plant succession, causing natural changes in the forest. They may remove single trees or entire stands to make room for younger trees.

The result may be a more diverse forest. Moreover, insects and diseases can help create a favorable environment for establishing pure stands of pioneer species such as quaking aspen or lodgepole pine.

When silviculturists and pest managers understand the role of insects and diseases, they seek out underlying causes of pest outbreaks. The presence of destructive levels of a pest is often a symptom of stress.

Stress can result if trees are not ideally suited to a given site, are overmature, too crowded, or suffering from long-term effects of drought. If only the pest is treated, it may reappear once treatment is ended. If the underlying cause is also treated, the result can be long-term protection.

Pine Beetle Know-How

We know some of the underlying causes for outbreaks of one of our major insect pests, the mountain pine beetle. In ponderosa pine forests of Colorado, Montana, eastern Oregon, and South Dakota, there is a relationship between mountain pine beetle attack and stand density. As numbers of trees per acre and tree size increase, a stand becomes more susceptible to attack.

During the late 1970's along the Front Range of Colorado, this knowledge was put into practice on a large scale.

A severe outbreak of mountain pine beetle was underway in the mountains west of Boulder. Land managers applied a number of pest management methods to reduce losses and to protect the remaining trees.

Treatments included thinning susceptible and infested stands, cultural methods designed to encourage growth of tree species that are not attacked by mountain pine beetle, and chemically treating infested trees.

Because of the mixture of landownerships within infested areas, the program depended upon close cooperation among a number of public agencies—the U.S. Forest Service, the Colorado State Forest Service, the U.S. Bureau of Land Management, the City and County of Boulder, and private landowners. The program succeeded. Now some of the same techniques are being used in other areas of the Front Range.

Pest Population Detection

Determining pest status on forest lands is a key part of IPM and includes detecting actual or potential problem areas, keeping track of the status of known outbreaks, and forecasting pest population trends and damage.

Ideally, pest outbreaks should be detected early, before widespread tree killing or growth reduction occurs. The most useful and timely detection is accomplished by on-the-ground foresters, technicians, and forest workers.

These people are acquainted with the forests they work in and should recognize the danger signals of pest activity at the earliest possible stages. They are trained by specialists within the U.S. Forest Service and State forestry agencies to insure that pest activity is recognized and reported.

For certain pests, it is necessary to monitor low-level populations to detect increasing trends before damage occurs. This is especially true of an insect like the Douglas-fir tussock moth, a defoliator of Douglas-fir and true fir in the West.

This insect has a cyclic pattern and becomes epidemic every 7 to 10 years in many areas. Outbreaks usually last 2 to 3 years, and then the population succumbs to a natural virus disease.

Large numbers of tussock moth larvae can strip a tree of all its foliage in a single growing season. Therefore, trees can be killed during the first year of an outbreak.

Sex Attractants

One way of detecting increases in pest levels is by using sex attractants. Success of mating and reproduction in many insects depends upon their response to chemical messengers called pheromones. Many of these pheromones—including the ones produced by female Douglas-fir tussock moths—have been chemically identified. They can now be produced synthetically in the laboratory.

Sticky traps containing minute quantities of the Douglas-fir tussock moth pheromone are placed in the forests when moths are active. If large numbers of moths are captured, the traps serve as an early warning of a possible outbreak. Entomologists can then determine where to conduct special followup surveys to identify areas that may require control.

For introduced insects such as the gypsy moth, which is now a major pest of hardwood forests in the Northeast, pheromone traps are used to determine if an insect is present in an area.

Capture of male gypsy moths in places far removed from the generally infested area in the Northeast indicates new infestations may have become established. Identification of infestations in Arkansas, California, Florida, North Carolina, Oregon, and Washington was made possible through using this technique.

Aerial Pinpointing

Tree killing or foliage injury caused by forest insects and diseases can be seen from long distances. In remote forest regions, aerial surveys are the primary means of detecting localized pest damage and monitoring the status and trend of known outbreaks.

Trained observers, flying in small aircraft, locate pest damage and plot its location on maps. These surveys provide es-

A sticky trap containing a chemical attractive to male Douglas-fir tussock moths is placed in a tree. If large numbers of moths are captured, the traps provide early warning of a possible outbreak.

timates of acres infested by certain pests. They also pinpoint the location of damage so that pest managers can make more detailed assessments to determine what action, if any, is needed.

Today the computer is a driving force in virtually all facets of modern society. Forest pest management is no exception.

In recent years, a number of computer-based mathematical models have been developed to simulate population trends of certain pest species. Field data on pest populations can be analyzed to predict what course an outbreak may take.

Pest models linked with forest growth and yield models are being developed to predict changes in resource outputs under various combinations of pest management alternatives. Projections of yield with and without control provide an economic basis for making decisions.

Control of Outbreaks

When direct control is needed to suppress an outbreak, several methods are normally used. An IPM approach to a foliage-feeding insect, such as the spruce budworm, may include use of a chemical insecticide over the generally infested area.

Environmentally sensitive areas, such as streams, lakes, or areas of human habitation, would be treated with a less toxic chemical, a biological insecticide, or may receive no treatment at all.

Direct control is often accompanied by long-range silvicultural treatments or accelerated harvesting to reduce the proportion of tree species and age classes favored by the pest.

When defoliating insects become epidemic in remote forest regions and treatment is required, insecticides are often applied by aircraft.

Aerial application of pesticides is a specialized science. Spray aircraft must be carefully calibrated to deliver the proper dosage and the optimum droplet size.

In rugged mountain terrain, helicopters or turbine-powered aircraft are used to insure precise application to target areas. Local weather conditions are closely monitored. If air currents increase or temperatures rise—creating conditions that prevent penetration of insecticide droplets into the forest canopy—spraying is terminated until more favorable conditions occur.

Biological Advances

In recent years, more attention is being given to use of biological insecticides, such as viruses or bacteria. These materials tend to be more host-specific, with less potential for damage to the environment than chemicals.

Recent advances in bacterial culture and formulations chemistry have resulted in commercial preparations of the bacterial insecticide *Bacillus thuringiensis* (B.t.), which are easy to mix and apply.

This bacterium causes disease in many caterpillars, some of which are important in forestry. B.t. has been used successfully against spruce budworm and gypsy moth; it is now the insecticide of choice for control of gypsy moth by several Eastern States.

Similarly, the virus disease that causes a natural collapse of Douglas-fir tussock moth populations is now being produced for use as an aerial spray. Scientists and technicians at a U.S. Forest Service laboratory in Corvallis, Ore., are rearing hundreds of thousands of tussock moth caterpillars. They infect the caterpillars and are recovering virus, which will be used when the next Douglas-fir tussock moth outbreak occurs.

Diseases are not the only biological agent used to control forest pests. During the late 1970's, an introduced pine sawfly expanded its range into western Virginia and North Carolina, causing severe damage to eastern white pine in the Blue Ridge

Commercial preparations of a bacterial insecticide are being used against the gypsy moth, shown here with egg masses. The bacterium causes disease in many caterpillars and has been chosen by several Eastern States for control of the gypsy moth.

Mountains. Large numbers of parasitic wasps were reared in field laboratories and released to help bring the outbreak under control.

Research and Development

IPM approaches are available today for only a few forest insects and diseases. In order for IPM to be fully viable and dynamic, it must be accompanied by a research and development effort.

For example, during the past decade, the U.S. Department of Agriculture accelerated research and development on Douglas-fir tussock moth, gypsy moth, and southern pine beetle. These programs provided greater insight into the biology and ecology of these insects and their hosts.

As a result, better methods for rating infestation hazard, mathematical models for predicting infestation trends and expected losses, and improved methods of control were developed and are now available for use.

When these programs were completed, research scientists turned their attention to other pests. An accelerated Canada/U.S. research and development program on spruce budworms and an expanded IPM research program on insects and diseases of southern pines are now underway.

The expanded programs are accompanied by a number of long-term research projects at Forest Service laboratories and universities throughout the country. These projects encompass a broad range of problems and continuously improve our knowledge of forest pests.

IPM provides an opportunity to take an indepth look at the basic causes of pest problems—and offers choices of actions that are longer lasting, less costly, and less damaging to the environment. IPM is the most practical approach to dealing with forest pests.

Road to Recovery After Eruption of Mt. St. Helens

By Joseph E. Means and Jack K. Winjum

Mount St. Helens and the surrounding forest land in southwest Washington State were heavily used before 1980 for mountain climbing, backpacking, hunting, and fishing, as well as tree farming. That changed on May 18, 1980, when the volcanic mountain erupted violently. It sent a massive avalanche of molten rock and other debris from the top and north side of Mount St. Helens into the North Toutle River valley.

Within 15 minutes, 151,000 acres of forest and recreation land were devastated by the lateral blast. This blast blew down forests on 52,000 acres, and its heat killed trees and other plants but left them standing on another 24,000 acres.

The large debris avalanche, pyroclastic flows, mudflows, new lakes, the volcano, and areas clearcut before the eruption comprised the rest of the devastated area. Most of the land was owned by the Weyerhaeuser Co. or Burlington Northern Timberlands, or was managed by the Forest Service or the Washington State Department of Natural Resources.

Mudflows scoured the North Toutle, South Toutle, and Muddy River valleys. Streams, choked with sediment, gurgled around the many trees blown into them. Cooked forest canopies were blown into lake waters warmed by the blast, killing the fish and other organisms.

The 9-hour eruption covered the area with 1 to 20 inches of

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Tim McCabe

Within 15 minutes of the Mt. St. Helens eruption, 151,000 acres of forest and recreation land were devastated.

tephra: ash, pumice, and rock pulverized by the blast.

Immediately after the eruption, the devastated area presented a picture painted in shades of gray—there were no signs of greenery or animals. We wondered, "How long will it be before these hills are green again? Fifty years? One hundred?"

Life Reappears

Life began to reappear on that landscape almost immediately after the eruption, however, with the springtime warming in the mountains. Essentially all plants that appeared the first growing season sprouted up through the tephra from the buried soil.

Trillium and huckleberry emerged amid the fallen trees, and even small silver fir and mountain hemlock trees sprang up in areas where they were protected from the force and heat of the blast by a heavy winter snowpack.

Fireweed and other plants common to old clearcuts sprouted readily through the tephra where it was less than 8 inches thick the first growing season.

Partial erosion of the tephra off hillsides allowed many plants to reach the surface. Indeed, plants emerging in rills were the only ones seen soon after the eruption in clearcuts with deep deposits of tephra.

Some streamside and lakeshore areas also recovered rapidly as water removed the tephra

Jerry Franklin

In the first growing season after the eruption, fireweed and other plants sprouted readily through the tephra (ash, pumice and pulverized rock) where it was less than 8 inches thick.

so sprouts from buried plants could reach the surface. In other areas tephra eroded off hillsides and, carried by streams, buried would-be survivors.

Oasis on Debris Avalanche

Plants survived even in the debris avalanche deposits in fist-size pieces of soil scraped from the valley floor and walls. Plants recovered most rapidly in western portions of the devastated area because the blast deposits were cooler and the tephra was generally thinner than in eastern portions.

Seeds had been blowing into the devastated area since the eruption. From these seeds, and seeds produced by surviving plants, natural seedlings became much more common starting the second year as the rate of erosion slowed.

Plant establishment from seed, though very sparse, was most important on the debris avalanche where residual plants were extremely rare and on the pyroclastic (volcanic) flows where they were nonexistent.

Plants with light, wind-dispersed seeds—such as purple-flowered thistle, yellow-flowered groundsel, and red-flowered fireweed seedlings—were appearing in unexpected places. One site on the debris avalanche had such lush vegetation in 1981 that researchers named it "the oasis," in contrast to the relatively barren miles of fragmented rock, gravel, and sand.

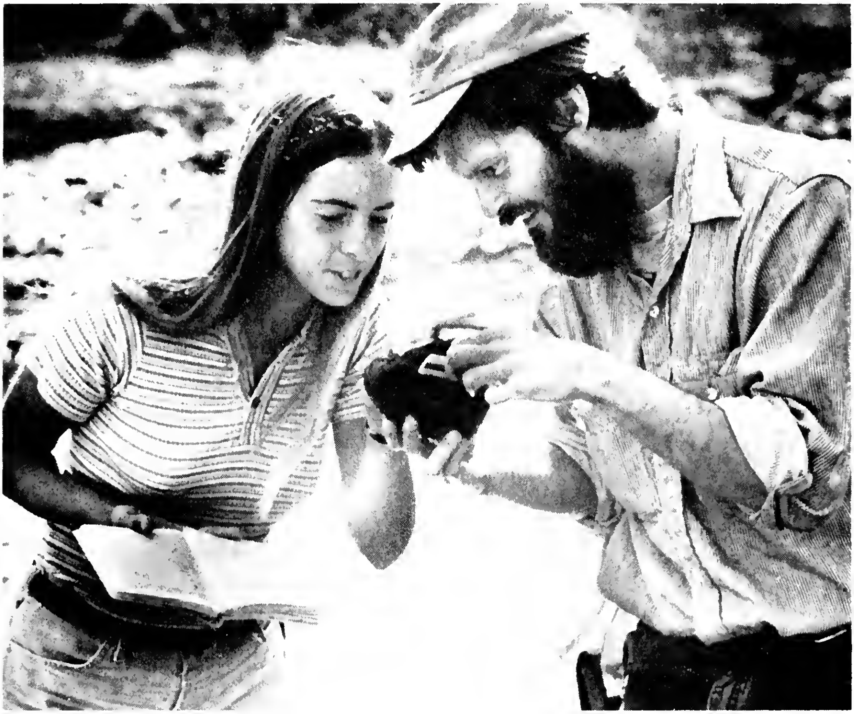
Animal, Fish Survivors

Like the plants, some of the first animals observed in the devastated area were those that survived the eruption under ground. Ants and gophers were the most common of these. Many small animals, such as mites and springtails, survived in rotten wood.

Fish, salamanders, aquatic insects, and micro-organisms survived in many lakes in the devastated area, chiefly those with ice and snow in them when the eruption occurred. A few fish also survived in streams, especially where water moving around logs or rocks created cool pools that fish could hide in and where cobbles (rounded stones) occurred on which live aquatic insects that fish use as food.

Unlike the plants, most vertebrate animals invaded the devastated area from the surrounding green forests in the first two years after the blast. In fact, deer and elk entered the area immediately after the eruption. Populations increased as returning vegetation provided food so that resident herds numbered in the hundreds in 1981 and 1982.

Birds occurred throughout the area the first summer. The sight of a hummingbird hovering in front of bright orange flagging held by a forester five miles from green forest was a very encouraging sign that life was beginning to return to the devastated zone.



James Hughes

Peggy Wilzbach, aquatic ecologist, and Tom Lisle, hydrologist, found aquatic insects on rocks in streams in the devastated area after the streams were washed clean of pumice and ash.

Spiders came many miles through the air by ballooning—letting out long filaments of web and being lofted long distances when the web was caught by the wind.

Fire-Fungi Feed Ants

Micro-organisms also played important roles in the recovery of these forest ecosystems. So-called "fire-fungi," common after forest fires in the Pacific Northwest, were seen within several weeks of the eruption because their spores were stimulated to germinate by the heat of the blast deposits.

Ants from different colonies competed for the whitish mats of fungus because they were one of the first food sources to appear.

Many kinds of fungi that occur in the buried soil form close associations (called *mycorrhizae*) with plant roots, in which the fungi grow between and within cells of the plant roots. These fungi obtain food from the plant and in turn bring important nutrients (such as phosphorus) to the plant from the soil.

Bacteria in the buried soil decompose organic matter and in the process release nitrogen, another important nutrient, in a form available to plants. When deposited, the tephra was essentially devoid of life, and the nutrients it contained were quickly leached into the buried soil by rainwater because the tephra could not hold them.

Thus one can see the importance of the buried soil, with its ability to hold nutrients and its teeming community of micro-organisms, to recovery of vegetation and productivity of future forests.

Ash Effect on Live Forest

The green forest outside the devastated area received a covering of ash that stuck to needles, killing some. No large trees died, however, and most grew just as much in 1980 as they had in previous years.

Growth on young trees in adjacent clearcuts increased dramatically in 1981 and 1982, possibly because the tephra acted as a mulch, retaining soil water for plant use. Understory plants of green forest fared poorly where tephra up to 8 inches thick killed huckleberries, other shrubs, many herbs, and small trees.

Bulb plants, such as avalanche lily, and some other herbs were able to sprout through the tephra, and at least a few survived in many places. Also, some understory trees grew roots from their trunks into the tephra, exploiting the water it held, a resource most other plants had not yet tapped.

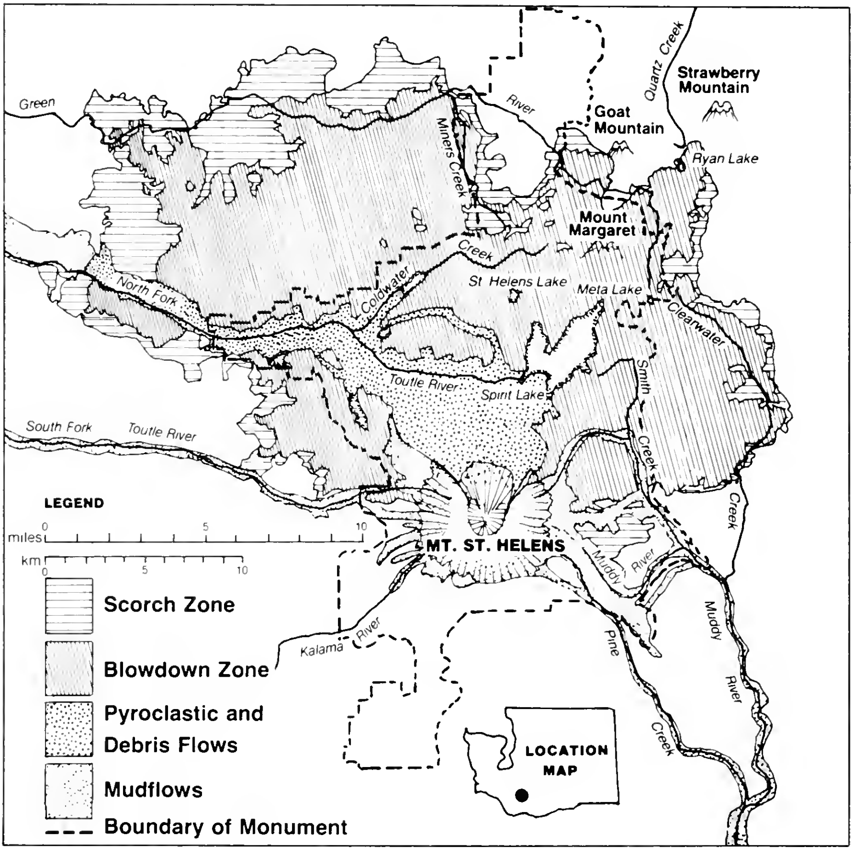
Managers' Response

Dealing with large natural catastrophes is not an unfamiliar job for forest land managers. Wildfire, windstorms, and insect epidemics are examples of natural phenomena that periodically devastate large areas of forest. In size and suddenness, the volcanic devastation around Mount St. Helens was not that unusual when compared with other catastrophes.

At the same time, forests blasted with lethally hot gases, then blanketed with falling tephra, and river valleys inundated with debris and mudflows were all quite new to the region's forest managers. Within a few days, however, the stunned reaction gave way to thoughts and plans for restoring the managed forest as had been done historically following other large catastrophes.

Assessing Losses

Assessment of losses came first. Within a few weeks, a tally from aerial photos and ground checks from helicopters showed that in the blast zone, forest stands of merchantable size occupied 82,600 acres and totaled 4.7 billion board feet in volume. Nonmerchantable stands, planted or seeded during the previous 20 years or so, covered another 48,000 acres.



These forests of dead trees—standing, broken off, blown down, or blown away—consisted primarily of Douglas-fir, western hemlock, noble fir, and silver fir, all commercially valuable conifer species.

Other critical losses included the transportation system and working equipment in the area, all important parts of a managed forest.

Over 500 miles of truck roads and 16 miles of railroads were buried under tephra deposits or mudflows. Twelve key bridges were out. Also destroyed or heavily damaged were three non-resident logging camps, dozens of woods vehicles, and heavy log-loading machinery from many logging sites.

Technical Help Sought

Restoration plans of land managers addressed the timing, resources, people, and safety considerations required to open and rebuild transportation systems, salvage and market dead but merchantable trees, reforest potentially productive lands covered with tephra deposits, and provide protection against further losses by wildfire, insects, or wood-rotting organisms.

Planning the restoration of managed forests in the blast zone called for technical information not previously available. Managers sought help from a myriad of engineers and scientists, including representatives from the physical, biological, and social sciences.

Geologists worked out an eruption forecasting system that was the basis for warning and evacuation plans. Industrial hygienists studied health hazards to people working in heavy volcanic dust and recommended that respirators be worn during dry, windy periods.

Log Value Holds Up

Wood scientists were flown into the blast zone early to check log quality. They found that charring or pitting by the blast was limited to bark layers of dead trees and that breakage caused by the blast caused little loss in usable volume; thus the wood had no significant loss in value.

No one, it seemed, knew much about the tephra, and chemists were quick to determine its chemical and physical properties—most important, it was nontoxic, largely inert, but physically quite abrasive. This information led engineers to develop special equipment and maintenance schedules to overcome abrasive effects of the tephra.

Knowing the tephra was not toxic and seeing many early signs that the ecosystems were beginning to recover, foresters and wildlife biologists realized that the normal complement of forest life would no doubt return to the devastated area. Indeed, they theorized that natural recovery might even be enhanced through management techniques.

Seeding by Air

Tephra erosion was severe the first summer and fall. Each rainstorm washed tephra from barren hillsides, and heavy sediment loads in streams and rivers raised beds and increased flood hazards.

To control surface erosion, 20,000 acres of the devastated area were aerially seeded and fertilized in the fall of 1980 with mixtures of grasses and legumes. Most hillside surface erosion, however, occurred by the end of the first winter, before significant vegetation—natural or seeded—was established.

Surface erosion of the tephra was greatly reduced naturally the second and third winters because the infiltration capacity increased, and rock fragments and pumice—exposed by sheet erosion and frost heaving—armored the surface against further erosion.

In rills and small gullies eroded in the tephra, seeded grasses, natural vegetation, roots, and buried branches helped control erosion of the valuable buried soil and probably reduced peak runoff rates during storms.

Logs Retrieved

Salvage logging began May 19, 1980, with the first retrieval of logs swept by mudflows down the Toutle River west of the volcano into the Cowlitz River and ultimately down the Columbia River. The logs had been stored at truck-to-rail transfer points along the Toutle River. East of the volcano, logs that had come down the Muddy River were salvaged from the Swift Reservoir.

Salvage operations in these waters took 4 months, and 15 million board feet of timber were recovered.

Meanwhile, reopening of roads in the blast zone was begun. During the first 2 years, nearly 700 miles of forest roads were reestablished or newly built, including bridge construction at key points.

Logging of dead timber in the blast zone was started in late summer 1980. Timing was very important. Operations could not safely and effectively begin until good information was available on the important technical questions discussed earlier in this chapter. Yet experience from other forest catastrophes underscored the need for rapid salvage.

Potential secondary problems could be a threat in a large area of newly killed forests. For instance, buildups of wood-boring insects and decay fungi can reduce the value of logs as time passes. During periods of dry weather, wildfire is a hazard. Also, the time the land is not producing trees is a substantial loss to the landowner.

1,000 Salvage Workers

Once underway, however, salvage operations were most intensive. At one point in 1981, over 60 logging settings involving more than 1,000 workers were operating simultaneously in the western blast zone. About 600 truckloads of logs a day were transported. This work pace shifted to the eastern side of the zone in 1982 and 1983.

By the end of 1984, plans call for completion of salvage logging on about 47,000 acres, totaling 2.7 billion board feet of timber. Remaining lands that contained merchantable timber were buried by debris or mud, were inundated by new lakes, or are in Mount St. Helens National Volcanic Monument and will not be salvaged.

Precautions Pay

Precautions designed into salvage plans paid off. Volcanic activity continued periodically and was accurately forecast. Evacuations and closures during these events prevented life-threatening situations for workers.

No significant increases in lost worktime were encountered as a result of heavy exphasis on health and safety. Extra maintenance kept excessive wear on equipment down except for rapid dulling of chains on powersaws. Use of carbide-toothed chains eventually solved this problem.

Overall logging costs were slightly greater than normal, primarily because of higher felling and bucking costs caused by the tephra.

Beneficial Effects

Salvage logging had several effects on recovery of these forest ecosystems. Mixing of the buried soil with the tephra and breaking up its continuous mantle increased infiltration of rainwater which decreased the threat of further surface erosion, allowed more buried plants to reach the surface, and made the buried soil—with its micro-organisms and nutrients—available to colonizing plants.

Logs blown into streams were often salvaged, although in several locations stable logs were left to maintain fish habitat at the request of fisheries biologists.

In June 1980, only a month after the blast, the first test of planting tree seedlings was begun with several hundred bareroot, two-year-old Douglas-fir and noble fir trees.

When roots were planted in contact with original buried soil, the seedlings survived and grew well. When planted so roots were only in tephra, performance was poor primarily because of a nitrogen deficiency. Shovels proved the most useful tool in clearing or scalping away thin tephra.

Operational Plantings

Based on these research results, plans were made to begin operational planting during the next scheduled period which started in February 1981. Open areas with less than 6 inches of tephra received the first plantings—about 6,000 acres in total the first winter after the eruption.

During the 1982 reforestation period, another 14,000 acres were planted, including many of the first acres that had been salvage logged. Douglas-fir was planted below 3,000 feet in elevation and noble fir above, both at densities of 350 to 500 trees per acre.

Reforestation was more difficult in 1983 because whole dense plantations of dead trees and sites with tephra up to 12 inches deep were encountered. Treatment was needed before planting could be done.

Dead trees were felled and burned, and crawler tractors with front-mounted V-blades were used in areas with deep tephra to clear rows along the contours down to buried soil. On slopes too steep for tractors, power augers proved effective in bringing the buried soil close to the surface in the planting hole so contact with tree roots was possible.

First test planting of tree seedlings was done in June 1980, just one month after the Mt. St. Helens eruption.

Experience to date indicates that planting costs are average to significantly greater than average, depending on site preparation and planting difficulty.

Elk Damage Seedlings

Survival and growth of seedlings have generally been favorable, though animal damage has been severe in some localities, particularly browsing by the growing herds of elk. By 1985, a total of about 70,000 acres will be reforested in the blast zone of Mount St. Helens.

Riparian zones along rivers and streams where tephra or mud accumulated several feet deep were reforested with cottonwood and willow cuttings because such soil conditions are not suitable for conifers. These hardwoods grow quickly, stabilizing the new deposits and providing shade that keeps water temperatures favorable for fish during sunny periods. Reforestation was conducted along the sides of 55 miles of river and stream in this manner.

Natural seedlings of red alder and cottonwood were common on mud deposits along many streams outside the blast zone.

Volcanic Monument

Some 110,000 acres of the area around the volcano is now Mount St. Helens National Volcanic Monument. It includes the volcano, Spirit Lake, the debris avalanche, and many other interesting features created by the eruption.

The monument will be managed by the Forest Service to "protect the geologic, ecologic and cultural resources . . . allowing geologic forces and ecologic succession to continue substantially unimpeded," according to the establishing Act. For years to come, its unique features will be available for public enjoyment and scientific study consistent with their protection.

Nature led the way to the recovery of forest ecosystems around Mount St. Helens. Plants, animals, and micro-organisms invaded the barren surface from below the ground, over the surface, and by air in the first three years. Perhaps this rapid recovery should have been expected.

Adapting to Volcanism

Many forests in the Cascade Range grow on soils of volcanic origin that have literally fallen from the sky. Also, eruptions often occur within the 400- to 800-year lifetimes of dominant forest trees such as Douglas-fir.

Eruptive periods of Mount St. Helens, the most active volcano in the Cascade Range, have been separated by only 100 to 500 years in the last 35 centuries. Evidence indicates some trees northeast of the volcano, an area repeatedly covered by tephra, are genetically adapted to repeated volcanism.

Families of Douglas-firs from this area survived temporary burial by the 1980 eruption better than trees from areas not so frequently covered by tephra at three planted test sites.

Further Reading

Mount St. Helens: One Year Later. S. A. C. Keller, ed. University Bookstore, 830 Elm Street, Cheney, Wash. 99004. $22 per copy.

Volcanic Eruptions of 1980 at Mount St. Helens: The First 100 Days. Bruce L. Foxworthy and Mary Hill. U.S. Geological Survey, Professional Paper 1249. Stock No. 004-001-03452-2. For sale by Superintendent of Documents, Washington, D.C. 20402.

Instant Forestry: Getting More Wood From Fewer Trees

By William E. Penoyar

The phrase "Instant Forestry" was recently coined to describe what happens when timber harvesters or wood processors improve the efficiency of their operations. It means that by improving the efficiency of timber harvesting and processing, the forest resource is instantly increased or extended without having to wait 30 or more years for a seedling to grow to a merchantable tree.

That aspect of forest management—getting more wood products out of each tree—is frequently overlooked when industry, legislators and others discuss the future need for more wood, but has significantly contributed to the country's economic well-being and balance of foreign trade. This chapter describes some of the opportunities which exist through improved wood processing and utilization, and how the Forest Products Utilization (FPU) programs of the State forestry agencies and the Forest Service contribute to the extension or increased availability of this valuable natural resource.

The timber industry was notorious for its "cut out and get out" practices from the time the first sawmill began operating in the early 1600's through the early 1900's, when the timber industry finally started to realize it could not continue operating as it had in the past. About that time, the founding fathers of the Forest Service also recognized the resource could be significantly extended if the timber in-

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Glued-laminated beams and decking were used in this bridge in the Gifford Pinchot National Forest. The technique resulted from research at the Forest Products Laboratory in Madison, Wis.

dustry improved the efficiency of its logging and manufacturing or conversion activities and discontinued wasteful practices.

In 1910, this recognition led to establishment of a Forest Products Laboratory (FPL) in Madison, Wis., to provide basic and applied research in wood product and process development and improvement.

Since the laboratory opened its doors, many research projects have led to successful development of improved or innovative ways to process and use wood, including such products as glued-laminated timbers, chemical stabilization and densification of wood, and improved packaging and wood construction techniques. The industry adopted many of these innovations over the years, but rapidly changing technologies have stimulated development of new and more effective methods.

Today, responsibility for providing national leadership in the area of utilization technology lies within the Forest Service's State and Private Forestry organization, with specific responsibility for transferring the results of forest products and engineering research at the Forest Products Laboratory and other Research Stations assigned to the Cooperative Forestry staff. One of its missions is to work through State Forestry Departments to assist private forest landowners and managers, forest operators, wood processors, public agencies and individuals in efficient harvesting, processing, marketing and utilization of timber and wood products.

Drain on Forests

Many people have come to realize it is essential to minimize wood waste or residues developed during timber harvesting and processing. Also, the residues should be put to productive use if the Nation is to meet its ever increasing need for forest products at affordable prices. At the same time, newer and more efficient conversion strategies were developed to ensure that a quality environment is maintained.

The obvious advantage of better utilization of wood is that improvements provide immediate supply gains, thereby reducing the drain on the forests. More lumber and other wood products actually get to the consumer from every acre harvested—we truly get more wood from fewer trees.

The Forest Products Utilization (FPU) program is a combination of several cooperative and direct technical assistance activities involving the Forest Service and participating States. State and Federal FPU specialists work directly with individual cooperators to encourage the application of improved technology.

This is done by organizing field trials for new products or processes, giving technical assistance to the target audiences of research findings through State cooperators, and identifying high priority forest products utilization problems that need research.

The overall FPU program of the Forest Service includes many activities and mini-programs in harvesting, primary processing, secondary processing and drying, and energy- and byproduct-related activities. Some examples of how the first three of these programs are extending our forest resource are discussed here, while energy-related items are discussed in a subsequent chapter.

Better Harvesting

The logging industry was once characterized by having relatively low product recovery from the standing tree. Despite several improvements in recent years, there are still many opportunities for reducing losses even more. Some of these losses are unavoidable, but many occur because timber operators become careless or are unaware of the costs that can be avoided.

Failure to harvest trees for maximum recovery, or to use the latest log handling and sawmilling information, contributes to lower recoveries than are technically possible.

The Improved Harvesting Program operated by the Cooperative Forestry staff of the Forest Service through State FPU specialists increases the net recovery of roundwood volume and value through more efficient harvesting.

As used here, harvesting activities include "felling" or cutting down trees and "bucking" or cutting the trees into desired log lengths. According to information gained from over 1,500 Felling and Bucking (FAB) evaluations and 300 Logged Area Analysis (LAA) studies, subunits of the Improved Harvesting Program, average operators lose about 6 percent of the wood volume they cut down because of careless logging practices.

Considering the annual harvest in 1976 as average, over 752 million cubic feet of timber is harvested—cut down—annually but not used.

2 Million Homes

This means industry could harvest over 88 million fewer trees, or 263,000 fewer acres of timberland, and produce the same amount of wood products by using more efficient logging practices. That is equivalent to a forest the width of an Interstate highway right-of-way 10,000 miles long. If all this wood were converted into structural lumber and panel products, it would be enough to build over 2 million homes.

The Felling and Bucking Technical Assistance Package was introduced in 1976 and is the most popular part of the Improved Harvesting Program. This program provides for a computerized evaluation of a logger's cutting practices.

Felled and bucked trees are mathematically reconstructed and then "computer bucked" to maximize volume and value of recovery. The evaluation determines how much wood is presently being salvaged by a cutting crew compared with what is technically possible.

After reviewing the computer printout, a logging superintendent or log purchaser can improve productivity of the logging crews through proper training and appropriate incentives. Such improved productivity means better wood and profit recovery.

The Logged Area Analysis Program was developed and made available to FPU specialists and others in 1981. This program determines quantity and quality of residue left in the woods following a logging operation. Once the field data are obtained, computer calculations are made which classify the residues by size, source and product potential. The program has become very popular as a tool for evaluating logging performance.

Besides these two programs, technical assistance and training is also available to landowners, loggers, and others through the State Forester offices in timber sale layout, equipment selection, safety, log grading, marketing, and other subjects associated with harvesting and marketing timber.

Less Logs, More Lumber

While most of the fiber content of logs going into sawmills today is used one way or another, generally less than half of each log winds up as the primary product—lumber.

In 1970, about 165 cubic feet of logs were required to produce 1,000 board feet of lumber. (A board foot equals the cubic contents of a piece of wood one foot square and one inch thick.) The volume of logs required to produce the same volume of lumber today has been reduced to about 125 cubic feet. That represents a 24 percent reduction in log requirements for comparable lumber production during the past 13 years.

This trend cannot be expected to continue indefinitely, but it is conservatively estimated that another 10 percent improvement can be achieved by 1990 if the industry continues to tighten its operations and upgrade its mills with the latest computer-assisted technology. Thus, the Nation's timber resources can be instantly extended through improved processing of logs at the sawmill.

Although the Sawmill Improvement Program (SIP) cannot be credited with achieving these improvements directly, the use of SIP studies helps industry determine what the lumber recovery is with its present equipment and identifies areas in the sawmilling process where improvements can result in increased productivity.

In the Sawmill Improvement Program, lumber output is tallied to determine current yield from study logs.

The original SIP was written for mills producing softwood dimension lumber and used the Best Opening Face technology developed at the Forest Products Laboratory to determine operating efficiency. This consists of a computer analysis of the end of a log to determine where the first sawline should be located to maximize the amount of lumber obtained from the log. Since then, SIP has been expanded to include computer analysis of mills cutting pine shop grade lumber and hardwood factory lumber, and for specific machine centers in either hardwood or softwood mills to determine the potential for improving lumber recovery.

A recent economic analysis of the program reviewed some 207 followup SIP studies on 169 softwood dimension mills. The studies showed average sawmill owners or operators had improved their mill efficiency and lumber recovery by 4.18 percent the first year following a SIP analysis. The average investment made to capture this additional material was $749 per million board feet of annual capacity improvement in lumber recovery.

75 Million Fewer Trees

With the potential for improving lumber recovery by another 10 percent during this decade, and assuming that lumber production in 1976 was an average year, the industry will be able to produce the same amount of lumber annually with 75 million fewer trees by the year 1990. This is equivalent to reducing the timber harvest by an additional 228,000 acres per year through improved sawmill efficiency.

Besides the Felling and Bucking, Logged Area Analysis and Sawmill Improvement studies conducted by the Forest Products Utilization staff of the Forest Service and States, many other programs and variations of programs are available. One series of studies used in the West combines the Felling and Bucking and SIP technologies to determine the extent to which mismanufacturing of logs affects volume, grade and financial return from the lumber. The studies were limited to four correctable defects: stump pull, breakage, slabbing and mechanical damage. First use of this methodology was in a grade cutting mill using ponderosa pine logs in California.

To define these terms, *stump pull* usually occurs during harvesting as a result of felling a tree where the undercut may not have been cut high enough, deep enough, or cleaned out properly. The effect is that splinters are pulled from the butt log, thus reducing the length of some of the lumber that could otherwise have been cut from that log.

Breakage occurs when a faller has started a felling pattern and then lays several logs across the trees which have already been felled, or drops a tree across uneven ground or over a large rock.

Slabbing is caused by various improper procedures in bucking or felling, but usually occurs when bucking a tree where an unsupported end is allowed to fall and split away from the main stem. *Mechanical damage* occurs to logs during handling, including damage from grapples, chains, cables, fork lifts and other equipment.

Logs Color Coded

In the prototype study, logs with one or more of these mismanufacturing defects were color coded as they entered the sawmill, and the loss of lumber volume and value was determined after the logs were processed.

The mill inventory showed the four defects occurred in nearly 16 percent of logs entering the mill and these mismanufactured logs caused the mill to lose 4.6 percent in lumber volume and 7.4 percent in lumber value. When this was brought to the attention of mill managers, they took corrective action to help logging crews avoid the losses.

Similar studies at other mills show this type of damage is quite common, and significant improvement can be made in lumber recovery and profit for a mill.

Following a sawmill improvement study at a mill in South Carolina, the owners substantially modified the mill and experienced an overall increase of 40 percent in lumber recovery. This was the largest improvement in lumber recovery ever recorded in the South and the third largest in the Nation.

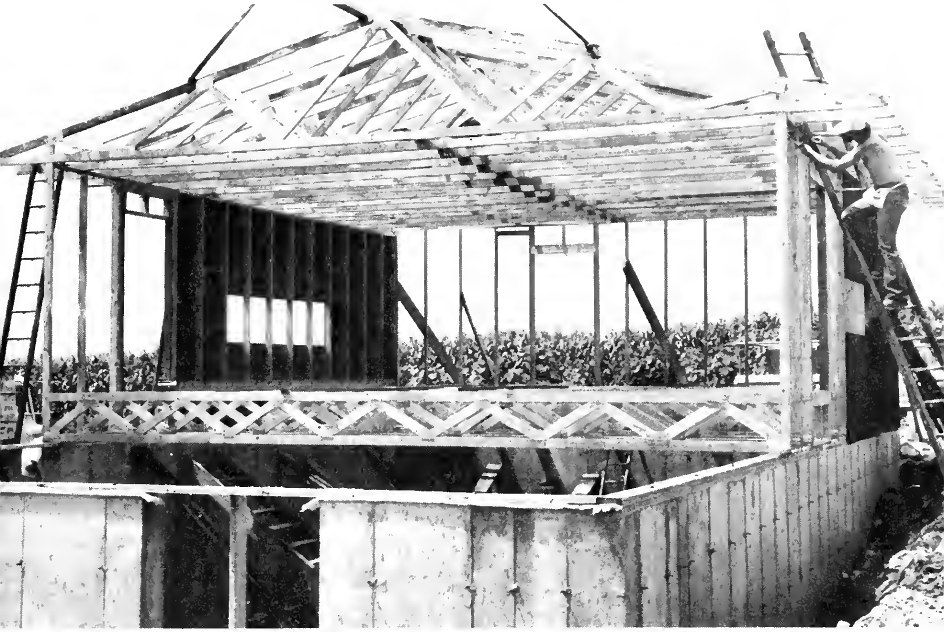
The gain in lumber recovery has the same effect on extending the timber resource as doubling the annual growth on 40,000 acres of South Carolina pine timberland every year that the mill operates at the improved level of efficiency.

3 Hours to Frame a House

Recently the Forest Products Laboratory developed a new method for constructing residential and light commercial buildings. The Truss-Framed System (TFS), as it is called, consists of attaching a roof truss, floor truss and wall studs securely together into a single rigid unit. The frames are placed 24 inches apart on the building foundation to form the skeleton of a structure.

It saves as much as 30 percent of the framing lumber used in a more traditionally built home where the wall studs, floor joists and roof rafters are placed 16 inches apart. Most truss frames can be manufactured out of 2 x 4 inch material—thus eliminating the need for wider, more expensive lumber.

Frames for an entire house can be manually erected in less than three hours using four or five persons, and the entire house can be completely enclosed and secured by the end of the first day. This rapid method of construction not only saves time and material but also provides a structure much stronger than conventional construction



Building with the Truss-Framed System. Roof truss, floor truss, and wall studs are secured together into a single rigid unit. Components are placed on 24-inch centers instead of the conventional 16-inch centers. As much as 30 percent less lumber is used than in a more traditionally built home.

and far more resistant to damage from windstorms, earthquakes, and other natural catastrophes.

Since its introduction in 1978, the Truss-Framed System has been used for buildings in over 20 States from Alaska to Florida and contributes significantly to providing affordable housing while saving our natural resources through more efficient wood products use.

Other programs in which the Forest Service and State agencies are involved, where additional savings can be made, include a veneer improvement program, an improved drying program for sawmills and other lumber processors, a roughmill improvement program for furniture and other secondary processing plants, and programs to improve the use of wood residues such as chips, slabs, branches, sawdust and shavings to produce energy.

If you are involved in a wood processing or using industry and wish to determine how you can participate in the instant forestry we have been talking about, contact your State Forester or the U.S. Forest Service office nearest you.

Edge in Fuel Costs Leads to Greater Wood Burning

By Mark Bailey and Ken Skog

The frigid winter winds swirled with fury and threw blankets of snow against the windows. Inside, the resident of the house nestled comfortably in an overstuffed chair, contemplated the crackling fire that sent forth a warming glow through the room, gently massaged the dog's ears, and mused: "Now that's the third time this wood has warmed me."

You should be able to enjoy the warmth provided by wood three times: When you cut and split it; when you burn it; and when you count the dollars saved by using wood energy.

Wood provides cooking and heating fuel to more people in the world than any other energy source. In the United States, wood energy contributes about 3 percent of the space-heat that is consumed yearly by households.

Until the mid-1800's wood was the major contributor of U.S. energy, but by 1900 provided only about 25 percent of this country's energy. As coal and petroleum products became more popular, wood energy use dropped to the point that just before the 1973–74 oil embargo, it was providing less than half of a percent of the total energy consumed.

Currently, wood energy is nearly equal to that supplied by nuclear energy. According to the Congressional Office of Technology Assessment, by the year 2000 as much as 6 percent of this Nation's energy could be supplied by wood.

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Supply Sources Differ

Wood energy is used by both the commercial/industrial sector and the residential sector. However, the supply sources of each of these sectors differ considerably.

Most of the fuelwood burned by the industrial/commercial sector is provided from residues, or wastes generated during the operation of these firms. Stripped bark and liquid residues are used by pulp and paper firms; planer shavings are used by furniture manufacturers; and sawmills utilize the slabwood produced when round logs are sawed into dimension lumber.

These firms, by utilizing a waste product that would otherwise create a disposal problem, make their operations more efficient. And their demands on the forest resource for additional fuelwood supplies are minimized.

The vast majority of households that heat with wood use wood in its basic form—trees that are cut to firewood length and, when necessary, split. As a consequence of this, together with the continuing increase in wood energy demand by the residential sector, many of those in forestry-related industries or services have a concern that the increase in demand for firewood could result in a situation that a logger could be "priced out" in an attempt to bid for trees. For this reason, the use of wood energy by the residential sector is examined in detail.

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During the 1980-81 winter, more than 22 million households burned 42 million cords of wood as a source of heat.

During the 1980–81 winter, 28 percent of U.S. households, or about 22.2 million, burned 40.5 million cords in their primary residences. An additional 1.5 million cords were burned in second, or vacation type, homes. (Most States require that wood be sold on a cord or fraction of a cord basis. A standard cord is a stack of wood that measures 4 feet wide, 4 feet high and 8 feet long, encompassing 128 cubic feet. A cord contains about 80 cubic feet of solid wood.)

Reasons for Home Use

The New England Fuelwood Study and a soon-to-be published national residential fuelwood survey examine the household sector to ascertain the amount of fuelwood being consumed, the relationships which a homeowner or renter considers when making the decision on whether or not to burn wood, and the possible impacts that wood burning may have on the forest resource base.

The most important influences on a household's decision to burn or not to burn are 1) The dollars that can be saved by burning wood rather than using a fossil fuel or electricity, 2) Having a nearby woodland, wood products plant, or an easy-to-obtain supply of wood, and 3) Nonmarket factors such as the desire to minimize inconveniences associated with conventional fuel supply interruptions.

Both the New England study and the national survey conclude that wood burning occurs more often as the cost advantage of wood relative to other fuel increases. For example, Vermont households having higher priced electricity and fuel oil used wood at the rate of 67 and 57 percent, respectively. This intensity of wood use is much greater than

Relative cost of alternative heating fuels, 1978 to 1981, Vermont

Energy Source and burner	*Cost/unit*		*Cost/mil. Btu's* [1]		*Relative cost per mil. Btu's* [2]	
	1978	*1981*	*1978*	*1981*	*1978*	*1981*
	—Dollars—				—Percent—	
Wood (cord)						
Airtight stove	60.00	85.00	5.00	7.00	100	100
Furnace	60.00	85.00	4.55	6.44	91	91
Electricity (kWh)	[3]0.044	[4]0.05	12.88	14.64	258	209
Natural gas furnace (l,000 cu ft)	[3]3.57	[5]6.50	5.10	9.28	102	133
LP gas (gal) (propane) furnace	[3].35	[5].80	5.50	12.56	110	179
#2 fuel oil (gal)	[3].55	[5]1.27	6.10	14.00	122	200

[1] Adjusted for average burning apparatus efficiency
[2] Computed by dividing various costs per million Btu's by the cost of wood energy products in an airtight stove
[3] Source: *State Energy Prices by Major Economic Sector*, 1960–77 (some for 1978), Preliminary Report Documentation, U.S. Dept. of Energy, July 1979
[4] Average price per kWh, 1980
[5] Source: Vermont Energy Office, Sept. 1981

NOTE: A Btu or British thermal unit is a standard unit for measuring heat energy. It is the quantity of heat needed to raise the temperature of one pound of water one degree Fahrenheit. A kWh or kilowatthour is a unit of power that measures the rate at which energy is produced or used.

While homeowners cut three-fourths of all residential firewood consumed, the impacts upon forest-related industries are minimal since most of the firewood is unusable for pulpwood or saw logs.

the 30 percent of households having less expensive natural gas who burned wood.

Access to woodland combined with higher conventional energy costs influence rural households to burn, on the average, more wood than their urban counterparts. Households in more densely populated areas with limited or no access to woodland are forced to purchase fuelwood at prices which discourage many from burning.

Households in colder climates burn more wood because costs of conventional heating fuels tend to be higher in the northern parts of this country and the potential savings are therefore greater. In these regions, more households burn wood, and each burns a higher average amount than those in warmer areas of the country.

Residential Impacts

The recent leveling off of petroleum prices has slowed somewhat the current rate of increase in the residential use of wood energy. However, given the potential price increases in natural gas, and assuming that the recent leveling off of petroleum prices is short term in nature, wood energy demand will continue to increase for the rest of this century.

An obvious question then arises: What impacts will the current and future demand for residential wood energy have upon forest resources?

The national survey found three relationships that support the contention that adverse impacts of residential fuelwood use are minimal.

1) Three-quarters of all fuelwood consumed is self-cut by

households. Thus, few, if any, loggers were drawn from cutting poletimber or sawtimber, and since no price was paid for this wood, it had no higher value to the forest-land owner. This self-cut fuelwood has no higher value since only a small proportion, less than 28 percent, came from trees that may have contained some portions that were usable for pulpwood or saw logs

2) Of the remaining one-quarter of fuelwood consumed, only a small proportion was potentially usable for pulpwood or saw logs

3) Average prices for purchased hardwood fuelwood, $56 per cord nationwide, are only slightly higher than for delivered hardwood pulpwood. But the logger cutting fuelwood probably does not pay much more for standing trees than a logger cutting for pulpwood. Loggers cutting for fuelwood must charge a higher price for delivered wood because they most often cut and split the wood, let it dry, and deliver it in small quantities. A pulpwood logger would not incur these expenses and could charge less than $56 per cord.

An additional question often raised is what impacts fuelwood has upon forest-related industries, and their ability to successfully compete for necessary wood supplies.

Studies Refute Critic

Recently, a member of a professional forestry organization was quoted as saying that local sawmills in his particular area were getting more money from logs delivered for firewood than they were for lumber after processing. The member termed that occurrence a disgrace.

This reaction suggests there is something wrong or intrinsically bad with such transactions, and that such occurrences are evidence that firewood demand is having an adverse impact upon forestry-related companies. But both the New England Fuelwood Study and the national survey conclude that residential fuelwood demand has little, if any, adverse impact upon the forest resource base or on forest-related industries or companies.

In the New England study, households were queried as to the amount of fuelwood they cut and the proportion that was marked for fuelwood use by a professional forester. Of the nearly 2 million cords of fuelwood self-cut by households, less than 20 percent was marked.

From that factor alone, one could surmise there is a potential that wood qualifying as saw logs ends up on the firewood pile. However, before making that judgment, it is necessary to be cognizant of the overall condition of the forest resource, which in New England is relatively poor. These regional forests are basically overstocked, and genetically suffer from previous harvesting techniques which included high grading. (High grading refers to harvesting the highest quality trees, resulting in lower quality trees becoming the genetic stock for future trees.)

These relationships suggest that the proportion of trees being cut for firewood which could otherwise be utilized for saw logs is minimal. That conclusion is further supported by the fact that the market for New England-grown saw logs is small.

Current Impact Minimal

These results tend to indicate most fuelwood is coming from waste categories of trees, and the merchantable quality trees being cut for fuelwood are bringing payment similar to prices for pulpwood. Although current competition for wood is low, it may increase slowly if more households purchase rather than cut themselves.

The current conditions of this Nation's forests should permit harvests of very large quantities of dead and down trees, and cull trees, with minimal adverse impacts.

Management, like baseball and apple pie, is regarded as intrinsically good. But before implementing any particular management strategy, forest-land owners should first identify the reasons or objectives of why they own forest land. Once those objectives have been defined and analyzed, one can then develop

The present condition of the Nation's forests should permit harvesting large quantities of dead and down trees, and cull trees, for firewood without adverse impacts on the forest resource base.

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and implement management strategies to obtain ownership objectives.

An important aspect of forest-land management is that forests can provide a myriad of goods and services that are not necessarily mutually exclusive.

Suppose an owner wishes to use the forest to grow trees for saw logs, provide fuelwood, contribute a wildlife habitat, and provide esthetic settings as well.

Properly managed, a forest can provide all these objectives. For example, thinning out overstocked, poorer quality trees to provide more room and nutrients for saw log quality trees can supply the owner with a source of fuelwood.

By leaving the higher quality trees, and some that provide food and shelter for wildlife, the owner can attain three of the four objectives. If properly planned and carried out, thinning operations can also make the stand more esthetically pleasing.

Boon to Owners

In one sense, the increasing demand for firewood may, in the final analysis, be a boon to forest-land owners.

Before the resurgence of wood energy, forest-land owners usually incurred annual management costs which they had to bear year in and year out until they sold their timber. However, given the existence of a firewood market, the owner now has an opportunity to sell cull material (poor quality trees) and dead trees, and thereby offset some if not all the costs of timberstand improvement measures.

Another often posed argument suggests that cutting for firewood does not generate as much economic activity as cutting for saw logs or for other forest products.

The argument goes something like this: A saw log is basically used for construction or building purposes, and from the time it is cut as a tree to its final use,

jobs and income are provided to cutters, sawmill operators, and builders. Firewood, on the other hand, since it is cut and then burned, only provides for the cutter and/or the user, and therefore has less of an impact upon the Nation's economy.

This argument contains only half the story, for it fails to consider savings that accrue to the homeowner who substitutes wood for conventional fuels. These savings, in many cases, are substantial. As a result, the homeowner has additional dollars to purchase items—such as food, clothing, and durable goods—which would not otherwise have been purchased.

Heating Fuels Displaced

The national residential fuelwood survey estimates that 2 to 3 percent of conventional residential heating fuels are displaced by wood energy. This amounts to 65 billion cubic feet

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The increased demand for firewood is a boon to many woodlot owners and small sawmill operators for it gives them the opportunity to sell cull and dead trees, and offset somewhat the costs of good forest management.

of natural gas, 653 million gallons of fuel oil, and 20 billion kWh of electricity.

Recognizing that prices for these sources vary considerably across the Nation (for example, New England's energy prices are higher than any region in the country), nearly $2 billion of conventional energy is being displaced by wood, and that is only in the residential sector.

As part of the New England Fuelwood Study, an economic model (input-output) was employed to estimate the net increase in economic activity resulting from burning over 3.2 million cords in the region. This economic activity resulted from homeowners spending the dollars they saved by using wood energy upon goods and services they otherwise would not have purchased. The net total gain amounted to nearly $400 million.

It should be noted that New England utilizes more imported petroleum than any other region. As a result, dollars spent on such energy flow from the region in a greater proportion than from other sections of the country. For that reason, each dollar of conventional energy savings has a greater economic impact in New England than in most other regions.

Land Requirements

Prospective wood-burning households and even some that currently use firewood often pose a question regarding the acreage of land required to provide, on a sustainable basis, adequate volumes of fuelwood. The answer to this question is complex since a myriad of factors must be considered.

Obviously, an important factor is an estimate of the number of cords that will be burned per year. That estimate depends upon the available species of trees used in firewood, efficiency of the burning apparatus which will be employed, price of the conventional energy used by the household, amount of insulation and other energy conservation measures installed, number of heating degree-days that usually occur in the region, and the price of cordwood.

In New England, households that heat their homes primarily with wood, use an airtight wood stove or wood-burning furnace, and self-cut some or all of their firewood, burn between 3.5 and 7.5 cords per year, although the majority burn an average of about 4 cords of hardwood per year. If softwood were burned, 6 to 8 cords would be needed to provide a similar amount of heat.

The amount of forest land needed to produce this volume of cordwood also depends upon many factors. Climatic conditions, the dominant species and the annual growth rates associated with it, density of the timberstand (overstocked, understocked), and management techniques that will be or can be applied are major factors that need to be considered.

Help With Estimates

An acre of well-managed forest land in the Northeast could provide 1 to 1.5 cords per year, and an acre in the South even more. Specific estimates of forest-land acreage required to supply a given amount of fuelwood in a particular area can be computed with the help of university Extension foresters, consulting foresters, or foresters employed by the various State Forest Departments.

Roughly 50 percent of all private forest-land owners, or 3.9 million households, cut fuelwood from their own land. Yet only 12 percent, or 460,000, of these owners cut their wood based on the advice of a professional forester. In addition, 3.4 million households cut fuelwood on privately owned forest land that is owned by someone else.

This large number of households that acquire some or all of their firewood from privately owned land suggests there is a great opportunity to disseminate additional information regarding management concepts and strategies to assist in assuring future fuelwood energy supplies.

Even though use of wood for energy is expected to increase through the remainder of this century, adverse impacts on the forest resource base will be minimal if appropriate management techniques are applied. Thus, our forests should be able to supply not only the industries and businesses that use or manufacture wood products, but also a greater proportion of this country's energy needs.

Notes for Wood Burners

- A pound of any type of wood contains about the same number of Btu's regardless of species. Since firewood is most often sold on a volume (cord) basis, the wise wood burner will purchase higher density or heavier hardwoods such as oak and hickory rather than lower density or lighter wood species. By doing so, the wood burner maximizes the heat content of a cord.
- For the most part, efficiency in wood-burning equipment is attained by controlling the amount of oxygen permitted to reach the fire. Since air flow is not controlled in fireplaces, most of the heat generated by a fire goes up the chimney and thereby reduces fireplace efficiency to around 5 percent. Airtight stoves and furnaces have efficiencies that range around 50 to 60 percent. Thus, wood burned in such a stove or furnace provides 10 times more usable heat from a cord of wood than does a fireplace.
- A cord of wood contains around 20 million Btu's which is equivalent to the energy content of 144 gallons of fuel oil, 20,000 cubic feet of natural gas, or 5,882 kWh of electricity. The amount of this heat that a burning apparatus can supply is based upon efficiency of the equipment. Thus, a wood stove that is 50 percent efficient would supply, on the average, usable heat amounting to 10 million Btu's per cord.

Wetlands—a Vanishing Resource

By Leigh H. Fredrickson

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When the Pilgrims reached North America, the continental United States held vast wetland resources from coast to coast and from high mountains to plains. The abundant supplies of readily available renewable resources in the form of shellfish, fish, birds, and mammals were exploited heavily by early Americans. Individuals harvested food for their families from wetlands. Market hunters and commercial fishermen exploited wetlands to supply urban markets with game, fish, and fowl until after the turn of the century.

The economic harvest of food and fur from natural wetlands continues today where extensive coastal wetlands exist in Louisiana and Texas. The sale of shrimp, oysters, fish, alligator meat and hides, and furbearers, as well as leases for sport fishing and hunting, account for millions of dollars of income annually in these two States.

Millions of acres of our best agricultural lands were once our best wetlands. In addition to wetland loss, degradation of the remaining wetlands continues daily because of activities related to transportation, urbanization, industrialization, agriculture, and other adverse impacts.

The abundance of birds and mammals associated with wetlands is a great attraction for people. Today most citizens generally recognize wetlands for their value as areas where fish and wildlife are produced. These naturally renewable resources have obvious recreational benefits derived from their harvest, enjoyment through wildlife observation, or for their commercial value.

Recently there has been growing awareness that wetlands have many inherent values for society that include the recycling of nutrients, flood control, detoxification of pollutants, and atmospheric stability.

Wetlands have been used successfully for water treatment because they retain substantial amounts of nutrients from domestic sewage.

Valley Storage Cut

The potential for flood control is documented in the lower Mississippi Alluvial Valley. When the entire 25-million-acre area was forested, the water-storage capacity was equivalent to a 60-day discharge at the mouth of the Mississippi River at the peak of the highest recorded flow during the flood of 1973.

Forest clearing for agricultural production of soybeans and other commercial crops reduced the forest area to 4.8 million acres and concurrently the water-holding capacity of this wetland system has been reduced from 60 to only 12 days. Devastating floods along the lower Mississippi River in Louisiana during 1982–83 indicate that the conversion of forested wetlands for agricultural purposes had many unexpected costs. The reduction in water-holding capacity resulted in higher flood peaks immediately following heavy rains.

The importance of wetlands for atmospheric stability is indicated by evidence that the production of methane in wetlands acts as a regulator for the ozone layer in our atmosphere where harmful ultraviolet radiation is controlled.

Classifying Wetlands

A relatively new classification system has been adopted that attempts to encompass the inherent complexity of wetland ecosystems. Within this new system, wetlands are defined as lands transitional between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by shallow water.

Wetlands must have one or more of the following three attributes: 1) At least periodically, the land supports predominantly water-loving plants, 2) The substrate is predominantly undrained hydric (wet) soil, and 3) The substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season each year.

Biologists and wetland specialists have made previous attempts to classify and inventory wetlands. The earliest classification separated wetlands in major groupings based on location (coastal or interior), type (fresh, saline, or alkaline), and permanence (permanent, semi-permanent, and temporary).

Because of widespread interest in prairie wetlands and declining duck populations during the drought years of the 1930's, many early attempts at classification were associated with habitats where ducks breed.

As environmental awareness increased in the 1960's and 70's, there was increasing need for a more widely applicable system for wetland classification by state and Federal agencies.

200,000 Types

To meet this need a hierarchical system was developed by the Fish and Wildlife Service to classify wetlands or areas where water depths were no greater than 6 feet. By using all possible combinations within the classification system there is the potential to identify over 200,000 different wetland types.

As wetland area continued to decrease and as the remaining wetlands were subjected to continuing degradation, the need to inventory and to identify wetland types became critical for good decisionmaking related to acquisition, protection, and management. Congress assigned the Fish and Wildlife Service the task of developing a comprehensive wetland inventory. This process is currently underway, and some wetland maps developed as a result of the inventory are now available.

Until the 1970's, wetlands were poorly protected unless they were acquired as public lands. Some private groups including the National Audubon Society, Nature Conservancy, and duck clubs were involved with wetland preservation. Private ownership of wetlands is very important in California where about 60 percent of the managed wetlands are owned by duck clubs. Nevertheless state and Federal agencies continue to hold the largest acreages in ownership.

Enactment of several Federal laws—including the National Environmental Policy Act of 1969, the Federal Water Pollution Control Act of 1972, the Coastal Zone Management Act of 1972, and the Endangered Species Act of 1973—bolstered the important Rivers and Harbor Act of 1899. Today the Environmental Protection Agency, National Marine Fisheries and the U.S. Army Corps of Engineers hold joint responsibilities for protecting wetlands through Section 404 of the Clean Water Act of 1977.

No one approach is the answer to protecting wetlands from loss and degradation, but rather a combination of acquisition, easements, regulations, tax benefits, and education is required.

Wetland Formation

Wetlands areformed from a variety of physical and biological agents. In the Northern Hemisphere the impacts of glaciation are of prime importance in creation of wetlands.

The most important breeding habitats for ducks and other waterbirds such as coots, grebes, and gulls is within the area impacted during the Wisconsin glaciation in the North Central States. The southernmost terminus of the glacier is

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Prairie potholes make prime nesting cover for coots, grebes and diving ducks. The pothole area extends from Iowa to the Dakotas and Canada.

just north of Des Moines, Iowa, and the impacted area extends north and westward into the Dakotas and Canada.

This region is generally described as the prairie potholes and is characterized by hot summers, cold winters, and recurring droughts. Most of these shallow wetlands are temporary or semipermanent. Few potholes have fish populations because they usually freeze to the bottom.

Extensive wetland areas were associated with river deltas in North America. The Mississippi Alluvial Plain and associated habitats along the Gulf Coast, and the Sacramento River Delta in California, are important wetlands. In Alaska vast wetland areas are associated within the Copper, Kuskokwim, and Yukon river deltas. Frost action, insolation, and substrate melting are important factors in wetland formation in arctic regions.

Catastrophic geological events such as earthquakes, landslides, or volcanoes produce isolated wetlands. Coastal wetlands in the northeast were formed when lands were uplifted after the glaciers retreated. As the Great Lakes decrease in area during this post-glacial interval, wetlands are formed along their periphery.

Beavers and alligators are wildlife that form or maintain wetland basins by damming streams or by deepening pools in shallow wetlands.

Manmade Wetlands

People's activities also produce wetlands by design or by accident. In general, manmade wetlands not designed specifically for wildlife have minimal value as replacements for natural wetlands because they lack dynamic water regimes.

Roads, levees, and diversions may block drainages and create as well as destroy wetlands. Borrow areas for highways and other construction create depressions that may become wetlands.

On public lands, wetland habitats are often developed as part of normal management procedures. Stock and fish ponds are examples of manmade wetland habitats on private lands.

Area in wetlands has changed dramatically since the 1800's. Because of conflicts between man's activities such as agriculture, urbanization, and industrialization, wetlands continue to decline in the 1980's at a rate of about 0.4 percent a year or nearly 500,000 acres a year.

The first wetland habitats to disappear were those that could be drained and converted to agricultural purposes easily.

Drainage in Iowa

Many of the productive soils in Iowa were formed by wetlands. Drainage began in the late 1800's and reached a peak between 1906–22. Most drainage was completed before the 1950's. By 1981, 94 percent of Iowa's wetlands had been drained and annual losses are currently estimated at about 0.2 percent per year.

Likewise, losses have been considerable throughout the prairie pothole region and especially in the Red River Valley of western Minnesota and eastern North Dakota. Minimal estimates suggest only 56 percent of the original prairie pothole area remained in 1980.

Many southern forested wetlands were not greatly affected by conversion to agriculture until the late 1940's. About this time soybeans were introduced as a cash crop and Federal assistance was available for drainage. Soybeans did well on these forest soils because they required a short growing season and were productive even though they were planted well into the summer.

In southeastern Missouri there was a gradual and continuous loss of the 2.5 million acres of forested wetlands starting in 1870. Rapid and effective drainage between 1910 and 1920 increased the rate of clearing, and by 1920 only 50 percent of the forested wetlands remained.

By 1983 an estimated 70,000 acres or only 3 percent of the original habitat was forested. Unfortunately, the majority of this habitat is in small blocks of less than 250 acres that are of insufficient size to meet requirements of many species. The largest remaining example is Mingo Swamp with 15,000 acres of lowland forest in state and Federal ownership.

Forest losses in the Mississippi Alluvial Plain are less severe than in Missouri but are estimated at 81 percent.

Losses in Louisiana

Agriculture is not the sole reason that wetlands are lost. The coastal marshes of Louisiana are disappearing at the alarming rate of 40 square miles per year. Formerly silt from the Mississippi River built substrates and recharged nutrients in these coastal areas. Silt-laden water now flows directly into the Gulf of Mexico because of levees, improved drainage, navigation channels, and forest clearing.

Not only are wetlands lost continually but most of the remaining wetlands in the Mississippi Valley are subjected to degradation. These wetlands are usually at lower elevations and often have drainage ditches running through or immediately adjacent to each parcel. The ditches carry excessive runoff from agricultural lands that are laced with herbicides and pesticides.

Urbanization has caused extensive wetland losses in coastal areas. Since the 1950's, some 372,000 acres of mangroves and coastal marshes have disappeared. Two-thirds of these losses have occurred in Florida and Louisiana.

Wetland communities are complex systems with interactions among physical and biological factors. Wetland quality and type depends upon the soil; quality, quantity, and chemistry of water; climate; hydroperiod (quantity and timing of water availability); and hydrologic (water-level fluctuations) regime.

Within each wetland are interactions among the biological components: Vegetation, animal life, and decomposing plants and animals. Other biological factors such as pathogens, parasites, and nonwetland wildlife also influence wetland communities. The hydroperiod is a controlling factor in wetlands. Constantly fluctuating waters—whether on a daily, annual, or long-term basis—determine wetland productivity and result in a continual state of change.

Examples of wetland losses or modification in the United States.

Locale	*Wetland*	*Area in Millions of Acres Original*	*1983*	*Percent loss*	*Major Cause of Loss*
Mississippi Delta	Lowland Hardwood	25.00	4.80	81	Agriculture
Missouri	Lowland Hardwood	2.50	0.07	97	Agriculture
Louisiana	Coastal Marsh	3.50	2.70	33	Water Development
North Central States	Prairie Potholes	127.00	70.00	56	Agriculture
Texas	Playa Lakes[1]	0.25	0.05	80	Agriculture

[1]Modified

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Wetlands must provide a variety of habitats for migratory birds, such as quality nesting areas, to insure productivity.

Ducks Well Adapted

The boom and bust of duck populations in the prairie potholes is related to annual and long-term fluctuations in precipitation that influence water levels within wetland basins. These pulses in water levels are essential for the continued productivity of potholes and the associated production of waterbirds.

Because ducks are long-lived species, they are well adapted to survive from one productive period in the wetland cycle to the next. Their mobility further enables them to effectively exploit the best breeding conditions when they occur.

Recent evidence suggests that wetlands must provide a variety of habitats for migratory birds during migration, breeding and winter. The availability, quality, and quantity of wetlands during the entire annual cycle may influence bird productivity on the breeding areas even though some of these wetlands are thousands of miles apart.

One of the most productive wetlands is the tidal fresh marsh. Tidal pulses occur frequently with daily and seasonal variations. These more frequent pulses in water level fluctuations in combination with freshwater provide a more compatible environment for growth and survival of plants and animals than saltwater. For example, many marine shellfish exploit tidal marshes during important juvenile growing periods.

The adaptations for wildlife to exploit wetlands are shaped by the short- and long-term pulses within the system. Short-term fluctuations provide the immediate cues that determine when wildlife will breed or migrate. The proximate cues along with long-term fluctuations provide the ultimate or evolutionary factors that determine how a species exploits wetlands. These adaptations include body size, bill shape, plumage, nest sites and behavior—just to name a few.

Plant-Bird Relationships

Each wetland has a profile that describes plant and animal distribution. Plants are associated with different water depths because they have different tolerances for the duration and depth of flooding. Hardstem bulrush and some species of cattail are good examples of water-tolerant vegetation that occur in the deeper portions of marshes. Sedges and grasses occur in shallow water.

Diving ducks, coots, yellow-headed blackbirds and grebes nest in robust vegetation over water in the deeper portions of marshes. American bitterns, rails, ring-necked ducks and some dabblers use shallow water areas for nesting and require dense vegetation. Dabbling ducks concentrate their nesting on the surrounding uplands.

Forested wetlands also have a distribution of vegetation related to the depth and duration of flooding. In southern flood-plain forests, cypress and tupelo trees occur in the lowest elevations where depth and duration of flooding are longest. Moving upward in elevation where flooding depth, duration, and frequency are less, trees with decreasing tolerance for flooding are overcup oak and red maple, pin oak and sweetgum, willow oak, cherrybark oak, swamp chestnut oak, elms, and then species such as shagbark hickory that are normally associated with upland habitats. Likewise the understory and herbaceous vegetation have a characteristic distribution related to the flooding regime.

No single wetland type can provide all the requirements needed by wildlife for reproduction and survival. Rather, each species requires several wetland habitats where different resources are used to meet nutritional behavior requirements during the annual cycle.

Ducks and the Potholes

The need for this wetland complex has long been recognized in

Newly arriving pairs of ducks use wetlands for isolation during reproductive activities and as a source of nutrients for breeding.

the prairie pothole region where a combination of temporary and semipermanent potholes are required for duck breeding success. Newly arriving pairs of ducks use temporarily flooded wetlands heavily for isolation during reproductive activities and as a source of nutrients for breeding. The more permanent wetlands are important later in the season to provide food and cover for molting adults and broods.

Wetland complexes are more difficult to recognize in riverine environments because wetland types do not occur as distinct wetland basins but rather lie along a flooding continuum roughly paralleling the stream. Wetland types might include open water, cypress-tupelo, scrub/shrub, overcup oak/red maple, and sweetgum/pin oak. Some of the higher areas may be flooded for only a month each season. Nevertheless, these temporarily flooded habitats are im-

B.C. McLean

portant components within the southern flood-plain forests because they provide important nutrients for breeding and wintering waterfowl.

An important part of our natural heritage is associated with wetlands. All Americans have a stake in the importance of wetlands for purposes as diverse as recreation, flood control, and atmospheric stability. Proper protection and management is essential to assure that future generations will have wetlands for economic, social, and recreational values.

Further Reading

Freshwater Marshes. Weller, M.W. University of Minnesota Press, 2037 University Avenue, SE, Minneapolis, Minn. 55414. For sale in paperback, $8.95, and cloth, $22.50

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Bottom Land Hardwoods—for Wildlife and Timber

By Edward R. Smith and Ramon L. Callahan

Bottom land hardwoods are one of the most productive forest types in the Nation for both timber and wildlife habitat. These forests are in flood plains of creeks, streams and rivers, alluvial swamps, bayous, savannas, and other poorly drained sites. The streams frequently overflow, bringing nutrients and moisture that promote the growth of trees and associated plant communities. The nutrients in turn are passed along to animals and birds that feed on the vegetation.

Flooding of bottom lands generally occurs during winter and spring, but can occur at any time of the year. In the Southern States, where alluvial forests receive an average rainfall of 50 inches annually, flooding can result from local rainstorms or from storms upstream. The elevation of a particular forest determines the frequency of flooding. Some areas, such as the cypress-tupelo swamps of the lower Mississippi Valley, are flooded most of the year. Higher elevations in the river bottoms may be flooded only once every 2 or 3 years.

Flooding creates the rich soils that are the foundation for the high productivity of bottom land hardwoods. Nutrients, both natural and man-applied, are washed into the streams and deposited on the bottom land when the river overflows its banks.

Properly managed, bottom land hardwood forests are rapid-growing stands of good form. Hardwood species common in these

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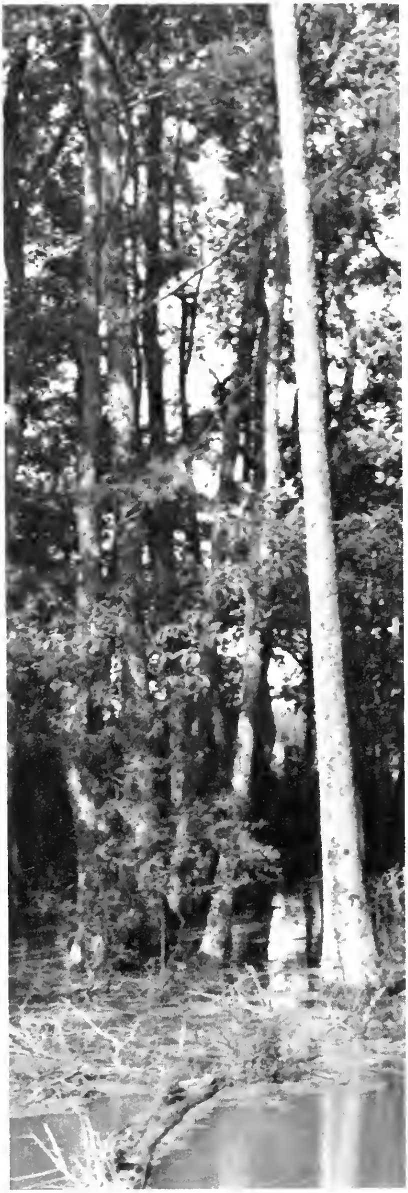
forests are oak, ash, willow, elm, hackberry, sugarberry, hickory, pecan, water tupelo, maple, cottonwood, sweetgum, magnolia, persimmon, and sycamore. Although baldcypress, Atlantic whitecedar, and pine are softwoods, they occur in some areas and are considered part of the bottom land hardwood forest.

The trees are adapted to soil that is covered with floodwater. Their roots can live without oxygen in the soil for long periods. This adaptive trait is especially pronounced in baldcypress, water tupelo, water elm, water hickory, and overcup oak.

Fish, Birds Benefit

Flooding creates conditions highly beneficial to fish from the streams and natural lakes of the area, which move into the flooded woodlands to feed. The foods taken at this time—such as crawfish, earthworms, and insects—are important to growth of the fish and put them in better condition for reproduction. Many fish species, among them bullheads, pickerel, bowfin, flyers, and warmouth, spawn in flooded bottom land hardwoods.

Lakes within the flooded area are recharged with nutrients and with forage fish from the river. Forage fish, such as shad, minnows, sunfish, and carp, are important food for the predators—bass, pickerel, and gar. Flooding is the reason these lakes are so productive. Many unpolluted oxbow (U-shaped) lakes of the Mississippi Valley produce 400 to 1,000 pounds of fish per acre.



USDA

Bottom land hardwoods, although subject to frequent flooding, are among the most productive forest types for both timber and wildlife habitat.

Long periods of flooding are beneficial to fish but detrimental to terrestrial wildlife. Shorter but more frequent periods of flooding are highly beneficial to terrestrial wildlife.

Bottom land hardwoods provide habitat for a wide variety of mammals and birds. A partial list includes wood duck and migratory waterfowl, deer, squirrels, rabbits, mink, raccoon, otter, beaver, and birds such as turkey, hawks, owls, woodpeckers, herons, sparrows, titmice, chickadees, and warblers.

The beautiful Prothonotary and Parula warblers are year-round residents of bottom land hardwoods. The Bachman's warbler, our rarest warbler and an endangered species, is an inhabitant of these forests. The ivory-billed woodpecker, which once inhabited the forests and is still on the endangered species list, probably is already extinct.

Ducks Winter Here

During spring and fall migration periods, these hardwoods play host to high populations of songbirds and ducks. Historically, flooded bottom land hardwoods have been the wintering grounds for mallard, black duck, and wood duck. The majority of the Nation's wood duck population nests and rears its young in bottom land hardwood wetlands.

Bottom land hardwood areas are capable of supporting higher populations of animals than are upland forests in the same geographic region. Squirrel populations are 2 or more per acre in many bottom land forests; in upland forests, populations are no more than one squirrel to every 2 acres. A deer per 20 acres is not uncommon in well-maintained bottom land forests; in nearby uplands as much as 100

Tim McCabe

During seasonal migrations flooded areas of bottom land hardwoods are host to many duck species like the mallard.

acres might be required to support one deer.

Despite their value as habitat for wildlife and as a source of timber, many areas of the forest have been cleared for other uses. When the Mississippi Valley States of Arkansas, Kentucky, Mississippi, Missouri, and Tennessee were in virgin timber, they had an estimated 24 million acres of bottom land hardwoods. By 1937, this had been reduced to 11.8 million acres; and by 1978, to 5.2 million acres. Experts in land use change have projected further clearing, leaving only 4.2 million acres by 1990.

From 1935-78, the bottom land hardwood area in the Southern Atlantic States (Georgia, Florida, North Carolina, South Carolina, and Virginia) increased from 12.5 to 12.9 million acres. The increase occurred primarily because farmers abandoned fields

in these low-lying areas. However, since 1978 the trend has reversed and the acreage has been substantially reduced as land has been cleared for crop production in eastern North Carolina, South Carolina, and Georgia.

Flood Control

There are advantages to preserving these bottom lands as forest rather than clearing the land for other uses and preventing the streams from flooding it. The forests are an important natural flood-control mechanism. Floodwater that collects in these low-lying areas is gradually released back to the parent stream. This reduces the peak flows downstream.

Bottom land forest ecosystems are nature's water purification plants. During flooding, sediments and associated nutrients and pollutants settle out. This "cleansing" of the water improves water quality and reduces eutrophication of waters downstream. Alterations of the bottom lands, such as clearing or channeling and leveeing, reduce opportunities for the flood plain to recycle nutrients, accumulate organic matter, and precipitate out pollutants.

During floods, water infiltrates the soil and recharges the regional and local aquifers. The recharge may appear many miles away if a regional aquifer receives the water. Water stored locally seeps laterally into swamps and river channels, keeping the water level up over a longer time.

Some efforts are being made to preserve remaining areas. The Water Bank Program, administered by the Agricultural Stabilization and Conservation Service, makes rental payments to landowners who preserve wetlands. Payments are based on a 10-year contract that can be renewed.

Section 404 of the Clean Water Act, administered by the Army Corps of Engineers, helps to preserve bottom land hardwood forests by regulating certain dredge and fill activities that would be destructive to the wetland nature of flood plains. Many States also require permits before allowing work in wetlands. The Fish and Wildlife Service, through its Wetland Acquisition Program, is buying key areas of bottom land hardwood areas to protect them from conversion to other uses.

Federal agencies must consider the impact their programs may have on wetlands. Executive Order 11990, Protection of Wetlands (1977), directs all Federal agencies to avoid, to the extent possible, actions that would cause long- or short-term damage through destruction or modification of wetlands. Executive Order 11988, Flood Plain Management (1977), provides similar guidelines for activities on flood plains.

Large Tracts Acquired

The Nature Conservancy, cooperating with timber companies, State and Federal agencies, and private organizations, has assisted in acquiring several large tracts in recent years. Many of these tracts would have been cleared for other uses had they not been purchased for preservation.

Notable purchases of recent years include the 32,000-acre Pascagoula River Tract in southeast Mississippi and the 20,000-acre Panther Creek Swamp in the Mississippi Delta. The Tensas and Bogue Chitto purchases in Louisiana, 65,000 acres, and the Lower Hatchie River Bottom Lands area of Tennessee are other significant acquisitions. Efforts are being made to purchase 30,000 to 40,000 acres of the Cache River Bottom Land Hardwoods in Arkansas.

In many areas where most of the flood plain has been cleared for other uses, only a fringe of trees remains along the streams. Even these stream corridors, as they are called, provide benefits for wildlife. They provide habitat for many forms of wildlife that would not survive in the area otherwise.

The tree fringe provides an "edge effect" important for many types of wildlife. Shade from the overhanging trees and brush keeps the water cool enough to provide habitat for forms of fish that could not survive in the stream if the water were warmed by the sun. These winding corridors break the monotony of an otherwise uniform landscape; many city parks and urban areas owe their beauty and wildlife to stream corridors.

In many areas where the forest

has been preserved it is in poor condition because alterations upstream or nearby have caused damage. Species composition and quality have been changed by improper timber harvest and by altered flooding schedules and excessive sedimentation. In some cases pollutants from oil wells, agricultural activities, and other sources have reduced tree growth and damaged wildlife and fish.

Highgrading Harmful

Improper timber harvesting has had a major impact. In many cases, only the best trees were removed. This "highgrading," as it is called by foresters, left many acres of the remaining bottom land hardwood forests in poor commercial condition, both in form and species composition. Owners of such lands are tempted to convert them to other uses they think will provide a quicker source of income.

Grazing has had an impact on these forests. Livestock should not be permitted to graze bottom land hardwoods. Cattle browsing on the hardwood seedlings kill or deform them. Under heavy grazing pressure there is little or no reproduction to replace the mature trees that are harvested.

Fire also has taken its toll. Hardwood trees have relatively thin bark, which provides little protection against fire damage to the life-supporting cambial layer. Even if the tree isn't killed outright, the lower trunk often develops various diseases that lead to decay.

Recently, beaver have become so numerous that they have been detrimental to some alluvial woodlands. They can and do kill large areas of bottom land hardwoods by flooding them permanently and cutting down or girdling trees for food. Beaver damage is particularly severe in Mississippi, Arkansas, Alabama, and Louisiana. So, between highgrading, flooding by beavers, grazing, and fire, many of the remaining stands are in poor condition and need intensive management.

Evening Out Tree Age

Foresters generally agree that the best way to produce quality timber products is even-age management. Even-age management means that all of the trees in the stand are about the same age. To create an even-age condition, the entire woodland should be divided into stands (compartments) and these stands harvested or managed towards an even-age condition.

Bottom land hardwoods can be restocked by natural regeneration or by replanting with seedlings. If the forest stand contains low-quality undesirable species, the best management is to fell and sell all merchantable trees and cut remaining trees to the ground. The more vigorous oak, ash, and other desirable species will take over. Regeneration by planting is more expensive and site selection is critical.

Bottom land hardwoods can be periodically thinned to favor trees of the best form and of de-

Louisiana Forestry Commission

When properly managed, bottom land hardwoods can produce fast-growing, high quality timber.

sirable species and give them more room to grow. The harvest of saw logs can be started when the trees reach merchantable size or at a planned age in the rotation.

With proper management, the tract will become a mosaic of even-age stands of different ages, each stand being no larger than about 40 acres. If the different age groups are distributed over the tract, the result is a diversity of habitat beneficial to wildlife. Deer find browse plentiful in the younger stands. The mature stands furnish mast crops for deer, duck, squirrel, raccoon, and turkey. Dens for wood duck, squirrel, and raccoon are found in the older stands.

Greentree Reservoirs

Other steps to improve wildlife habitat quality are the creation of greentree reservoirs, the planting of existing openings, or the creation of new openings for planting desirable wildlife food plants.

Greentree reservoirs are developed to attract ducks. Greentree areas are leveed on three or four sides, depending on the topography, and flooded from October to March. The impoundments are located in fairly level areas of bottom land hardwoods where the species composition is 40 percent or more mast-bearing oaks.

The levee must have a water-control structure to regulate the water level, and water must be available to flood the area in October. The water supply can be a river, stream, lake, or well. The levee can be constructed with bulldozers or draglines and should be vegetated as soon as complete to prevent erosion. Average water depth should not exceed 15 inches over the impounded area.

Natural or created openings within the impounded area can be planted to foods attractive to ducks and that resist decay when flooded. Corn, browntop millet, and Japanese millet are three of the best for this purpose.

Water must be removed from the areas by the first of March, so as not to interfere with survival and growth of the trees. Greentree reservoirs benefit both ducks and trees. Studies of greentree areas show some trees increase in growth when properly flooded.

Openings within the forest can be used also for food plantings for rabbits, deer, and turkeys, if these are the preferred species. One to 5 percent of the woodlands should be in openings of some form. These openings can be fields, roadways, or utility rights-of-way. Clovers, various millets, ryegrass, milos, and other desirable foods may be planted.

Bottom lands—the timber, wildlife, wetlands, and beauty—are an important part of our landscape. Only in recent years have we begun to realize the richness, productivity, and many benefits that make bottom land hardwoods one of our more valuable ecosystems.

Prairie Wetlands: Home for Over 100 Wildlife Species

By Erling B. (Punch) Podoll

Back in the 1930's, when I was a youngster in northern South Dakota, I used to "swim" in a seasonal wetland. It was a muddy little depression in a pasture, and we never gave much thought to how safe and clean it was—or wasn't—and how it happened to be there.

We knew it would most likely dry up, and we had to enjoy it before the water was gone. We also knew we shared our little pond with birds and frogs and turtles and snails and many other life forms. We sensed the pond was good because it was fun to play in and it was fun to see and hear the wildlife attracted to it. In later years it was my good fortune to become acquainted with prairie wetland ecology.

Glaciers formed these depressions about 10,000 years ago by depositing huge pieces of landscape picked up with their advance. This action destroyed entire river drainage systems. The melting of the glaciers left rolling lands with depressions of all sizes. These depressions are known as prairie wetlands, or prairie potholes.

The mantle of glacial till left by the glaciers influenced a major portion of the United States. The prairie wetlands are largely confined to an area east and north of the Missouri River and west of the forested area of the upper Mississippi River. In the United States this takes in northeastern Montana, northern and eastern North Dakota, western Minnesota, eastern South Dakota and

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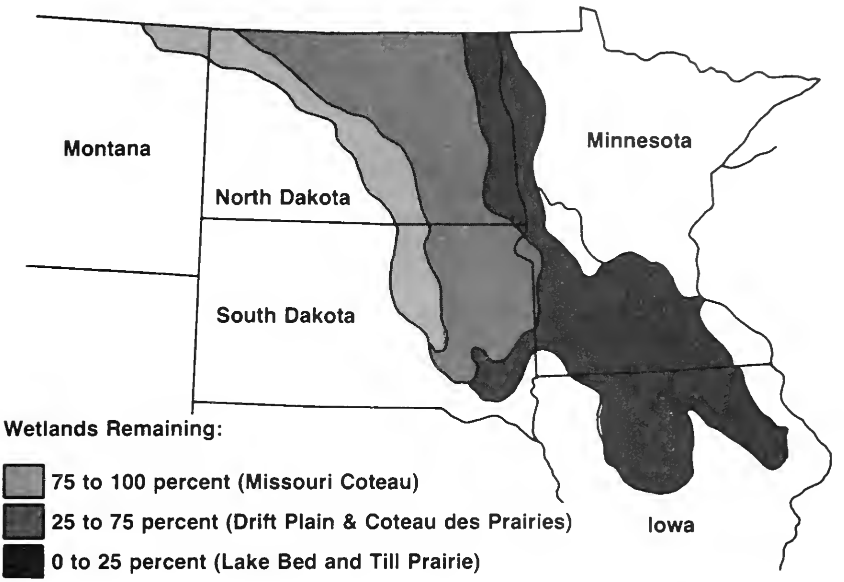
Principal Prairie Wetland Region of the United States



northern Iowa. Historically, from 15 to 40 percent of this area was wetland.

Prairie wetlands are extraordinary in their diversity. The time that water is present in them ranges from ephemeral to continuous. The water itself ranges from very fresh to three times as salty as seawater. Surface area of wetlands ranges from a few hundred square feet to hundreds of acres. Their diverse plant communities provide home for more than 100 species of birds and mammals.

Wetland Characteristics

Prairie wetlands are classified by the relative amount of time, during an average year, that they have surface water and the plant community they support.

Temporary wetlands usually dry up every year, fairly early in the growing season. They support herbaceous plants that are generally of medium height and fine texture. Migrating birds depend on these wetlands for high-quality food.

Temporary wetlands are the backbone of the prairie wildlife resource. Since most of these wetlands are shallow, they warm up fairly early in spring. Wildlife food production (small invertebrates) begins as soon as the ice melts. A high protein food supply is available even for the earliest-arriving migrant waterfowl. Deeper wetlands warm up more slowly.

Prairie plants and animals are adapted to the unpredictable ups and downs of prairie wetland water levels. For example, snails, insects and crustaceans—major waterfowl foods in early spring—thrive under temporary ponding.

Shallow Marshes

Seasonal wetlands, or shallow prairie marshes, usually go dry late in the growing season. Seasonal wetlands support plants of medium height and coarse texture.

In dry years these wetlands may only supplement the temporarily ponded areas as a food source. In wet years they provide high-quality foods, space for waterfowl breeding territories, and habitat to raise waterfowl broods. They may even support muskrats and other furbearers.

The unreliability of seasonal wetlands as a water source makes them all the more reliable as water catchments and wildlife habitat. If they didn't dry up often, nutrients that are carried in would stay tied up in the bottom sediments, unavailable for many choice wildlife food plants.

Semipermanent wetlands, or deep marshes, also are very productive, precisely because they're not immune to drought. Their drying out may appear to be a catastrophe for wildlife, but in reality this is necessary for maintaining productivity. Semipermanent wetlands grow tall, robust plants.

E.B. Podell

Prairie wetlands are remarkably diverse. The water ranges from very fresh to three times the salinity of seawater.

Wildlife depend on these areas later in the growing season. Many bird species including waterfowl utilize them for nesting and rearing their young.

Permanent Wetlands

Permanent wetlands are less capable of producing wildlife than other wetlands, mainly because they produce less wildlife food than those which dry up.

Permanent wetlands are either too deep or too salty to support emergent aquatic plants. The freshwater wetlands are used heavily during spring and fall migrations, however. The submerged plants they support are relished by diving ducks.

Saline (salty) permanent wetlands furnish food for shore birds and canvasback ducks. Because the saline wetlands are usually shallow and free of emergent aquatic plants, migrating sandhill cranes prefer them for nighttime roosting. Some terns, and plovers, and the avocet prefer their open sandy beaches for nesting.

The lure of private economic gain continues to transform wet areas hostile to the plow. Private incentive to drain is high. Drainage is a profitable and easy way to increase cropland production.

Most undrained seasonal wetlands in the prairie are high livestock forage producers and can compete economically with drained wetlands used for small grain production. Preserving wetlands for forage production is highly desirable during drought years because good production is assured, and the wetlands are dry so the total production can be harvested.

Values Unrecognized

The problem lies in failure to recognize the public values of prairie wetlands. These include flood prevention, sediment retention, nutrient retention, ground water recharge, furbearer production, nonmigratory wildlife habitat, nongame wildlife production, waterfowl production, erosion control, moisture conservation and natural beauty.

These values are usually overlooked because they are hard to measure in dollars, acres of crops, or other convenient units. Only the municipal water treatment plant operator knows the difference in treatment costs for water supplies with high nutrient and sediment loads and those without.

Few people know the cost of increased streambank erosion due to increased runoff. Few people know the public monetary savings that could accrue for each acre-foot of water held on the land, versus adding it to an already overburdened watercourse.

Most prairie wetlands do not overflow. Consequently any nutrients or sediment reaching them are retained instead of contributing to stream pollution, dredging costs, and the like. Because wetlands retain storm runoff, they help prevent flooding.

When a wetland is drained, however, the runoff it would have retained is delivered to the stream system. In effect, the stream's drainage area is increased. With the additional runoff, it is more likely that the stream's capacity will be exceeded—and that floods will occur.

Wildlife Production

Some say wetlands are inefficient even for wildlife production, because on the average about two ducks are produced per acre of surface water. Again values for other wildlife production are overlooked.

Wildlife produced in prairie wetlands touch the lives of many people east of the Rocky Mountains. Persons most aware of this are birders and hunters. Their contacts and sightings are widely distributed, but some localities are legendary.

The canvasback ducks of Chesapeake Bay, the mallards of Stuttgart, Ark., the teal of Florida and the West Indies and the pintail ducks of Louisiana are all largely products of prairie wetland areas. This too indicates how the economy of the eastern United States is enhanced by production from the prairie.

Natural drainage patterns in the prairie wetlands area are geologically young and poorly defined. The large glacial lakebeds had the highest percentage of wetlands—and were the easiest and first to be drained for cultivation.

The gently rolling or undulating areas called the drift prairie were somewhat more difficult to drain, and extensive drainage pressure did not begin until after World War II. The areas most difficult to drain are in the Missouri coteau and Coteau des prairies (hills of the prairie) in Northeastern South Dakota—still some of the best wetlands in the world.

Losses Up to 90 Pct.

About 125 years ago the prairie wetlands area teemed with birdlife and vast herds of bison, elk, deer and pronghorn. It is now an area of intensive agriculture.

Iowa, Minnesota, southeastern South Dakota and eastern North Dakota have lost more than 90 percent of their prime prairie wetland. About a third of the wetlands are gone from the drift prairie and the Coteau des prairies of northeastern South Dakota.

The Missouri coteau still has more than 80 percent of its original wetland base, but drainage is continuing here too.

Best estimates indicate there were 25 million acres of northern prairie wetlands in the United States before settlement. The present estimate of prairie wetlands remaining is about 6 million acres. This would indicate about three-fourths of our prairie wetlands are gone. The uncompleted National Wetlands Inventory will provide better figures in a few years.

Wetland Protection

Protecting these wetland ecosystems amid intensive agriculture has proved very difficult. No single program or system has been implemented to satisfy all political, social and economic pressures.

Protection of prairie wetlands has been carried out most successfully by the U.S. Fish and Wildlife Service through its Small Wetlands Acquisition Program in Minnesota, North and South Dakota, and in small areas of Nebraska and Montana. This program has preserved about 185,000 acres of prairie wetlands through fee purchase and about 1.2 million acres by perpetual easement.

The Federal Water Bank Program is administered by the U.S. Department of Agriculture (USDA) through contracts with landowners. It has been very popular with landowners in the prairie wetlands region.

Since 1970, landowners and USDA have contracted to protect 130,000 acres of seasonal, semipermanent, and permanent freshwater wetlands and 380,000 acres of adjacent nesting cover.

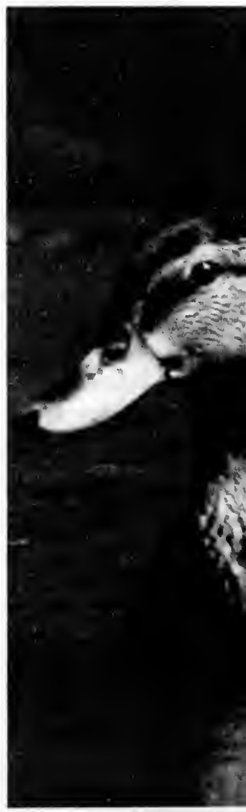
Contracts are for 10 years, and a new contract can be considered at the end of that period. The program's annual payments to landowners are set somewhat lower than local rates for cash rental of land.

Local and State agencies and private groups in North Dakota, as well as Federal agencies, developed the Federal Water Bank Program. Their hope was that the program would slow wetland loss while wetland protection programs were being implemented.

Action by States

Minnesota, North Dakota, South Dakota, and Iowa have initiated legislation, proposed plans, or have existing programs for wetland protection.

The North Dakota legislature passed a State Water Bank Program in 1981 but has not funded it. South Dakota has operated a

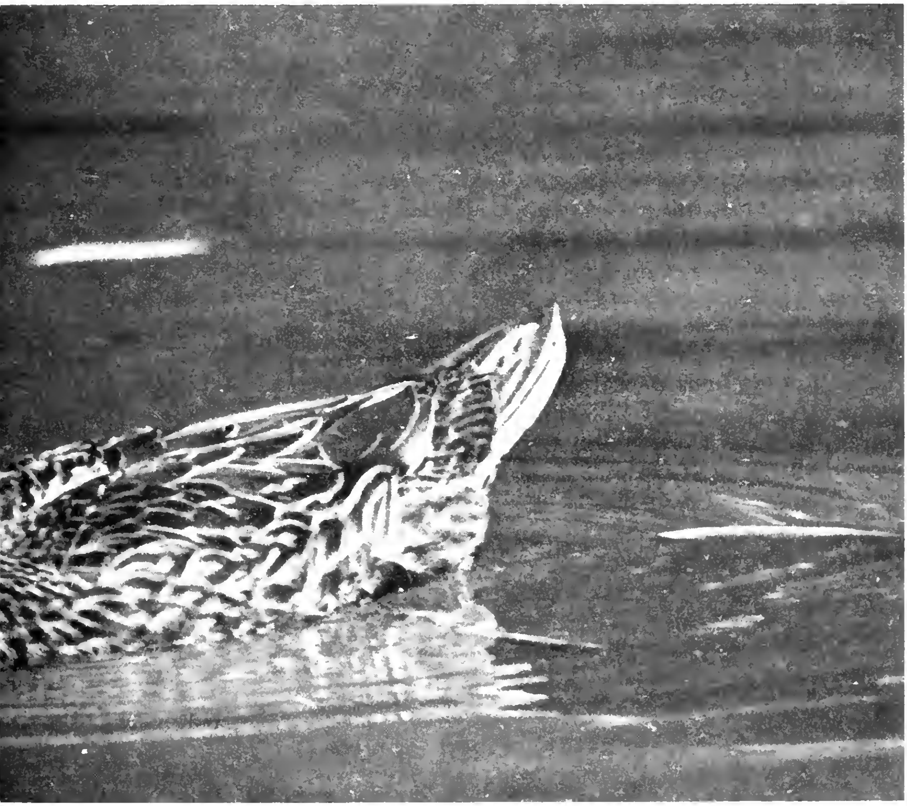


Waterfowl produced in prairie wetlands are legendary and touch the lives of many people east of the Rockies.

wetland purchase program since the 1940's. In the late 1960's the State conveyed control of 160,000 acres of meandered wetlands and waters to its Game, Fish, and Parks Department.

Minnesota is making a concerted effort to retain its remaining prairie wetlands. The State has passed the halfway point toward its goal of protecting at least 600,000 acres of prairie wetlands. The Minnesota Department of Natural Resources uses several methods: Fee purchase, easement, State Water Bank contracts, tax exemptions, and tax credits. Because of the many alternatives available, Minnesota has a good chance of reaching the 600,000-acre goal.

In 1982 the Iowa legislature passed a bill to permit counties to exempt certain wild lands and waters from property taxes. The exemption program is subject to approval by county boards of supervisors. Each county has a 3,000-acre ceiling for land that may be exempted under the program. By May 1983, 31 of Iowa's 99 counties were participating.



Tim McCabe

A major local initiative to retain wetlands occurred in Walsh County, North Dakota. As a supplement to a small watershed project, the county protected more than 70 percent of the wetland acreage in the drainage area by purchase or easement.

Wetland Management

Management of prairie wetlands should attempt to maintain diverse wetlands types, which will support diverse plant communities. Each type of prairie wetland has a niche in the ecosystem that no other type could fill.

Prairie wetlands are often managed for hay and grazing. When managed for wildlife they usually are managed for waterfowl. Wetlands that support aquatic plants are also managed for wildlife such as muskrat, pheasant, and deer; in winter they provide critical habitat for pheasant and deer.

Management of prairie wetlands is far different from that of wetlands in other parts of the United States, because of the highly variable runoff and water levels. Water levels in most instances cannot be controlled, but duck species such as the mallard and pintail are adapted to this situation, as contrasted to species such as the black duck adapted to stable water that occurs in the Northeast.

Manmade wetlands and ponds are often a good substitute for natural wetlands, but their limitations should be recognized. If they are constructed in dryland sites—by excavation or embankments—it is impossible to duplicate the water regime and plant diversity of natural prairie wetlands.

A well-intended but misconceived idea for improving a wetland is to drain one into another to create a more stable water level. Rather than increasing it, the wetland's capacity to produce wildlife is actually reduced. Unfortunately, this has happened in much of the prairie wetland area.

Ditching, Embankments

Techniques for increasing the use of prairie wetlands by wildlife include level ditching, water control structures to fulfill certain management needs, wetland restoration, and constructing nesting islands in seasonal, semipermanent and permanent wetlands.

Level ditching is the excavation of a small part of an existing wetland to create open water in a vegetation-choked area or to extend the period when water is present during summer. The practice often improves an area for bank-denning muskrats. Spoil from level ditches can be used to build nesting islands.

Water control structures are usually embankments that serve as a dike or dam to impound water. Water depths on newly built areas are planned to provide a water habitat that is not present in the area and will complement existing wetlands.

Embankments used to restore

drained wetlands are more productive because they take advantage of an established landform and water regime that is capable of providing habitat for a greater diversity of plants and animals.

Through management of neighboring uplands, prairie wetlands can attract more waterfowl and shore birds that regularly nest in uplands as far as two miles from water. Brood mortality tends to increase with the distance a hen must move her brood to suitable brood habitat. As wetlands are lost, brood mortality increases.

Nesting Cover

It's a good idea to provide nesting cover at locations throughout the prairie wetland area. Excellent results have been obtained from plantings of a tall wheatgrass, intermediate wheatgrass and legume mixture or tall wheatgrass alone or switchgrass alone. A wide range of resident and migratory bird species use this tall, dense, rank cover. Nesting success is high.

Management of uplands and wetlands requires that blocks of good nesting cover and part of the wetlands—especially the semipermanent types of wetlands—be protected to maintain necessary plant cover.

Very often the temporary and seasonal wetlands can be hayed or grazed without detracting unduly from wildlife food production or attractiveness for aquatic bird-breeding territories. However, haying and grazing can seriously lessen their value for resident wildlife such as partridge and pheasant.

When I was a young farm lad, I had my muddy-bottom seasonal wetland to play in, but what about kids of the next century? Will there still be wetlands for them?

As I look back on that boy in South Dakota, I seriously ponder the thought of whether another one of this Nation's outstanding natural resources is to be lost forever.

We have enjoyed wetlands without thought about their part in our environment. When they were in the way of immediate economic gain we deemed it best to get rid of them. Hopefully we recognize this past error and public awareness will mature in time to see the integral part wetlands play in our prairie environment.

If their values remain unknown to planners and ordinary citizens, these complex ecosystems could be lost. But this need not occur, even where the dominant land use is agriculture, if proper measures are used to preserve them and to restore them where necessary.

Further Reading

Our National Wetland Heritage: A Protection Handbook, By Jon A. Kusler. Environmental Law Institute, Suite 600, 1346 Connecticut Ave. N.W., Washington, D.C. 20036. Price: $16.

Louisiana Story: The Gulf Coast Wetlands

By Billy R. Craft

Louisiana's 3.7 million acres of coastal marshes are some of the most productive areas in the world in terms of fish and wildlife habitat and economic returns. The coastal marshes of Louisiana extend about 285 air miles from east to west. They vary from 15 to 50 miles from north to south. About 57 percent of the coastal marshes along the Nation's gulf and Atlantic coasts are in Louisiana.

The marshes are interspersed with a variety of plant communities and water bodies. About one-half of the Louisiana coastal area is water, one-third natural marshes, and the rest beaches, sandy ridges, spoil deposits, and artificially drained marshes.

The productivity and economic importance of Louisiana's coastal marshes can be readily illustrated. Louisiana's fur harvest, valued at $8.5 million in 1982, exceeds that of all other States and Canada combined. During the 1982 alligator season, 17,142 animals were harvested, and sold for $1.7 million.

In 1982 Louisiana produced 1.6 billion pounds of commercial fish with a dockside value of $221 million. The State's production of oysters and crabs, valued at $12 million dockside, is about 50 percent of the U.S. total.

Annually, the marshes provide wintering habitat for about 4.5 million ducks and 400,000 geese. This wildlife provides untold recreational benefits. The estuaries are highly productive and serve as nursery areas for

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The fresh marsh in Louisiana is normally in the northernmost portion of the coastal area and typically borders a wooded swamp. It has the most diverse plant community of the coastal marshes.

many species of marine and estuarine organisms. Dockside value of the 1982 shrimp catch was $146 million.

Livestock enterprises make a significant contribution to the economy. The mineral industry is a dominant economic contributor. Louisiana ranks second only to Texas in oil and gas production.

Plants and Salinity

Saline marsh is adjacent to the Gulf of Mexico. Plants growing in the area tolerate high levels of salinity and are regularly inundated by tidal water from the gulf.

Dominant in this plant community are smooth cordgrass, seashore saltgrass, needlegrass rush, bushy sea-oxeye, woody glasswort, and maritime saltwort. This marsh type has the least diverse plant community of the coastal marsh types.

For the entire coastal area, average salinity for the saline marshes is about 16 parts per thousand (ppt), which is 46 percent sea strength. Salinity, tides, and elevation affect the distribution of coastal marsh plants.

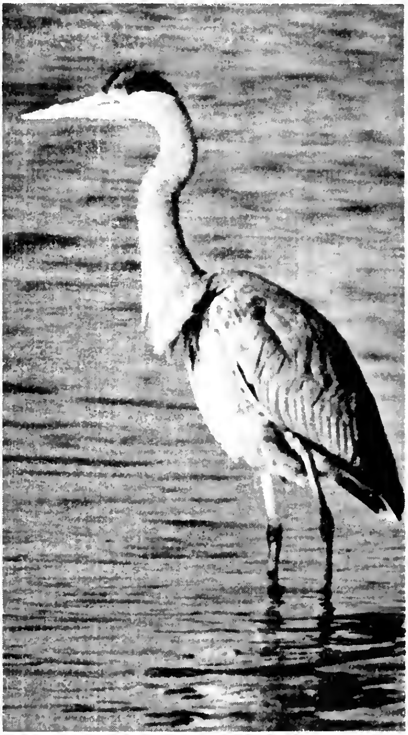
Brackish marsh lies between the saline and intermediate marshes. In its earlier successional stages, it is high-value wildlife habitat. Dominant plants in the brackish marsh are marshhay cordgrass, seashore saltgrass, olney bulrush, dwarf spikesedge, coast water-hyssop, and marsh morningglory. Average salinity for the brackish marsh along the entire coastal area is 8 ppt, or 23 percent sea strength.

Intermediate marsh is a transitional vegetative zone between the brackish marsh and the fresh marsh. The intermediate marsh is generally a narrower zone than either the brackish or fresh marshes. This plant community contains many plants of each of the overlapping brackish and fresh marsh communities. Salinity in the intermediate marshes averages about 3.3 ppt, or 9 percent sea strength.

Fresh marsh is generally in the northernmost part of the coastal area. These marshes have very low salinity or are nonsaline, and the vegetation is very intolerant of salt. This marsh type has the most diverse plant community. Typical plants are maidencane, bulltongue, alligatorweed, cattail, giant cutgrass, pickerelweed, smartweed, and common rush.

150 Bird Species

Ducks favor the fresh and intermediate marshes where seeds and tubers of sedges, grasses, and weeds are available. Geese favor the brackish marshes where olney bulrush, saltmarsh bulrush, and tender grass leaves are available.



Tim McCabe

The marshes of Louisiana offer excellent nongame habitat. Here, a great blue heron searches for food along the edge of a tidal marsh.

The marshes offer excellent habitat for nongame birds because of their diverse plant and water communities. The marshes are located at the end of the Mississippi flyway. Annual Christmas bird counts in the marsh have regularly recorded over 150 bird species.

Important furbearers of the

coastal marshes are muskrat, nutria, raccoon, otter, and mink. The muskrat's preferred habitat is brackish marsh, but in some years intermediate and saline marshes have good numbers of muskrat. Nutria are most abundant in fresh marshes, and populations decrease as salinity increases. Mink, otter, and raccoon inhabit all four marsh types.

Alligators

Favored habitat for the alligator is the fresh and intermediate marshes. In Louisiana, alligators have increased in response to protection and habitat management, resulting in a special harvest season to remove surplus animals. In the period 1976 to 1981, a total of 58,725 alligators were harvested.

Many other wildlife species in the marshes have value for recreation or sport or are unique. Both rabbits and white-tailed deer are abundant and provide many man-days of outdoor recreational hunting.

Larval and juvenile forms of fishes and crustaceans—such as shrimp, blue crab, croaker, menhaden, mullet, and bay anchovy—enter the estuaries and marshes while very small. They grow to varying degrees of maturity, depending on species, before moving back to the gulf.

Erosion Big Problem

Excessive erosion of coastal marshlands, currently totaling 40 square miles annually, is the major problem. This staggering loss seriously affects Louisiana's multi-million-dollar fish and wildlife resources, with subsequent effects on the national economy. Erosion losses currently threatening the coastal area are caused by both natural conditions and human activities.

Saltwater intrusion is the major factor in deterioration and erosion of coastal marshes. This intrusion has been accelerated by navigation channel dredging, canal dredging for oil and gas exploration, agricultural drainage channels, subsidence, and shoreline erosion.

Marsh plants die when saltwater invades fresh marshes. The vegetative mat at the surface is lost, and organic soil material dispersed and washed out into the gulf by the tides. That leaves open water areas in place of the marsh. Consequently, this landmass with its highly productive capacity for fish and wildlife is lost forever.

Coastal marshes are dynamic and delicately balanced resource systems. Over many years, conservation management practices have been developed that help to maintain and enhance the marsh resource. At present, landowners use management practices for improving marshes for waterfowl, furbearers, and cattle on a regular basis.

Louisiana State University's Cooperative Fisheries Unit and the U.S. Soil Conservation Service are engaged in a cooperative effort to develop management practices for marine-estuarine larval forms that depend on the

One of the most promising plants to control shoreline erosion is smooth cordgrass, a native marsh grass found growing in saline marshes.

Tim McCabe

marshes. Management practices have to be compatible for all resources. Following are some management techniques currently used:

Weirs are low-level dams, usually with a fixed crest, placed in marsh watercourses to regulate water levels in the marsh and marsh ponds. They help maintain minimum water levels in bayous and marsh ponds to prevent these areas from drying out during extended dry periods and in winter when strong north winds blow water out of the marshes.

Weirs also reduce water salinity and turbidity. They insure access to marsh areas for trapping and hunting, since water is in the bayous, canals, and ponds all year. Weirs have been most effective in brackish and intermediate marshes.

Prescribed burning is used to "set back" plant succession to maintain desirable vegetative conditions. Habitat for both waterfowl and furbearers can thus be improved. Burning should be done at the time of year and under conditions that produce the desired objectives. In Louisiana, fall burning produces the best results.

Leveed impoundments can be used in all the marsh types if soils are suitable and management objectives compatible. Waterfowl are especially attracted to these impoundments with the abundant food provided by wild millet, widgeongrass, dwarf spikesedge, and other plants. Almost all wildlife species benefit from impoundments.

Management should be tailored to objectives of the landowner and existing marsh conditions such as salinity, vegetative communities, tides, and soils.

Plants for Erosion Control

Marsh plants help stabilize bayou banks and bay and lake shorelines, reducing land loss and improving water quality. Several plants currently are being evaluated for erosion control along shorelines and mudflats.

One of the most promising plants for use on shorelines is smooth cordgrass. A native marsh grass, it grows in saline marshes in the daily tidal zone. Field plantings of smooth cordgrass on several coastal lakes have done exceptionally well in protecting shorelines from further erosion.

Smooth cordgrass has five characteristics that make it a superior plant for erosion control in saline marshes: 1) It has a high survival rate for plantings, 2) It spreads rapidly into the adjacent tidal zone, 3) It is easily obtained, 4) It has a long planting season extending from March through August, and 5) It has the ability to stabilize shorelines in the daily tidal zone.

Conservation measures by individual landowners are not adequate to protect the marshes against some severe and large-scale problems, which can be alleviated only by measures that apply to a large management unit. One example is the Cameron-Creole Watershed Project, being constructed under the Watershed Protection and Flood Prevention Act (Public Law 83-566).

19-Mile Levee

This project, in Cameron Parish, covers a 100,000-acre marsh area that is deteriorating as a result of saltwater intrusion. A 19-mile levee has been constructed along the eastern edge of Calcasieu Lake to reduce saltwater intrusion into adjacent marshes. Several water-control structures will soon be installed in the levee at the mouth of major watercourses. The structures will allow tidal flow into the marshes and permit estuarine-dependent organisms to come and go.

With installation of the levee, water control structures, and other conservation practices, salinity in the marsh will be reduced and water levels stabilized, and marsh recovery will begin.

The 1981 special session of the Louisiana Legislature established a Coastal Protection Trust Fund and appropriated $35 million for projects to combat saltwater intrusion, erosion, subsidence, and other problems in coastal marsh.

In 1982 the Governor established a Coastal Protection Task Force. Its primary functions are to show ways to control erosion, deter saltwater intrusion, demonstrate marshland building and beach nourishment programs, and to protect and nourish barrier islands.

Chesapeake Bay's Coastal Wetlands, a Biological Treasure

By Elder A. Ghigiarelli, Jr., and William S. Sipple

Chesapeake Bay is the Nation's largest and most productive estuary. Located entirely within the borders of Maryland and Virginia, it is some 180 miles long, and has a mean width of 15 miles. The bay has depths up to 175 feet, but the average depth of the entire estuarine system—including tributaries—is about 21 feet.

The bay proper has a surface area of around 2,500 square miles, but the total estuarine system is about 4,400 square miles. The Chesapeake's greatly indented shoreline totals 8,100 miles, 4,000 miles in Maryland and 4,100 in Virginia.

Major sources of freshwater to the Chesapeake come from two large interstate rivers—the Susquehanna and the Potomac. They have a combined average flow of about 58,000 cubic feet per second. This flow varies, reaching a peak in late winter and spring, with low flows in late summer and fall.

The immense biological value of the Chesapeake Bay resulting from the complex interactions inherent in its makeup is summarized by Eugene Cronin in the foreword of Alice Lippson's *Chesapeake Bay in Maryland—An Atlas of Natural Resources* (1973):

"The result is a biological treasure. The nutrients make it possible for plankton and rooted aquatic plants to produce enormous quantities of organic material. These feed the world's largest crops of oysters and clams in water salty enough for them but

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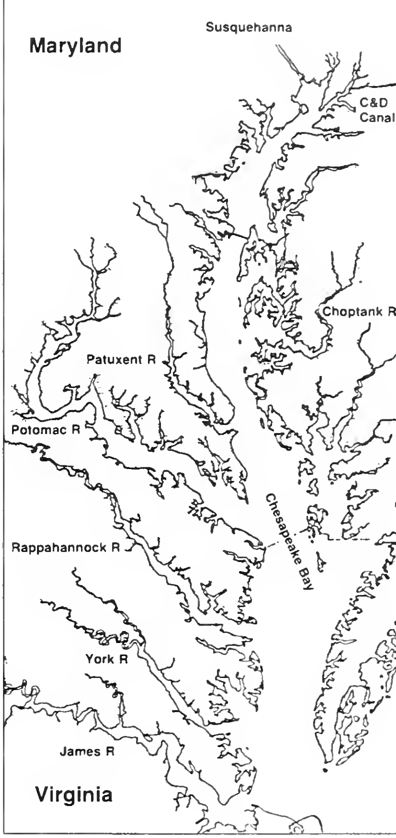
The Chesapeake Bay Region



not salty enough for their worst natural predators.

"The estuarine waters of Maryland also support large populations of many species of fish, and the vital low-salinity region, where salt content is between 0 and 10 parts of salt per 1,000 parts of water, is the required habitat for an almost invisible resource, the eggs and larvae of rock, shad, herring, and many other species which spawn in the rivers, bay, and ocean.

"This is the most important spawning and nursery area in the world for the rock or striped bass, and it is of extraordinary importance for other species . . ."

EPA Study Made

The importance of Chesapeake Bay is borne out by the fact that in 1976 Congress directed the Environmental Protection Agency to conduct a $25 million study of the environmental quality and management of the bay's resources. A major objective of this study, known as the Chesapeake Bay Program, was to coordinate research to assess the principal factors adversely impacting the bay's water quality. Three major areas received extensive attention in the study: Nutrient enrichment, toxic chemicals, and submerged aquatic vegetation. Results of this effort are presently being published.

Among vital components of the bay's ecology are its coastal wetlands. These areas, subject to regular or periodic tidal action, support aquatic growth, which is a principal source of food and cover for many animal species that inhabit the Chesapeake Bay estuary, its tidal tributaries, and the nearshore ocean. Waterfowl, songbirds, mammals, fish and shellfish depend to varying degrees on the coastal wetlands during a portion of their life cycle.

Although many details of the production, distribution, and consumption of the wetland food supply are not known, available information reveals that an abundance of food is produced. Some is harvested directly by animals and a large amount becomes available in the form of detritus, a pulverized form resulting from decay of dead plant tissues. This decomposition also returns important nutrients to the water system.

Many of the animal species that depend upon the coastal wetlands during a portion of their life cycle—such as fish, shellfish, and furbearing animals—are of direct commercial value. Others are of recreational value to fishermen, hunters, and observers of nature.

Water Quality Role

The coastal wetlands also provide several functions important to water quality. They serve as settling or filtering basins—collecting sediment, overland runoff, and attendant pollutants. Their absorption and storage capabilities can temporarily retain water from overland runoff and tidal inundation, and then gradually release it to the estuarine system.

Coastal wetlands not subject to direct ocean exposure also provide erosion control benefits. Shoal waters, immediately channelward of the vegetated wetlands, are shallow and tend to reduce wave energy before it reaches the wetland. The low profile of the wetland vegetation then in turn dissipates the remaining wave energy over its surface. By absorbing the energy of waves, wetland vegetation reduces velocity of the water flow.

Both Maryland and Virginia are well endowed with coastal wetlands, most of which are located on the Eastern Shore of Chesapeake Bay. There are an estimated 280,000 acres of vegetated tidal wetlands in Virginia. In Maryland, the vegetated tidal wetland resource, including submerged aquatic vegetation, is about 250,000 acres. Thus, the total for the Chesapeake Bay region, including coastal bays on the Atlantic shoreline, is about 530,000 acres.

Vegetated coastal wetlands of the bay can generally be divided into four categories: Shrub swamp, swamp forest, herbaceous marsh, and submerged plants. Herbaceous marshes generally are discussed in terms of fresh, brackish, or saline marsh. Thus, the vegetated coastal wetlands can be divided into these general types: Shrub swamps, swamp forests, fresh marshes, brackish marshes, saline marshes, and submerged aquatic vegetation.

Maryland Categories

The Maryland wetlands classification system distinguishes 35 wetland types, 32 vegetated and 3 unvegetated types. Besides the 4 vegetative forms mentioned above, also recognized are categories of unvegetated wetlands (open water, mudflats, and beaches/sandbars), three ranges of salinity within the marshes (fresh, brackish, and saline), and two tidal ranges within the brackish and saline marshes (low, or regularly flooded, and high, or less frequently flooded).

The wetland types discussed are based on a report prepared for the Maryland Department of Natural Resources by McCormick and Somes, *The Coastal Wetlands of Maryland* (1982). Types described apply to the entire Chesapeake Bay system, Maryland and Virginia. Unless otherwise indicated, acreage figures apply only to the Maryland portion of Chesapeake Bay.

The most extensive wetland types of the Chesapeake Bay are the brackish marshes. This is because the various wetland types form a continuum; that is, they tend to merge gradually from one extreme to the other extreme.

At one extreme are the freshwater wetlands near the head of the tide. These wetlands are never exposed to salt concentrations of more than 0.5 parts per thousand (ppt). At the other end of the spectrum are the saline wetlands that are regularly flooded by waters of the Atlantic Ocean, which contain salt at concentrations of 35 ppt or more.

The brackish wetlands occupy a large portion of the area between these two extremes. Because the basic variable feature within the wetland spectrum is salinity, environmental limits of the fresh, brackish, and saline wetlands must by definition be somewhat arbitrary.

Acreage and Percentage of the General Coastal Wetland Types in Maryland

	Acres	*Percentage*
Shrub Swamps	2,600	1.0
Swamp Forests	16,798	6.4
Fresh Marshes	25,563	9.8
Brackish High Marshes	126,569	48.4
Brackish Low Marshes	25,079	9.6
Saline High Marshes	4,205	1.6
Saline Low Marshes	9,544	3.7
Open Water (Ponds)	5,556	2.1
Sandbar/Beach/ Mudflats	1,797	.7
Submerged Aquatic Vegetation	42,309	16.2

General Types

Following is a brief description of the general types of vegetated coastal wetlands of Chesapeake Bay.

Shrub Swamps. Ranging in size from less than one acre to a hundred acres or more, shrub swamps occur in the form of linear thickets along upland margins of fresh and brackish marshes, and as relatively extensive swamps at headwater areas of many tidewater streams.

The baldcypress swamp forest is one of three major types of swamp forests in the Chesapeake Bay region. Here, a spatterdock fresh marsh lies between the swamp and open water.

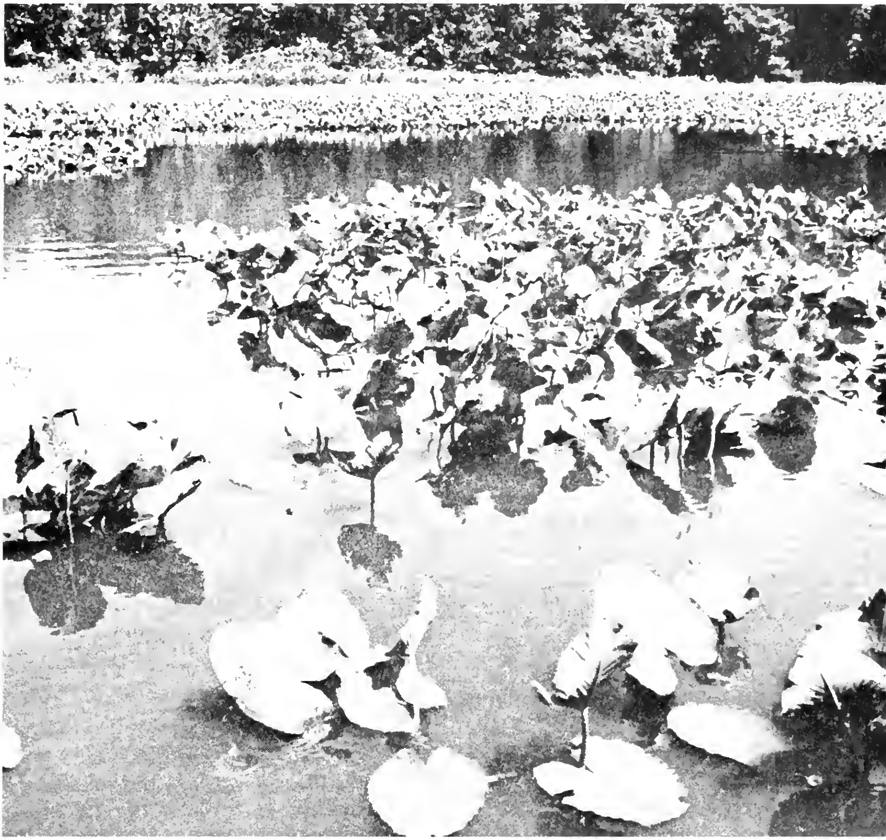
There are three major types of shrub swamps—swamp rose, smooth alder/black willow, and red maple/ash. The most extensive type is the red maple/ash shrub swamp.

Swamp Forests. There are three principal types of swamp forests in the Chesapeake Bay region. They occur most commonly at headwater areas of tidewater streams or peripheral to fresh tidal marshes. The most extensive is the red maple/ash swamp forest. Major trees in the broadleaf red maple/ash swamp forest type are red maple, green ash, blackgum, and sweetbay.

In Maryland, baldcypress swamp forests occur mainly in two lower Eastern Shore counties. The baldcypress is a winter-bare, needleleaf tree. Although it forms small, nearly pure stands in some areas, the baldcypress grows more commonly in narrow fringes along the margins of tidewater streams. Baldcypress occurs as a dominant also in some Virginia tidal swamps, a good example being along the Chickahominy River.

Loblolly pine swamp forests commonly occupy sites adjacent to brackish marshes, and frequently the undergrowth of these pine forests is a continuation of brackish marsh vegetation. Although stands of loblolly pine may be quite dense, frequently it occurs in stands that are open and savannalike, with widely spaced trees.

Fresh Marshes. An interesting feature of the coastal wetlands is that the number of species of plants increases as the salinity of adjacent waters decreases. Thus, freshwater marshes generally have the greatest diversity in terms of the



The freshwater marshes in the Bay region may consist of masses of broad-leaved plants such as spatterdock.

number of plant species. Brackish marshes are of intermediate diversity, and saline wetlands exhibit the least diversity. Vegetation in a freshwater marsh also tends to be randomly distributed, whereas vegetation in brackish and saline marshes tends to occur in a more regular sequence from the shore to upland edges of the wetlands.

Vegetative stands in the freshwater marshes may consist of tall grasslike plants such as wildrice, big cordgrass, common reed, threesquares, bulrushes, cattails, and sweetflag; masses of broad-leaved plants such as spatterdock, arrowarum, burreeds, pickerelweeds, arrowheads, and white waterlily; or stands of tall, single-stemmed herbaceous plants such as burmarigolds, waterhemp, and spotted touch-me-not. Other components include herbaceous thickets consisting of smartweeds, tearthumbs, burmarigolds; low stands of tangled grasses such as rice cutgrass; and shrublike thickets containing rosemallow and water willow.

Fresh tidal wetlands occur most extensively along upper portions of the bay's tributaries, such as the Patuxent, Nanticoke, Wicomico and Choptank Rivers in Maryland and the Mattaponi, Pamunkey, James and Rappahannock Rivers in Virginia.

Brackish Marshes. The brackish marshes can be divided into two classes, low marshes and high marshes. The main difference, as indicated, is in their relative elevation, but they also differ in types of vegetation they support. The low marshes, characterized by stands of smooth cordgrass, are partly or wholly inundated during periods of high tide.

Brackish marshes are the most extensive wetlands along Chesapeake Bay, covering 151,648 acres in Maryland alone, or 58 percent of that State's coastal wetland resource. The most extensive marshes are along the middle and lower Eastern Shore of the bay.

Brackish high marshes are much more extensive than brackish low marshes. High marshes often are characterized by extensive stands of needlerush and meadow cordgrass/spikegrass, which also are the most abundant coastal wetland types in Maryland. Both vegetation types are represented by homogeneous, and sometimes extensive, stands of vegetation. Smooth cordgrass, which also tends to occur in homogeneous stands, is the only type of brackish low marsh.

Saline Marshes. The saline coastal wetlands are not located on the shores of Chesapeake Bay, but exist in the seaside bay areas of Maryland and Virginia. The seaside bays along the Atlantic shoreline of Maryland and Virginia—Assawoman Bay, Sinepuxent Bay, Chincoteague Bay, Hog Island Bay, Cobb Bay, and South Bay—contain vast saltmarshes, particularly in the Hog Island, Cobb Bay, and South Bay areas of Virginia. These areas contain the most extensive tidal wetland systems in Virginia.

Like brackish marshes, saline marshes contain low and high marsh sites. In contrast to brackish marshes, however, a higher percentage of the total saline marsh occurs as low marsh.

Smooth cordgrass in the saline low marshes occurs in tall growth and short growth forms. The tall growth form, reaching 2 to 4 feet or more, grows along margins of bays and tidal channels. The short growth form, generally not exceeding a foot in height, grows farther back on the marsh surface.

As noted earlier, saline marshes exhibit the least diversity compared to fresh and brackish marshes. There are three predominant vegetation types in the saline high marshes.

The short-growth form of smooth cordgrass surrounds a shallow salt pond in a saline low marsh. Saline coastal wetlands are in the seaside bay areas of Maryland and Virginia.

Meadow cordgrass/spikegrass is most abundant. Two shrubby plants, marshelder and groundselbush, make up the second type. These shrubs occur in highest portions of the marsh, generally near the upland edges but also on higher ground scattered through the marsh. Although extensive in brackish high marshes, needlerush, the third saline high marsh type, is less abundant in the saline marshes.

Submerged Aquatic Vegetation. Made up of at least 24 species of flowering plants and 7 kinds of macroscopic algae, submerged aquatic vegetation occurs in shallow waters of Chesapeake Bay and its tidal tributaries and marsh ponds. It is also found in the seaside bays along the Atlantic shoreline. Stands of these plants may be small or extensive, and they are subject to vast fluctuations in their populations. Areas covered by luxurious stands of submerged plants in one year may be nearly barren the next. The stands may or may not redevelop in subsequent years.

The sensitive nature of submerged aquatic vegetation makes it difficult to estimate the extent of this wetland type at any given time.

Although during the last several decades there has been a general decline in submerged vegetation in the bay, the decline has been dramatic since 1970. Because of its importance to the bay system, the decline of submerged vegetation was included as a critical research area in the Chesapeake Bay Program mentioned earlier.

While specific reasons for the decline in submerged vegetation may vary from area to area, the bay program study results indicate that a general increase in nutrients to the bay system may be a major factor contributing to the decline. Nutrients are needed for survival of submerged vegetation; however, excessive nutrient enrichment can cause algal blooms which in turn block out light available to the submerged grasses.

Nature also has her means of affecting populations of submerged plants. Prolonged droughts allow brackish water to encroach farther upstream than normal and can destroy submerged plants restricted to freshwater areas. On the other hand, rapid increases in freshwater to the bay also can have an adverse effect. This was evidenced in the early 1970's when tropical storm Agnes passed through the Chesapeake region and produced an abrupt halt to what had been a general trend toward recovery of submerged plants in many bay areas.

Managing Bay Wetlands

Importance of coastal wetlands to the Chesapeake Bay ecosystem cannot be overestimated. Public awareness of the value of these tidal areas led to passage of legislation in both Maryland (1970) and Virginia (1972). Intent of the Maryland and Virginia Wetlands Acts is to conserve the coastal wetlands and ensure the wisest use of these valuable areas. Both States have established a public policy of preserving coastal wetlands and preventing their despoliation and destruction.

Before passage of the Maryland Wetlands Act, it is estimated that wetland losses in Maryland exceeded 23,000 acres for the period 1942–1967. For the 60-year period prior to 1967, however, wetland destruction may have approached 200,000 acres. This is based on a 500,000-acre total reported to exist in Maryland in 1908. In Virginia, before passage of that State's Wetlands Act, it was predicted that wetland loss would approximate 400 acres per year during the 1970's.

The Maryland Wetlands Act established a permit and licensing program administered at the State level. Any proposal to dredge or fill tidal wetlands requires a private wetlands permit (if the project is landward of the mean high water shoreline) or a State wetlands license (if the project is located channelward of the mean high water shoreline). In Virginia, a permit is also required for any activity that may affect its tidal wetlands. In that

State, this permit review process is handled by local review boards with State oversight.

Losses Curtailed

Both State programs have been effective in curtailing wetland losses. During the first four years of its program, wetland losses in Virginia were reduced to less than 20 acres per year. Wetland losses have been reduced to the same amount in Maryland since inception of its program.

Over the past 10 to 15 years, the values of our coastal wetlands have become well recognized. This has had a significant impact because it presents several challenges to the wetland manager today. One is fostering even greater public awareness, along with education programs. A second is keeping wetland losses below limiting thresholds, beyond which natural forces cannot compensate for the damage.

Each specific instance of wetland destruction or alteration may not seem significant or important; however, from a regional or statewide perspective, the accumulation of acreage losses becomes more meaningful. In these challenges, natural processes versus man-caused impacts must be dealt with from this overall standpoint, as well as on a project-by-project basis. The true art in wetlands management is balancing the two so that human endeavors, to the extent possible, can be accommodated while at the same time integrity of the natural environment is maintained.

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Ever-Changing Network of Our Streams, Rivers and Lakes

By L. Dean Marriage and Ronald F. Batchelor

Sitting on a streambank on a pleasant afternoon, one is easily lulled by the harmony of continuously changing images and sounds. The water ripples past, its music quick but soft. A water strider skips across a quiet backwater eddy. Below a tree overhanging the bank, light and shadow perform an intricate dance directed by shifting breeze and swirling water.

A peaceful scene, but will it someday be only a memory? For the truth is that our water resources are today under great pressure of use—and abuse. Nature provides a seemingly unlimited variety of quantity, quality, and other characteristics of surface water. These characteristics change from place to place, season to season. And they are further changed, too often for the worse, by our quest for a better life.

Average daily runoff in the United States is about 1.2 trillion gallons. Most of this volume is carried off the landscape to the ocean in a network of 3.25 million miles of streams and rivers from 21 major drainage basins. Much is stored in natural lakes, ponds, swamps, and marshes. In addition, manmade diversions, reservoirs, and canals store water and transport it—often hundreds of miles—to water-short areas, or store seasonal runoff for flood control and use during the drier part of the year.

Excluding the Great Lakes, water bodies larger than 40 acres account for almost 65,000

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Today's use of the Nation's streams, rivers, and lakes is varied and substantial—municipal and other water supplies, irrigation, generation of electrical power, transportation of goods and people, and recreation.

square miles of water surface. Several million acres of smaller ponds, lakes, and reservoirs also dot the landscape.

This network of streams, rivers, and lakes provided the Nation with avenues for its westward expansion and for commerce—avenues that continue to be used today. If properly managed, the fish and other aquatic life they support represent a resource of great natural, esthetic, and economic value.

Recreation Base

Water sustains our lives, our crops, and our industries. It generates electricity and transports our goods. Water is also the base for many forms of recreation. For example, in 1980 about 36.4 million fishermen participated in more than 710.6 million days of fishing in the Nation's fresh waters (excluding the Great Lakes). And water-based recreation is expected to nearly double by the year 2000.

More than 240 million acres of public-administered recreation areas either contain or are adjacent to accessible water. A large number of privately owned, water-oriented recreation areas also depend on water as their major attraction.

From its beginning in the highlands, to its mouth downstream, the stream drains its watershed. Typically, the streambanks are lined by moisture-loving grasses, forbs, shrubs, and trees, their shade cooling the waters, their root systems stabilizing the banks. Collectively, this band of plants makes up the stream's riparian zone.

From a distance, the riparian zone snaking its way across the landscape is often the most prominent sign of a stream. It provides important habitat for a great variety and abundance of wildlife species and the necessary streamside shade and other elements for the stream's fish and other aquatic life. In the arid West the riparian zone is the single most important habitat for wildlife.

A stream system consists of a large network of small streams, which flow into larger and larger streams that in turn are gathered by rivers. The parts of the network can be described by their "order." The smallest streams, like the outermost twigs of an old oak tree, are order one. First-order "twigs" join to form second-order "branches"

F.L. Robbins

Like this stream in northern Wisconsin, streams typically begin in high elevations and are fed by snowmelt, precipitation, springs, and ground water.

and so on. The Mississippi River, like the trunk of the old oak, is the last or 12th-order river.

The river environment consists of three distinct but interrelated parts: 1) The water, 2) the river channel and flood plain, and 3) a network of tributary streams that comprise the drainage basin. Over time, each part influences and is influenced by the others.

Natural Levees

Stream channels generally overtop their banks about every year or two. The overbank flooding slowly builds the flood plain. It saturates soils of the flood plain and deposits sediment and nutrients from upstream sources.

The sediment and nutrients support growth of riparian vegetation and the building of natural levees along the stream channel. The resulting patterns of topography and vegetation create an extremely valuable and diverse wildlife habitat. Where people infringe on these naturally flooded areas for "higher" development uses, problems can arise.

In flowing from its headwaters to the sea, a stream undergoes many changes. A typical stream begins at a high elevation, such as in the mountains. It is fed by snowmelt, precipitation, and springs, and by ground water. Headwater streams have high energy and great erosive force, particularly during periods of high runoff. The channel is well defined and has a steep slope and in many places is strewn with boulders. The finer streambed materials are transported downstream.

In the foothills, the channel is not so steep and is more apt to be straight. The stream has less energy and the channel bottom is paved with cobbles. Riffles outnumber pools.

As the stream reaches the valley floor, it slows down further and deposits larger particles such as gravel and coarse sand. Smaller particles continue downstream. Stream bottom materials are constantly, if slowly, being moved and resorted after high-flow events, such as heavy storms or rapid snowmelt.

Braided Channel

In upper reaches of the valley, the channel may be unstable in places. It may be braided—divided into several channels—as a result of decreased slope, reduced velocity or current, and deposition of bottom materials carried from upstream. Farther downstream, the channel meanders within the flood plain. Pools and riffles are found in about equal number. The stream's energy is moderate and bottom material is mainly small gravel.

In lowest reaches of the stream, the gravel bottom gives way to silt and sands. Pools outnumber riffles, and the current may increase because of a greater volume of flow. The water is often turbid, and water temperature is warmer.

As the stream reaches the coastline, freshwater becomes mixed with saltwater in the estuarine zone. Mudflats and meanders are common. Bankside vegetation must be salt-tolerant to withstand the brackish water. Kinds and patterns of vegetation are many and varied.

What determines the kinds of plants and animals that inhabit the stream and riparian zone? Among the important forces are the stream's annual and seasonal flow pattern, the channel's shape and slope, and the bottom materials.

Silting and Scouring

The rich variety of organisms inhabiting streams and rivers are influenced by several environmental features, including light, temperature, nutrients, and current. As a response to varying rate and volume of streamflow, the stream may deposit silt at one moment and scour it away at another. On the other hand, the considerable exchange between land and stream often serves to enrich the nutrient supply. Current-created turbulence helps keep physical and chemical conditions relatively uniform, and helps prevent stratification of water layers that occurs in most lakes and reservoirs.

Near the shore, stream bottom plants and animals are especially dependent upon a stable, constant delivery of nutrients by the current.

An overwhelming variety in number and kinds of organisms inhabit stream bottoms. These include

1) attached animals such as mussels, worms, and algae,

2) creeping organisms such as snails, worms, and insects,

3) burrowers such as clams, worms, and some insects, and

4) fish.

Substrate of the lower stream course typically is fine sand, silt, mud, or a mixture of these. The water is usually turbid and sluggish. Stream floor animals are not unlike those of some communities found in lakes: Clams, mussels, and burrowing insects. Also common are several species of mud-grubbing fish—such as suckers—that feed on plant litter.

The upper stream course is characterized by pools, stretches of fast water, and riffles. Each of these harbors distinct plant and animal communities. In pools are such common fish as minnows and sunfish. Riffles are inhabited mainly by insects, often of many species.

Adapting to Current

Plants and animals that live in rapids and mountain streams must be adapted to the swift current. Algae are the most common plants. They firmly attach themselves to the substrate or grow as slippery masses covering rocks. Bottom dwelling animals have a variety of adaptations that fit them for life in rapid water. These include streamlined or flattened bodies, suckers for attachment, and claws for holding.

Changes in biotic communities are likely to be more pronounced in the first mile of a headwater stream than in the last 50 miles. In the upper reaches, gradient, volume of flow, and chemical composition change rapidly, and organisms tolerate a wider range of conditions than organisms farther downstream.

Replacement of species throughout a river system is not a matter of a uniform, continuous change. Conditions and plant and animal populations may reappear at intervals.

Velocity of the current molds a stream's character and depends on many variables: Size, shape, and steepness of the stream channel; roughness of the bottom, water depth, and precipitation that falls in the watershed.

Productivity High

Flowing water transports nutrients to—and carries waste products away from—many aquatic organisms. It may even sweep the organisms away, but the current continuously reintroduces others from upstream. Similarly, as some nutrients are washed downstream, more are carried in.

Because of this nutrient renewal and waste removal, the natural productivity of a stream can be 6 to 30 times that of a lake or pond. Substances such as humus, silt, plant litter, and insects produced outside the stream environment provide the energy base for much of a stream's productivity.

Temperature of a stream is not constant. A change of 10°–20° F in a 24-hour period is not uncommon, particularly in streams lacking streamside shade. In general, temperature of a small stream tends to follow (but lags behind) warming and cooling trends of air temperatures. Streams with large areas exposed to direct sunlight are warmer than those shaded by trees, shrubs, and high banks. Water temperature is especially important because it largely determines makeup of stream communities.

Constant swirling and churning of water over riffles and falls results in greater contact with the atmosphere and contributes to the high oxygen content of stream water. Only in deep pools does dissolved oxygen show any significant decline. Carbon dioxide content and the degree of acidity or alkalinity are other factors important to a stream system's health.

Riffles and Pools

Many fast streams consist of two different but interrelated environments—the turbulent riffle and the quiet pool. Each influences the other.

Riffles are the plant and animal factories of the stream, the sites where organic matter is produced. Pools are catch basins, the sites of decomposition, where slow current allows material to settle out. The carbon dioxide essential to the riffle plant communities is formed mainly in pools.

Production of plant and animal organic matter in a stream is influenced by the bottom. Pools with sandy bottoms are least productive, because the sand shifts. There is not much stable surface to which aquatic organisms can attach.

Bedrock, although solid, is likely to be so exposed to currents that only the most tenacious organisms can maintain themselves. Gravel and rubble bottoms support the most abundant life because they offer the greatest surface area and are the most stable. They provide nooks and crannies that bottom-dwelling animals need for protection.

Insect production in a riffle decreases if the diameter of the bottom materials is smaller than about 6 inches or larger than 12 inches.

Some animals in the riffles are carried by current to pools. Trout and other fish move back and forth between the two, seeking food in riffles and shelter in pools. A good trout stream has a mix of pools and riffles. Most stream inhabitants live under rubble and gravel in riffles, sheltered from the current.

Traveling Community

Many bottom-dwelling organisms tend to drift downstream to form a sort of traveling community. This drifting has a relatively consistent pattern of day and night variations throughout the year. Insect drift is the highest at night, especially soon after sunset; it is lowest during daylight hours.

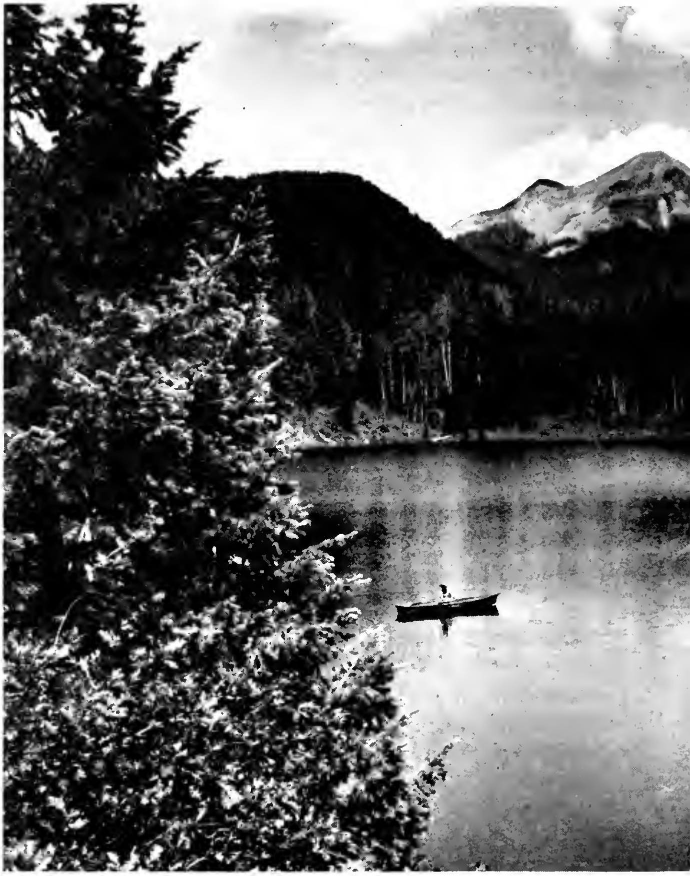
Rate of drift can serve as an index of a stream's productivity. Drift provides a means of colonizing depleted downstream riffles, as well as providing food for fish and other animals. In western streams, cutthroat trout feed a great deal on drift, while brown trout prefer to feed on insects that enter the stream from outside.

Insects are an essential link in the food chain of a stream. Larval forms of certain species of stoneflies, caddisflies, and craneflies are found in headwaters. These larvae shred leaves, twigs, and other organic matter, reducing this material to particles smaller than about 1/25th of an inch in size. "Collector" insects, which collect and feed on these smaller particles, are most plentiful in lower reaches of the stream system.

Dominant collectors are larval forms of netspinning caddisflies, blackflies, clams, and certain fly species that filter small particles from the passing water. "Grazers", found in middle reaches of a stream system, include larval forms of certain species of caddisflies, mayflies, snails, and beetles.

The middle reach of a river is the major zone of plant growth. Fish in a river system grade from invertebrate eaters in headwaters, to fish and bottom invertebrate eaters in middle reaches, to invertebrate and plankton eaters in the lower reaches.

Lakes in the Rocky Mountains are generally found above 4,000 feet. This Colorado lake, typical of the region, offers good recreation and wildlife habitat.



Aubrey L. Roach

Variety in Lakes

Unlike streams, where water continually passes through the system, lakes are more or less closed systems. But in lakes as well as streams, variety is the rule although there are some regional similarities. There are millions of acres of lakes in the Nation.

Lakes in the Northeast, both deep and shallow, are mainly of glacial origin. The growing season is relatively short. In the Southeast, natural lakes are numerous and mainly shallow. The growing season is long. In the north-central region, lakes also are numerous; and winter and summer temperatures can be extreme.

Rocky Mountain lakes are typically at an elevation above 4,000 feet. Their waters are cold. The Southwest has few natural lakes. The Northwest has thousands of small and large lakes totaling more than 1 million acres in surface area. They vary from

shallow to deep mountain lakes, ranging from about 2,500 to 5,000 feet or more in elevation, to shallow lakes formed in valleys dammed by alluvial deposits. A few deep, extinct volcanic crater lakes exist.

More productive lakes are relatively warm, high in nutrients and dissolved solids, and have a large water area of less than about 20 feet deep. Shallow lakes warm faster than deep ones. During the day, sunlight and photosynthesis make the warm, shallow areas major sites of food production.

As bacteria, algae and rooted plants consume nutrients and minerals, they absorb carbon dioxide and release oxygen to the water. At night the process is reversed: the plants absorb oxygen and give off carbon dioxide. Oxygen also enters and leaves the lake at its surface. Oxygen levels and other lake water properties can also be influenced by inflow from streams.

Turnover Period

Most lakes and reservoirs undergo an important phenomenon known as "turnover"—when the oxygenless bottom water containing nutrients and dissolved gases is thoroughly mixed with oxygen-rich surface water.

As summer passes into fall the surface water begins to cool. When temperature of the surface equals that of deeper water, all the water has the same density. At that point very little wind energy is required to turn the lake water "upside down." Muddy water is common during the turnover period.

Lake turnover may also take place in spring. Fish often die during spring turnover because of lack of oxygen or release of toxic hydrogen sulfide from the bottom. Turnover rejuvenates a lake and its organisms by making nutrients from the bottom available for algae and plant growth.

The chemistry of lake and reservoir waters varies by geographical region. Dissolved solids contain some of the primary building blocks of the food chain. They range from less than 120 parts per million in parts of the Northwest, Southeast, and Northeast, to more than 350 parts per million in the Southwest and Central States. Waters with the higher amounts of dissolved solids have been found to be more productive, and more favorable for fish growth. Salinity and turbidity also vary widely and are important considerations for aquatic plants and animals.

Lake temperature is influenced by air temperature. Lakes at high altitudes such as those in the Rocky Mountains, or in the northern latitudes, are cold. Those at lower elevations and in the southern latitudes are warm. Shallower lakes warm more efficiently than deepwater lakes.

Some fish, such as trout and salmon, require cold water. Others such as bass, bluegill, and catfish, need a warm-water environment. Warm-water lakes with high natural fertility can produce 100 to 150 pounds of fish per surface acre a year; cold-water lakes with low fertility produce less than 20 pounds per acre.

Large Lake Problems

Reservoirs or large lakes are more difficult to manage than small ones. The manager has less opportunity to alter habitat quality and less control over conditions influencing fish populations. Often there is no practical opportunity for correcting management mistakes. For example, correcting an imbalance in the predator/prey relationship in a large reservoir can be costly and sometimes impossible. In a small pond or reservoir, the same problem can be resolved by removing the fish or draining the impoundment and restocking it. Water weeds are considerably harder to control in a large lake or reservoir.

Reservoirs constructed for more than one use—irrigation, fisheries, power generation, flood prevention, recreation, and storage for downstream release—present managers with a considerable challenge. Conflicts among the various uses must be resolved, often to the detriment of one or more of the uses. For example, releasing reservoir water for irrigating crops during bass and bluegill spawning periods can result in unsuccessful spawning and poor fishing several years later. The problem can be minimized by considering agriculture and fishery needs during the design of a project through adjustment of the reservoir release schedule and shaping of the shorelines.

People have affected the Nation's streams, rivers and lakes in many ways. To meet human needs, natural lakes have been greatly supplemented by thousands of manmade ponds and reservoirs.

A healthy fish population can be maintained in these water bodies by regulating the temperature and other water characteristics. Fishery biologists have learned how to manipulate stocks of fish for optimum production. Many reservoirs can be drawn down to control aquatic weeds and unwanted fish. The water level, which depends on watershed runoff, can be predicted so that fish stocking rates can be set scientifically.

Reducing Erosion

Conservation practices in many drainage areas have reduced the amounts of sediment and other pollutants reaching lakes and reservoirs. Practices for reducing soil erosion, installed by public agencies and by private landowners, benefit the Nation's streams, rivers, and lakes. Such practices include conservation tillage, proper forest harvest practices, terraces, proper grazing use, critical area treatment, sediment traps, vegetative filter strips, and stripcropping. Stream corridor management is being promoted, particularly in the West, as a means of enhancing fish and wildlife habitat and improving channel stability.

Thus, in many areas we are learning to live in closer harmony with the environment. However, excessive nutrients washed from the land have shortened the lives of many lakes and reservoirs by causing overproduction of plant and animal life. This overproduction makes the lakes unfit for fish and speeds up the filling-in process.

Acid rain caused by industrial air pollution has reduced the productivity of many lakes, particularly in the Northeast. Sediment from poorly managed agricultural land, logging activities, mining, and urban development has smothered life on many stream and lake bottoms. Insufficiently treated industrial and municipal wastes have been allowed to pollute our streams, lakes, and reservoirs. Carelessness with pesticides has resulted in fish kills.

Poor land management practices also degrade streams by smothering fish eggs and aquatic insects with sediment, changing the stream bottom from gravel to mud, causing the stream to change course—or otherwise altering the channel's physical characteristics, changing cold-water streams to warm-water streams, and altering the seasonal runoff pattern.

We don't have room here to provide more than an inkling of the many opportunities to alleviate problems faced by the Nation's streams, rivers, and lakes. Because of the complexity of river, stream, and lake systems, the advice of a number of specialists—hydrologists, geologists, biologists, and engineers—is needed to make the best management decisions. As our understanding grows, so will our ability to solve problems.

To understanding and ability, however, we must add a will to act. We can set this will in motion by remembering that our streams, rivers, and lakes are the veins of the earth, through which its life blood flows.

Colorado River: Life Stream of the West

By Jan van Schilfgaarde

The Colorado, one of the great rivers of our West, is many things to many people. To some, it is the river that cut the spectacular Grand Canyon. To others, it represents the source of water for irrigation and thus the basis for their livelihood. For others again, it is the source of their drinking water, of their domestic water supply. And to many Indians, it is their ancestral homeland.

The Colorado Basin is richly endowed with diverse natural resources. Yet much of the Basin suffers from a severe shortage of water. Extensive mineral resources intermingle with agricultural and grazing lands. The beautiful landscape creates tremendous recreational values: Hunting, fishing, hiking, and camping attract enthusiasts from nearby areas and afar.

Once unruly and subject to frequent floods, the river gained its name, Colorado, from the heavy silt load it always carried. Before construction of regulatory structures, the river passed half a million tons of sediment a day across the Mexican border. The rugged terrain through which it flows attests to the erosion that has taken place.

The Colorado is 1,440 miles long and drains a basin 244,000 square miles in an area that includes parts of seven States and a piece of Mexico. It rises in the high mountains of Colorado. After winding its way from the

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mountains through the canyons and past the deserts, what is left of it drains into the Gulf of California. What is left of it . . . most of its flow has been used up by that time and only a small brackish stream of drainage water remains.

The Colorado may well be the most regulated—and most litigated—river of all. The story of the Colorado is one of success as well as conflict, of engineering triumphs and human failings. In this story, we shall sketch some of these developments, emphasizing the role of agriculture.

Imperial Valley Role

As rivers go, the Colorado is not large. The average annual virgin flow—the flow one would see without man's interference—is variously estimated between 13 and 15 million acre-feet per year, depending on what period of record one believes. (An acre-foot is the volume represented by a depth of one foot spread over an area of one acre.) Starting in the 1850's, water for irrigation was taken from the river or its tributaries in various places in Utah, Colorado, Arizona, and California.

By the 1920's, the area irrigated in the Basin had grown to nearly 2 million acres, including some 400,000 acres in the Imperial Valley of California. This valley is a depression around 200 feet below sea level. Without water, it is nothing but a desert. Construction of a canal from the Colorado through Mexico

Tim McCabe

The Colorado River provides irrigation water to areas that would otherwise be desert. In California's Imperial Valley, fields such as this planted to cotton have thrived on water diverted from the Colorado since the early 1900's.

brought water, and the chance of development, to the Imperial Valley around 1900.

In those days, the river was still subject to severe floods as well as extended dry periods. In fact, in 1905, when a flood on the Gila River, an Arizona tributary, coincided with a flood crest on the main stem, the whole Colorado River was diverted into the irrigation canal leading to the Imperial Valley, forming the Salton Sea. The effort required to redirect the river to the ocean was enormous.

Incidents such as the filling of the Salton Sea illustrate the growing need for greater and more dependable supplies of water for agriculture, for cities and for hydropower, and the desire to reduce flooding. This need led to development of plans for constructing facilities such as the present Hoover Dam.

To get political agreement from those in the upstream regions to build storage for supply in the lower regions required long and arduous negotiations that provided some degree of assurance that future upstream demands would not be preopted by downstream development. It would take a book to detail the process. Let it suffice to state that, from a compact developed among the seven basin States in 1922, to legislation introduced in Congress in 1983, there has been a continuous stream of agreements, laws, court decisions and treaties from which has developed "the law of the river."

Treaty with Mexico

Among its most important provisions is the agreement that the Upper Basin (the four States above Lee's Ferry) and the Lower Basin (basically, Arizona, Nevada and California) each have a right to 7.5 million acre-feet per year, and each will share equally as needed to meet demands from Mexico. A treaty with Mexico allots 1.5 million acre-feet per year for use in that country. Thus, the total allocated by decree is 16.5 million acre-feet, substantially more than nature provides—and therein lies another tale.

Now we have Flaming Gorge, Glen Canyon, Navajo and Hoover Dams to regulate the river; Imperial Dam and the All American Canal to service the Imperial and Coachella Valleys; Parker Dam to facilitate diversion of water to Los Angeles; and Morales Dam to serve the Mexicali Valley south of the border. We generate power at several of these dam sites and even from some of the drops on the All American Canal.

We direct water across (through) the Rocky Mountains to help supply Coloradans on the east slope with water from the west side. We also have under construction the Central Arizona Project to deliver water to Phoenix, Tucson and points en route.

In other words, tremendous development has taken place and the Lower Basin States have essentially used up their allotment. When the Central Arizona Project goes into operation, California will have to reduce its rate of water use.

In the Upper Basin, development has not been as fast, but the changing energy picture suggests substantial development of coal and oil shale resources in the future. Such development will require additional water supplies and, potentially, may cause water quality problems. We shall return to one aspect of energy development later.

Irrigation Effects

Besides water quantity, we must concern ourselves with quality. When snowmelt water starts its path towards the oceans, its purity is proverbial. It soon picks up salt, however, from the rocks and soils it passes through—a dissolution effect.

As water is taken from the river for irrigation, the crops return part of it to the atmosphere by transpiration, but part is returned to the river as drainage. This drainage water carries a higher concentration of salts than the irrigation water. Because the plants transpire pure water, the salts are left behind in a smaller volume of water—a concentrating effect. As water flows through the soil and rocks, it may encounter (and displace) saline ground water—a displacement effect.

For much of their lengths, the Colorado and its tributaries flow through a landscape of marine origin that contains large quantities of salts. Hence, the subsurface water that enters the river often is quite saline. As development of the river took place, the volume of water remaining decreased while its salinity increased. In the 1970's, a typical level of salinity near Imperial Dam was 850 milligrams (mg) per liter. Predictions were that, after full river development, this level could increase to 1,200 or more.

An increase in salinity makes water less valuable for irrigation. Some crops are highly sensitive to salt; others are relatively tolerant. The range where adverse effects begin to be significant for agriculture depends on the particular makeup of the salts, the crop being grown, and the soil being irrigated. For example, sodium chloride is likely to harm soils and crops more than calcium carbonate. Above 900 mg per liter, however, there is a basis for serious concern.

Public health standards have set 500 mg per liter as a desirable upper limit for drinking water. Water high in calcium and bicarbonates leads to scaling and is especially harmful to plumbing fixtures, boilers and cooling towers. In the case of the Colorado River, a detailed economic study concluded that damage resulting from an increase of each mg per liter above 850 at Imperial Dam was $540,000 per year in 1983 dollars.

Close to 40 percent of the salt load in the river has been attributed to the effects of irrigation. Other sources of salt include a number of saline springs, industrial activity such as power generating plants, and drainage from the natural landscape.

Control Program Authorized

In all, salinity is now recognized as a problem equally as serious as water supply. This concern was put into focus when the Government of Mexico expressed serious concern about the ever-increasing salinity combined with smaller amounts of water that crossed the international border. For Mexico, the problem was greatly aggravated because a substantial amount of saline drainage water from the Wellton-Mohawk Irrigation District was returned to the river just above the border.

With the "Mexican problem" as the trigger, legislation was passed in 1974 that authorized a Colorada River Basin Salinity Control Program. The program was to make possible the delivery to Mexico of the same amount of water as before, but now with a lid on salinity tied closely to that of the salinity encountered by U.S. farmers in the Imperial Valley.

The seven Basin States, however, insisted the agreement not lead to a loss of water; this implied that the brackish Wellton-Mohawk drainage could not simply be bypassed to the ocean. They also demanded Federal support for a program of salinity control up and down the river, above and beyond the solution of the "Mexican problem."

Preliminary estimates indicated a whole range of actions that might be used to reduce salt in the river. They included a huge desalting plant near Yuma, Arizona, capping abandoned wells, and lining canals.

Help to Farmers

Of interest to agriculture was the observation that modernization of irrigation systems could well be the most cost effective approach in many instances. Replacing open ditches with lined canals or pipelines to reduce transit losses, land leveling to improve uniformity of water application, use of trickle irrigation in place of flood irrigation—these are some of the practices that enable closer control over irrigation water and thus reduce the salt returned to the river in drainage. In the Grand Valley of the Colorado, for example, it is expected that the annual salt contribution to the river can be reduced by more than 200,000 tons through irrigation improvements.

Federal technical assistance and cost sharing programs are currently in operation in areas of Arizona, Colorado and Utah. These programs play an integral part in working towards the goal of controlling river salinity. They also assist farmers and ranchers in making their operations more effective and, one hopes, more profitable. They help increase water use efficiency and reduce erosion, cut farm labor requirements, and boost crop yields. Rather than a single-purpose

Tim McCabe

In some agricultural areas adjacent to the Colorado River, salinity is recognized as a problem equally as serious as water supply. For example, this alfalfa crop has been severely damaged by salty irrigation water.

objective, the programs aid in improving natural resource use across the board.

By necessity, cooperation and coordination have always been paramount in development of water policy for the Colorado, even if by pleading one's case before a judge. The salinity program has broadened the level of coordination substantially. Local, state and Federal agencies constantly work together and with local residents in resolving problems.

Interesting questions arise frequently and the answers are not always perceived alike by all parties. Who benefits from salt load reduction in Grand Valley, and who pays for the improvements? Need one mitigate the loss of water for wildlife when lining a poorly constructed canal cuts off the seepage? Though differences in view occur and are often argued vigorously, most problems are resolved amicably. Progress, though slow, is being made steadily.

Modernization of irrigation systems may well be one of the best approaches to reducing salt levels in the Colorado. Here, the use of trickle irrigation in place of flood irrigation reduces runoff greatly and concentrates the water just around the crop.

Aquatrain and Coal

Diversity of the activities, the participants and the clientele is further illustrated by Aquatrain, a concept currently under study. Aquatrain would intercept saline waters from natural springs in Colorado and pipe this water to the Pacific Coast. The water would be used as the carrier to transport coal from the Colorado Basin, encapsuled in plastic, through the pipeline. At the coast, the brine could be discharged into the ocean and the coal either used or shipped overseas.

Tim McCabe

This scheme was proposed by industry after development of the technology. It cannot be implemented without close cooperation from State and Federal governments, but it would benefit all parties—public and private—in the Basin.

It would improve water quality by diverting saline water from the river. It would reduce the cost and make more competitive the coal waiting to be burned in Colorado and Wyoming. It would convert a liability—saline water—into an asset.

Some of the "most eligible" springs are found near Glenwood and Dotsero, Colo. Over 300,000 tons per year could be kept from entering the river in that section. However, the narrow canyon through which the river flows at Glenwood-Dotsero is one of the most scenic sections of the mountains; construction of a pipeline without insult to the environment is no small challenge.

Irrigation for Navajos

We could have described the development of water supplies on the San Juan River in New Mexico for irrigation of over 100,000 acres of land on the Navajo Indian Reservation. We could have discussed how such a development runs counter to traditional values of the Navajos, and how equitable development of the water resource without injury to the native population requires a degree of sensitivity and the skills of a most capable administrator.

Such a story would illustrate one more aspect of the balance that is being maintained as the resources of the Colorado Basin are put to use.

The housewife in Las Vegas doesn't worry about the Colorado when she loads her clothes washer, nor does the plumber in Los Angeles who replaces a prematurely tired water heater. The Colorado skier cares little about the water yield of the snowpack, and the Wyoming rancher doesn't have much interest in irrigation efficiency in Arizona. Yet the system on which all these people depend—the system that provides water to city dweller and farmer alike, that provides for the hunter, the hiker and the rancher as well—is a delicately balanced system that is stretched to the limit.

Through the dedicated efforts of people in various levels of government and without, the Colorado has been developed to an unparalleled level. With further dedication, continued cooperation and a fair measure of luck, the Colorado will serve us well into the future.

Further Reading

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The Catfish Story: Farmers, State Services Create New Industry

By Thomas L. Wellborn, Jr.

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In Mississippi a truck driver pulls a lever and watches 15,000 pounds of channel catfish slide down a chute into a large holding vat at a processing plant. In Georgia two men finish taking the last channel catfish out of a seine they have just pulled through a 1-acre pond. And in Idaho a farmer has just fed 10,000 pounds of channel catfish which are being raised in 60-foot-long dirt raceways.

Fish farming, or aquaculture, although more than 3,000 years old, is a relatively new industry in the United States. Trout, crawfish, and oysters, as well as several other species, are being farmed for food in the United States. But the really big success story is the production of channel catfish as a farm crop. Although the catfish industry is centered in the Mississippi Delta, catfish are farmed from California and Idaho to Georgia and South Carolina.

Work was done in the 1920's and 1930's in Kansas and Oklahoma by J.B. Dose, J.M. Murphee and others on how to produce channel catfish fingerlings. But it wasn't until the late 1950's in Arkansas that commercial production of channel catfish as a food crop really started. By 1966 Arkansas had 9,750 acres of channel catfish in production. Texas, Louisiana, Alabama, and Georgia also had acreage in catfish production.

The first pond built in Mississippi specifically for raising food-size channel catfish was a 40-acre pond built in Sharkey

Although fish farming, or aquaculture, is more than 3,000 years old, it is a relatively new industry in the United States. This "farmer" is harvesting channel catfish near Monticello, Ark.

County 1965 by W.T. "Billy" McKinney and Raymond Brown of Anguilla. Tom L. Reed III of Belzoni, Humphreys County, was the second farmer in Mississippi to go into catfish production with three 10-acre ponds built in 1966.

Mississippi, Arkansas Lead

From that start in 1965, the farm-raised channel catfish industry in Mississippi—the number one catfish-producing State—has grown to 62,289 acres in December 1982. The State also has two catfish feed mills and six major catfish processing plants. Arkansas is second in production of farm-raised channel catfish, with about 9,300 acres; Alabama third, with about 8,200 acres.

When Tommy B. Taylor came to Humphreys County, Mississippi, as county agent for the Mississippi Cooperative Extension Service in the fall of 1965, cotton was king. After Tom L. Reed III and others in Humphreys County started raising catfish, they requested Taylor's help. Through Taylor's efforts, State Extension administrators recognized the potential for fish farming in Mississippi and the need to provide educational programs and technical aid to this fledgling industry.

The Mississippi Cooperative Extension Service, with the help of the Mississippi Agricultural and Forestry Experiment Station, Mississippi State University, conducted the first educational workshop on water quality management for catfish farmers in the State in the fall of 1969, taught by the author.

The first annual Catfish Processors Workshop was organized and held at Mississippi State University in 1971. Since then the State Extension Service has held workshops, seminars, and demonstrations to train farmers in all aspects of catfish farming, from fingerling production to use of microcomputers for recordkeeping and management purposes.

Little was known about producing food-size channel catfish in 1965, so many developments in the early years were a result of trial and error by innovative catfish farmers. Farmers tried all sizes of ponds up to 120 acres.

20-Acre Pond Standard

In 1972 an experiment station analysis of the cost-size relationships in producing channel catfish in the Mississippi Delta showed that a pond built on 20 land acres (about 17.7 water acres) was best in terms of economics and management. Since then the "20-acre" pond has, for the most part, become the standard sized production unit in Mississippi.

The idea of raising channel catfish for food first occurred to "Billy" McKinney when he read an article in a farm publication. After talking it over with his neighbor, Raymond Brown, and with W.F. "Skinner" Anderson of Yazoo City, one of the early catfish fingerling producers in Mississippi, McKinney and Brown built a 40-acre catfish pond. They stocked it with 2,000 fin-

Acres of Catfish Ponds in Mississippi

	Water Acres in Production			
	Food Fish	*Fingerlings*	*Total*	*Percent Increase*
May 1977	15,182	1,969	17,151	-
Mar. 1979	22,541	2,171	24,712	44.1
Dec. 1980	36,437	3,932	40,369	63.4
Dec. 1981	50,688	5,249	55,937	38.6
Dec. 1982	56,191	6,098	62,289	11.4

gerlings per acre in the early summer of 1965.

With the help of Gear Research personnel from the U.S. Fish and Wildlife Service Farming Experiment Station, Stuttgart, Ark., they harvested their first crop of farm-raised channel catfish in January 1966. They sold part of their crop, about 10,000 pounds of catfish, to Howard Heck, Kaw Valley Fish Farms, Lawrence, Kans., who processed the fish for sale. The catfish were transported to Kansas by a minnow farmer who had a large fish hauling truck.

For the next several years almost all the catfish produced by Mississippi catfish farmers were sold to live haulers.

Stocking rates in the first 6 to 8 years of the catfish industry in Mississippi stayed at about 1,500 to 2,500 fingerlings per acre. Ponds were usually stocked in late winter or early spring. Catfish were fed through the summer, the ponds drained and all the catfish harvested in late summer or fall.

Problems Develop

By the late 1960's problems began to develop in selling farm-raised catfish because of increased production, lack of processing facilities, lack of marketing efforts and availability of catfish only in fall and winter. Although some catfish processing plants were already operating in other States, the first catfish processing plant in Mississippi was organized and built in 1968 in Morgan City.

Lack of processing and suitable market outlets and a sporadic supply of catfish continued to plague the industry until about 1974. A change in production methods initiated by Paul Smith, Yazoo City, enabled farmers to supply catfish throughout the year. That substantially improved market potential of this new crop.

Because of this change it can be said that farm-raised catfish became an "industry" in 1974. The change from clean-cropping—harvesting all catfish in the pond at one time—to multiple harvesting or topping throughout the year had a significant impact on the industry.

Production in the early years ranged from about 1,500 to as much as 2,300 pounds per acre.

Pounds of Farm-Raised Channel Catfish Sold to Processors

Year	*Round Weight Processed in Millions of Pounds*	*Percent Yearly Increase*
1975	16.1	—
1976	18.9	17.4
1977	22.1	16.9
1978	30.2	36.7
1979	40.6	34.4
1980	46.5	14.5
1981	60.1	29.2
1982	99.4	65.4

From *Catfish Processors Report*, Crop Reporting Board, USDA.

At that time catfish farmers were not able to feed more than 30 pounds of feed per acre a day without causing water quality problems due to lack of suitable management techniques. Another problem that helped hold down production in the early years was a lack of high quality catfish feed.

Farmers Lead Way

A meeting at Silver City in 1972 discussed forming a cooperative to build a catfish feed mill. As a result the Producers Feed Mill was built in Isola and started producing catfish feed of uniformly high quality in 1974. Feed was formulated according to the best knowledge available at that time, and its quality became quickly apparent through improved growth and decreased feed conversion rates.

Probably no other single factor had a greater impact on the catfish industry in Mississippi than the building of this catfish feed mill wholely owned and controlled by catfish farmers, although managed by MFC Services. Catfish farmers were now assured of having high quality feed available when needed.

In 1969 a fisheries scientist chided catfish farmers for trying and adopting new ideas as soon as they were conceived, rather than waiting for research and experimental testing programs to prove their value. Yet catfish farmers led the way in developing new techniques that allowed them to produce catfish year-round and at rates considered impossible or uneconomical by researchers just a few years previously.

Tim McCabe

Productivity is up in Mississippi, thanks to development of new techniques in raising catfish. Production increased from 1,500 pounds per acre in the late 1960's to about 3,500 pounds annually in 1982. Many farmers are harvesting well over 5,000 pounds per acre.

Production per acre in Mississippi has increased from about 1,500 pounds per acre in the late 1960's to about 3,500 pounds annually in 1982, with many farmers getting well over 5,000 pounds per acre. These rates have been achieved by a good program of monitoring ponds for oxygen, un-ionized ammonia, and nitrite, and taking prompt corrective measures to prevent water quality problems from developing; and by increased stocking rates and using multiple harvesting rather than clean-cropping.

Producers Form Co-op

In Mississippi the acreage in production of channel catfish increased between 1977 and 1982 from 17,171 acres to 62,289. This rise in acreage and in production per acre created marketing problems for catfish farmers, starting in mid-1981 and lasting through 1982. Existing processing plants were not able to develop new markets fast enough to take care of the increased poundage of channel catfish being raised by Mississippi catfish farmers.

A number of catfish farmers realized in 1979 there would soon be a problem of overproduction and formed a corporation, with features of a cooperative, to build a new farmer-owned catfish processing plant. The plant, with a capacity of 60,000 pounds per day, was built in Indianola and went into production in April 1981. Delta Catfish Processors, Inc. now has a capacity to process 250,000 pounds of catfish per day.

All the catfish processing plants in the United States have done an excellent job in developing new markets for farm-raised channel catfish. In the past 8 years the poundage of farm-raised catfish processed has increased from 16.1 million pounds in 1975 to 99.4 million pounds in 1982.

Catfish farmers have proved that raising high quality animal protein in water is not only feasible in the United States but profitable. Mississippi catfish farmers produced about 140 million pounds of food-sized channel catfish in 1982. At a 60 percent dress-out this amounts to 84 million pounds of low calorie, low fat, and high quality animal protein available for consumption by American consumers.

Catfish farming is a success story, particularly in Mississippi. It has had a tremendous economic impact on a whole region, the Mississippi Delta, which comprises the northwest section of the State. The catfish industry in the delta employs directly more than 3,000 people on catfish farms, in catfish feed mills and in processing plants, with an annual payroll exceeding $30.8 million. This does not include all the people employed in support industries that supply the equipment and chemicals needed by the catfish farming industry.

Why Mississippi?

The catfish farming industry concentrated in Mississippi for several reasons:

1) Flat land that holds water well and abundant ground water that can be pumped at reasonable cost,

2) The support that Mississippi State University provided the catfish industry through Extension education programs since 1969 which have trained farmers in all aspects of catfish farming, the Extension disease diagnostic services for fish farmers, and the research programs that apply basic research findings to actual commercial fish

Tim McCabe

Processing plants, such as this one in Arkansas, helped bring nearly 100 million pounds of farm-raised catfish to market in 1982—up from 16 million pounds in 1975.

farms, feed mills, and processing plants,

3) Catfish farming has been profitable, and

4) Probably the most important reason, hard-working farmers who weren't afraid to try something new and had the faith and determination to see a fledgling industry through difficult times.

"Billy" McKinney—who along with Tom Reed and Raymond Brown started the farm-raised catfish industry in Mississippi—now raises channel catfish on 460 acres in Sharkey County. Brown, McKinney's partner in building the first catfish pond, now farms 600 acres of catfish in the county. Reed, the second catfish farmer in the State, now produces catfish on 1,640 acres in Humphreys and Yazoo Counties.

25,000 at Catfish Festival

More than 25,000 people from at least 25 States attended the Eighth Annual World Catfish Festival in Belzoni (Humphreys County) on April 9, 1983. This gives an idea of the popularity of channel catfish and what has been done through efforts of the catfish industry and the Mississippi Extension Service to promote and market this new farm crop. In 1982 in Humphreys County, where cotton was king in 1964, catfish generated $52 million in farm income, while cotton generated only $30 million in farm income.

Not only has catfish farming become a big business producing high quality protein for consumption, but raising channel catfish in farm ponds for recreation has also caught the fancy of tens of thousands of people throughout the country.

Ponds are being stocked at the rate of 50 to 300 per acre in combination with largemouth bass and bluegill. And as many as 1,500 channel catfish per acre are being stocked for a single species fishery by many ponds that owners use not only for recreation but to provide food for their families.

Besides channel catfish, other aquatic species are producing high quality protein for consumption by the American consumer. Crawfish are being raised in Louisiana (about 80,000 acres), Texas (about 5,000 acres), Arkansas (about 500 acres), and Mississippi (about 1,000 acres). Production averages about 600 to 800 pounds per acre annually industry-wide. Most of the crawfish produced is consumed locally.

Trout are being raised in 14 States on 263 farms. Idaho is the largest producer of trout, with 36.6 million pounds raised from September 1980 to August 1981. Total trout production during that time was 42.9 million pounds.

Annual production of aquatic species raised in the United States for human consumption is estimated at about 300 million pounds. This is a significant amount of protein produced from our aquatic resources, and it is certain that production of aquatic animals for human consumption in the United States will continue to increase in the future.

Anyone interested in starting an aquacultural enterprise should obtain all the information available on that particular enterprise, particularly with respect to marketing, distribution, site selection, quantity and quality of water available, and cost of production. Information about aquaculture opportunities can be obtained through the local Cooperative Extension Agent in each county.

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Seagoing Migrants: Our Northwestern Salmon and Trout

By William R. Meehan

Along the West Coast of North America, from California to Alaska, the many rivers and streams that empty into the Pacific Ocean are habitat for a unique and valuable resource—the famous runs of seagoing salmon and trout, or anadromous salmonids.

Eight major species of anadromous salmonids are produced in this region: five salmon—chinook (king), coho (silver), sockeye (red), chum (dog), and pink (humpback); two trout—steelhead and cutthroat; and one char—Dolly Varden. Most species live 2 to 6 years. In that time, some fish can attain 30 pounds or more.

These migratory species have evolved a complex reproductive process that requires two primary habitats: freshwater streams and the Pacific Ocean.

Anadromous fish generally reproduce in streams flowing from forested watersheds, spend the first part of their lives in fresh water, then migrate to the ocean where they spend most of their lives. When they finally return to fresh water to spawn, a strong homing instinct leads them back to the stream of their birth, often to the same spawning riffle where they began their life.

Some anadromous fish travel hundreds or even thousands of miles and spend much of their life migrating from freshwater tributaries to salt water and back again.

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William R. Meehan

The famous runs of seagoing salmon and trout—or anadromous salmonids—occur in rivers and streams that empty into the Pacific Ocean. This anadromous salmonid stream is in western rangeland.

Chinook Saga

For example, young chinook salmon make a journey of 1,000 miles in a pilgrimage from the tributaries of the Salmon River in Idaho down the Columbia River to the sea. The return trip for the adult salmon is a difficult one that leaves the fish spent and exhausted from the long upstream journey. In the headwaters, the fish spawn and die, their one-time mating ritual a vital link to survival of the species.

To early inhabitants of the Pacific Coast, the abundant salmon runs were an invaluable resource. Today the fish are still important for recreational and commercial fishing, and in some cases for subsistence. But over the years the great runs of seagoing salmon and trout have declined dramatically.

No single factor can be blamed for depletion of the anadromous fish stocks. Excessive harvest of fish by commercial and sport interests and destruction of habitat are certainly major contributors.

Numerous hydroelectric dams have been constructed since the 1930's on many of the major anadromous fish rivers. These, along with many irrigation dams and diversions, have greatly hampered fish migration. Pollution from industrial development has also reduced the anadromous fish resource.

No one knows how much each of these factors has contributed to decline of the salmon runs, but we do know that the resource is an exceptional heritage and worth protecting. Two objectives of management are essential: 1) Maintaining adequate freshwater habitat, and 2) Limiting the number of fish caught.

Habitat is especially important in resource management. While the harvest of fish can be and is being regulated, habitat management is a more difficult task.

In general, the environmental requirements of all species of anadromous salmonids are similar and greatly influence the success and abundance of the fish. Three general types of freshwater habitat are important:

1) Spawning habitats where the adult fish deposit and fertilize the eggs which then incubate until the fry hatch,

2) Rearing habitats where the young fish feed and grow until they are ready to begin their downstream migration to the sea, and

3) Migration habitats that the young fish use to reach the ocean and the adults use to return from the sea to the spawning areas.

When specific requirements of these habitats are not met, fish production declines.

Spawning Habitat

The basic requirements of good spawning habitat are cool, well-oxygenated water, and a stable, highly permeable gravel bed. The maturing fish enter their "home" stream at specific times throughout the year and, depending upon the species, may spawn from early summer to early spring.

The female chooses a site and digs a spawning nest or "redd." The redd site is in a gravel bed that either has little fine sediment or contains loose sediment that can be dislodged and washed downstream during the digging process.

As the eggs are deposited into the redd, they are simultaneously fertilized by one to several males. The eggs are then buried by the female to a depth of about 6 to 16 inches, depending upon the species.

The fertilized eggs are termed "embryos" and for the next month or two are extremely sensitive to any movement or shock. When the embryos hatch, they are called "alevins" and are able to move about within the spaces between gravel particles. When the alevins have absorbed their yolk sacs they emerge from the gravel and are termed "fry."

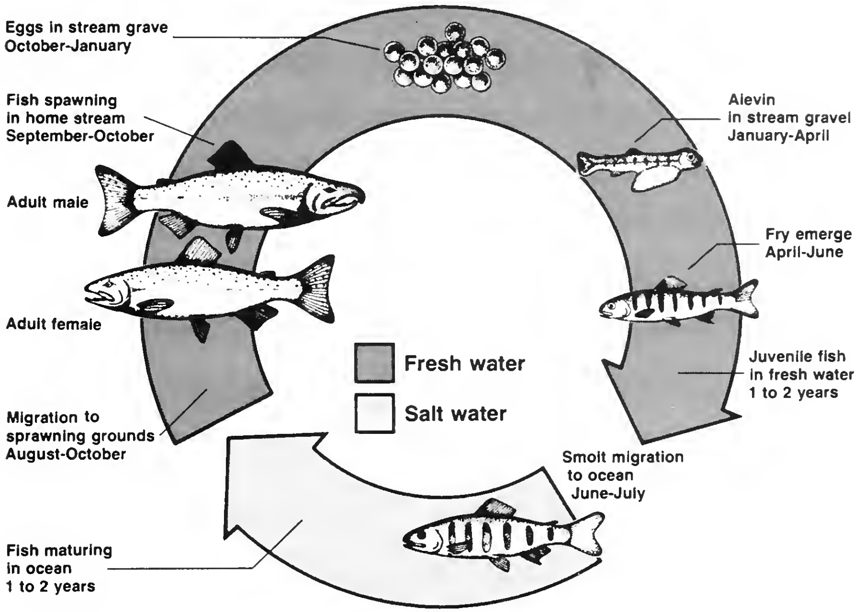
This entire process of development may take 2 to 10 months, depending on the species and water temperatures involved.

Rearing Needs

Once the fry emerge from the gravel, their requirements for rearing habitat and their length of residency in fresh water vary by species.

Following emergence, most fry of pink and chum salmon immediately migrate downstream to the ocean (a few remain briefly

Typical Life Cycle of Anadromous Salmonids



in the estuary) where they grow to maturity. Sockeye salmon fry follow a similar pattern, except they migrate to a lake within the spawning system where they may remain one to three years before migrating to the ocean.

A physiological process occurs in a young anadromous salmonid to prepare it for the difference in physical and chemical properties between fresh and salt water. When this adaptation occurs and the migration to sea begins, the young migrant is called a "smolt."

Coho salmon fry remain in the stream system and use small tributaries, beaver ponds, backwater sloughs, and other areas away from main channels for one to three years before becoming smolts.

Chinook salmon fry generally live in pools of larger river systems (in some instances they use smaller streams) for three months to two years before migrating to the sea.

Fry of steelhead and anadromous cutthroat trout require the faster moving waters of small tributaries and streams where they live two to four years before entering salt water. Dolly Varden char have a life history similar to the steelhead's, except that after entering salt water some individuals return to lakes where they spend the winter.

Living Room

Basic factors important to quality of the rearing habitat for all salmonids are food, space or "living room" (including resting or escape cover), and water quality—particularly temperature. One characteristic of living space is visual isolation that may be provided by large organic debris in the stream. In addition, shape of the stream channel and volume of water contribute to living space and are directly influenced by debris.

Woody debris also forms an important base for transfer of energy through the food chain from bacteria and other microorganisms, algae, aquatic insects, and ultimately to the fish. Spatial distribution of trout, char, and juvenile salmon within a stream may be affected by competition for food.

Although spawning and rearing habitats are the critical freshwater components of the life history of anadromous salmonids, migration habitat is also important. Without access to the ocean and back to the spawning streams, the fish could not survive.

Hazards From Dams

Many salmonids—both juveniles and adults—are lost as a direct result of dams built for generating hydroelectric power, impounding irrigation water, and flood control. A good example of this is the series of dams on the Columbia River and its major tributaries.

Physical barriers to migration are one problem, but more subtle problems that produce stress in the migrating fish are equally important. Many migrants bound for the sea die as they pass through the turbines of hydroelectric dams. Others die or suffer stress in the plunge pools below the dams where the sudden change in pressure alters the normal composition of dissolved gases in the water.

Most of the problems faced by returning adults are related to the energy expended bypassing the system of dams. This dramatically increases stress on the fish from an already difficult migration.

Less spectacular but important migration barriers are accumulations of organic or inorganic debris. Logjams and rockslides may form impassable barriers.

Water velocity and thermal barriers can also impede fish migration. Extremely high water temperatures can cause adult fish to pause days or even weeks during their upstream migration until the water cools to a temperature acceptable to the fish. In general, ideal migration habitat is a river or stream free of barriers, with adequate pools or other resting places giving protective cover, and having enough water flow to allow easy passage.

Depend on Watersheds

The anadromous fisheries resources of western North America depend in large part on the forested watersheds of this re-

K V. Koski

Anadromous fisheries resources of western North America depend in large part on forested watersheds of that region. This anadromous salmonid stream is in western old-growth forest.

gion. Watersheds control the physical and chemical makeup of the streams and lakes that drain them. Geology of the watershed, its climate, vegetation, soils, topography, and hydrology influence aquatic components and how they function as habitat for salmon and trout.

Anadromous fish are only one of many resources found in these watersheds. Others are timber, minerals, and the water itself.

Alteration of watershed characteristics that directly affect water quantity and quality, or indirectly affect aquatic habitat, will affect fisheries productivity. Logging, road construction, livestock grazing, mining, water development projects, urbanization, agriculture, and recreation can all affect the quality of anadromous fish habitat.

Streamside or "riparian" vegetation strongly influences the quality of habitat for anadromous fish. It provides shade and prevents extreme changes in water temperature. Roots of trees and shrubs help to stabilize streambanks and provide cover in the form of overhanging banks.

Riparian vegetation helps to prevent sediment from entering streams and provides organic material that forms the base of the food chain for aquatic insects and fish. The addition of large pieces of wood as trees fall across or into a stream provides cover and helps to create and maintain pools. Removal of streamside vegetation by logging, road construction, and other activities can reduce the quality of fish habitat.

Sediment Problems

Sediment enters streams through natural processes such as landslides and erosion. Human activities can, and often do, accelerate these processes. When too much fine sediment enters a stream, habitats for both spawning and rearing suffer.

Sediment can smother eggs, inhibit emergence of fry from the redd area to the streambed surface, and clog the gills of juvenile fish, inhibiting respiration. Heavy sedimentation can also decrease the number of aquatic insects and, consequently, affect the growth and condition of juvenile fish that feed on them.

Major land-use activities in the western United States that affect anadromous fish habitat are timber harvesting and livestock grazing. Road construction associated with logging has the greatest potential for adding sediment to stream channels.

The most common logging system used in western forests is clearcutting; that is, all the timber in a given area is cut. The size of clearcuttings has decreased over the years as problems associated with large clearcuttings have been identified. For example, in southeast Alaska it was not uncommon in the 1950's and 1960's to clearcut several hundred acres to more than a thousand. Today, clearcuttings on National Forests are generally limited to less than 100 acres.

In the early days of clearcutting, trees were often cut to the banks of streams, essentially leaving the streams with no canopy of streamside vegetation. Today, buffer strips varying from a few feet to several hundred feet are usually left along streambanks.

Blowdown of Trees

A problem associated with buffer strips is the potential within them for blowdown of trees. When forest edges are exposed, the trees become more susceptible to wind, and retained trees may blow down during severe windstorms.

Research is being done to predict the potential for blowdown in buffer strips of varying width and configuration. The result of this research may be buffer strips that are more "wind firm."

Another hypothesis being studied is that a buffer strip that partially or entirely blows down may in some cases be more acceptable, in terms of its contribution to cover and nutrients in the stream, than not leaving the strip at all.

In the West, livestock regularly use valley bottoms adjacent to streams for grazing and resting. Unrestricted livestock use along streams can result in overgrazing of riparian vegetation. This in turn can cause increased water runoff and soil erosion, and ultimately an increase of sediment deposits in stream channels.

Destruction of the streambanks by trampling can cause the loss of undercut banks, which are a prime rearing habitat of anadromous salmonids, and increased sediment in the gravels used for spawning.

Various grazing systems have been used in recent years to control livestock use of the streamside zone throughout the grazing season. Success of these systems in protecting stream habitat is yet to be demonstrated.

The surest method of protecting fish habitat is to fence the streamside zone against livestock use and provide alternate sources of water, such as stock ponds, within the pastures. Cost of fencing, however, is very high and usually prohibitive.

Work on Habitat

Several Federal and state agencies responsible for managing public lands and fishery resources in western North America, as well as various colleges and universities, are developing ways to protect and improve anadromous fish habitat that are compatible with other land-use activities. For example, the anadromous fish habitat program of the Forest Service recognizes numerous ways to improve passage for migrating adult and juvenile salmon and to restore and improve spawning and rearing habitats.

Research includes learning the habitat requirements of the different species of anadromous salmonids. Here, biologists are electrofishing to evaluate habitat use by salmonids.

William R. Meehan

Research conducted by the Forest Service through its Forest and Range Experiment Stations in the West is focused on:

1) Learning habitat requirements of the different species of anadromous salmonids,

2) Identifying effects of various land-use activities on fish habitat, and

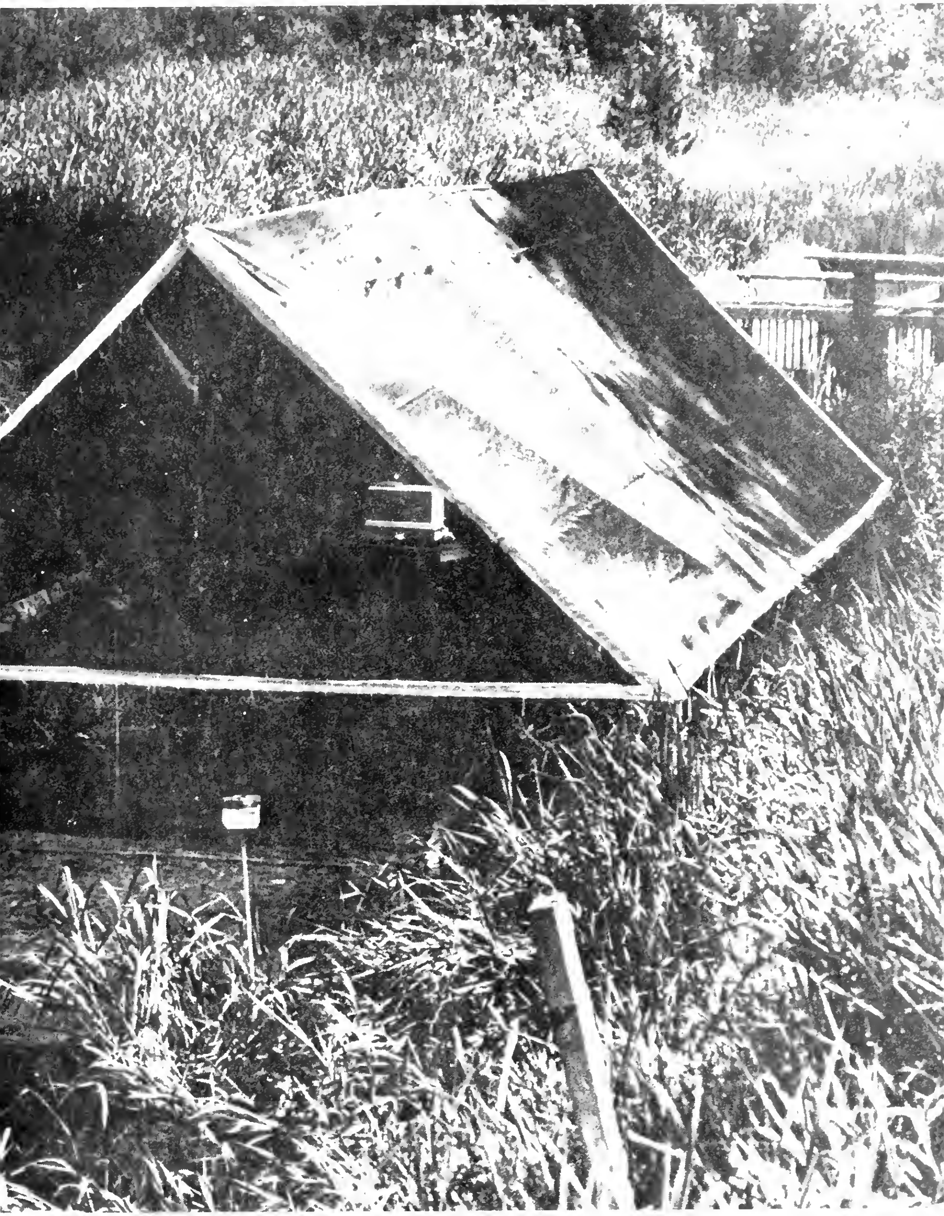
3) Developing methods to restore and improve habitat that has been degraded or that is not producing fish to its full potential.

Replanting streamside areas is one way to minimize the effects of improper logging or grazing practices. Researchers are studying trees and shrubs to identify those that can benefit fish habitat in the shortest time.

Facilities are being designed and installed to provide access for fish to spawning and rearing areas that have been blocked by dams, falls, irrigation systems, or debris accumulations. Stream improvement structures that provide cover, create pools, and channel waterflow are also being designed and installed.

Our anadromous fisheries are an important resource that must be protected and improved. Inappropriate uses of the watersheds of western North America have degraded fish habitat in the past. But enlightened management, based on adequate and appropriate research, can assure the continued runs of seagoing salmon and trout for future generations.

William R. Meehan



Shade is important for anadromous fish—so important that researchers have created it here to test its effects on the distribution of young salmonids. Normally, shade is provided by streamside vegetation and extreme changes in water temperature are prevented.

Upper Great Lakes Sportfishery Establishment Has Spectacular Impact

By Howard Tanner, Mercer Patriarche, and William Mullendore

Howard Tanner is former Director, Michigan Department of Natural Resources, Lansing.

Mercer Patriarche and William Mullendore are retired from the Michigan Department of Natural Resources.

Successful rehabilitation of the Upper Great Lakes fishery resources has been heralded as North America's most outstanding fish management achievement. Certainly it has been the most spectacular in terms of both public enthusiasm and magnitude of results. In the short span of 15 years, these vast inland seas—the world's largest body of freshwater by far—have been converted from a biological bad dream to an angler's paradise.

The Upper Great Lakes fisheries today contribute more than half a billion dollars annually to the economy of Michigan alone. More than half a million persons participate by spending more than 20 million angler-days a year fishing on the lakes. About one Michigan resident among three is an angler.

Other States bordering on the Great Lakes have followed Michigan's example and developed similar programs on a scale consistent with their geographical shares of the lakes.

Today there is no better freshwater sportfishery anywhere in the world available at relatively low travel cost to large numbers of people. More than 50 million people live within a day's automobile drive of the Great Lakes.

The five Great Lakes constitute a tremendous, valuable and precious resource of 94,710 square miles shared by the United States and Canada.

Upper Lakes Story

The management program to be described here applies to Lakes Superior, Michigan and Huron. Of these three Upper Great Lakes, well over 40 percent—some 38,000 square miles—are within Michigan's boundaries. The lakes are clear, cold and deep.

Lake Superior is a very large, cold, clear, and generally unproductive body of water. Lakes Michigan and Huron have "aged" significantly because of enrichment traceable to sewage contamination and agricultural land runoff; however, they are still clear and only moderately productive. The aging process in both has been dramatically slowed by improved wastewater treatment technology and facilities, and by better land use practices.

Historically, fish stocks of the Upper Great Lakes were used almost entirely for commercial purposes. The limited amount of sportfishing that did occur was concentrated in a few sheltered bays and estuaries. The sportfishery was so relatively unimportant that until 1970 no license was required to fish for sport in Michigan waters of the Great Lakes.

Commercial fishing can be said to have begun on a significant scale in the Upper Great Lakes about 1800, as European settlement created a demand for fish as food. Commercial fishing with increasing inputs of energy and more efficient gear devastated most Great Lakes fish stocks in little more than a century. The fact that there was virtually no regulation of the fishery during that period served to hasten the demise.

Long before the rehabilitation program was undertaken, several introductions of exotic species had occurred, some by accident, others by intent. The two most important were accidental and both had far-reaching consequences.

Sea Lamprey Comes In

Construction of a system of canals to bypass the natural barrier to shipping imposed by Niagara Falls at the lower end of Lake Erie opened the way to invasion of the Upper Great Lakes by marine species capable of adapting to a freshwater environment.

First to come in was the sea lamprey, a parasitic predator on salmonids, (salmon, trout) and other soft-skinned species. In less than three decades, lampreys had all but wiped out the deepwater predators in all three lakes.

Pressure added by sea lamprey predation to diminishing stocks of lake trout already being overharvested by commercial fishermen resulted in elimination of the species from both Lakes Huron and Michigan. Only in Lake Superior did a small population survive.

The alewife came close on the heels of the sea lamprey. Another marine species, the alewife was first noted in Lake Huron in 1933; by 1953 it was present in

Lake Superior. The virtual absence of predators caused by feeding habits of the sea lamprey and the relentless commercial fishery created a biological void. This small, prolific, plankton-eating fish exploded into superabundance. By 1964 it comprised as much as 90 percent of the fish population, by weight, in Lakes Huron and Michigan.

In 1964, a complex combination of negative and positive biological, economic, political and social factors were present which may be very briefly summarized as follows:

1) The Upper Great Lakes were a virtual "water wasteland," replete with billions of pounds of alewives which had virtually no economic value. The long-established commercial fishery was dying a slow but certain death. No realistic sportfishery existed anywhere in the Upper Great Lakes. Commercial fishing interests remained firmly in control of fishery management.

2) Michigan sport fishermen were growing restless. Interest in traditional inland fishing had declined as more and more people put pressure on the limited inland resource. Sport fishing license sales had dropped slowly but steadily. A study showed Michigan residents were going to other States and Canada to fish

3) An especially important socio-economic problem had been created by the buildup of alewife populations in the Upper Great Lakes. These short-lived little fish died by the millions every spring, following spawning, and washed ashore. There they decayed and created a nuisance of almost unbelievable proportions. The tourist industry—Michigan's second-largest after manufacturing—suffered enormous losses, estimated in hundreds of millions of dollars annually. It was impossible to deal with the sheer volume of dead alewives

4) There were a few factors on the positive side. In 1954, the United States and Canada had joined to wage war against the sea lamprey, forming an international Great Lakes Commission and giving it a mandate to control lampreys so that lake trout could be restored. A second positive factor was public receptivity to ideas for change in the existing sorry situation of the Upper Great Lakes. Both sport and commercial fishermen wanted something better. They were ready to listen and be persuaded.

Preliminary thinking toward the decision which in 1964 resulted in launching a massive fisheries rehabilitation program in the Upper Great Lakes centered on the magnitude of the water resource itself. No other government entity anywhere in the world has under its jurisdiction such a large expanse of fresh water.

'Can't Lose' Prospect

Here indeed was a challenge. That the Upper Great Lakes fisheries were in an all but unproductive condition, insofar as valuable economic and recreational returns were concerned, served to magnify both the challenge

Michigan Dept of Natural Resources

Twenty years ago, the alewife—a short-lived fish of virtually no commercial value—comprised as much as 90 percent of the fish population in Lakes Huron and Michigan. Every spring, following spawning, these fish died by the millions, creating a nuisance of almost unbelievable proportions.

and the urgency to meet it. Past mistakes and failures could be utilized as a springboard; any change for the better would be welcome. The overall situation came as close to being a "can't lose" prospect as any fishery manager is likely to encounter. The political climate definitely favored action of some kind.

The question, of course, was what specific action or actions should be taken. At that point biological considerations came into play. Two were of special significance: 1) The sea lamprey control program had progressed to a stage where ultimate success could be confidently predicted, and 2) There existed an unbelievable abundance of forage fish, available to predators, in the Upper Great Lakes.

Before any choice could be made on which particular predator(s) might be introduced to take advantage of the forage abundance, a key decision had to be reached on how the Upper Great Lakes fisheries were to be managed in the future. The alternatives were clear: management could be concentrated upon either a commercial fishery or a sportfishery.

Historical precedent definitely favored commercial fishing, the traditional prime use of the Great Lakes fishery. To continue that pattern would have been the easy and convenient way to go.

The potential for a commercial fishery, however successful, was limited. Anything better than the peak production achieved during the early 1900's seemed unattainable.

Spinoffs from Sport

Sportfishing, on the other hand, was perceived to have potential economic and social benefits of immense importance.

A sportfishery could generate a manifold, greater economic value than the commercial fishery ever had produced, or ever could. It was envisioned that a productive Upper Great Lakes sportfishery would have many spinoff economic benefits.

An outstanding sportfishery in the Upper Great Lakes would help significantly to fulfill the recreational needs of the 50 million people who live within a day's automobile drive of some segment of the shoreline. And it would, incidentally but very importantly, help to clean up the problem of dead alewives on beaches and thus earn further political gains.

Thus the decision to favor the sportfishery in allocation of Great Lakes fish stocks was a good conservation decision, embracing the age-old precepts of wise use of a resource for the greatest good of the largest number of people over the longest period of time, without damage to the resource itself.

Michigan fish managers next turned attention toward particular species to be introduced. No predators were naturally present which could be reasonably expected to meet requirements of the situation. The lakes were so far out of biological balance, as the result of earlier human-caused upsets, that only further intervention by people could have any hope of restoring that balance within a time frame of several years. Once having decided to act, the public and their political leaders typically want fast—and, in some cases, virtually instant—results, and they did in this instance.

Salmon Considered

Even though the lamprey control program had apparently opened the way to restore lake trout, that objective by itself did not meet requirements of the situation and fulfill the opportunity offered.

There was reason to doubt whether lake trout could alone overcome the alewife preponderance and restore a satisfactory predator-prey balance in the Upper Great Lakes.

Obviously some other predator besides lake trout was required, one that would feed heavily on alewives. A species with a short life cycle characterized by rapid growth suggested itself. The desired combination of characteristics pointed to Pacific salmon as a logical choice for trial. In general, all species of Pacific salmon feed heavily and grow rapidly. Several species were studied, including:

Kokanee salmon, a variant of the sockeye salmon adapted to a freshwater life cycle.

Coho (silver) salmon, prized by anglers for its exciting fighting qualities when hooked.

Chinook (king) salmon, noted for its exceptionally large size and good sporting attributes.

A discouraging fact was that earlier efforts to introduce both coho and chinook into the Upper Great Lakes had failed. Available records showed that over 13 million coho and chinook fry had been released into the Great Lakes over the years.

Freshwater Failures

So in 1964 the probability of success in introducing coho and chinook into the Great Lakes was by no means assured. Traditional thinking among fisheries biologists was that both had to migrate to saltwater as part of their life cycle. Attempts to establish coho and chinook in freshwater situations had by and large failed.

However, there were some documented exceptions, and the literature also contained isolated, but significant, examples of discrete stocks which had adapted to life in natural freshwater.

After careful consideration, the decision was made to attempt introduction of both coho and chinook into the Upper Great Lakes.

The coho was selected for the first effort, primarily because of its short three-year life cycle as compared to the chinook's five-year span. Success or failure could be demonstrated in less time. Moreover, coho eggs were immediately available, and the technology for hatchery culture somewhat better known.

The coho was in every way a highly desirable species for the purpose of Great Lakes rehabilitation: Heavy feeding, fast growing, easy to catch on sporting tackle, hard-fighting, good on the table. All things considered, it rated slightly ahead of the chinook in priority. Not least important, coho at that time made up 80 percent of the sport catch of salmon on the West Coast.

Pacific Know-How

For many years before 1964, West Coast States—principally Washington and Oregon—had been rearing and releasing coho and chinook salmon to replace and augment natural reproduction lost by construction of hydroelectric dams which blocked access to upstream spawning grounds.

As time went on, West Coast biologists learned the techniques needed to sustain a successful salmon fishery through hatchery culture. An important breakthrough was made in 1959 with formulation of the Oregon Moist Pellet, a diet which met nutritional needs of young salmon and made possible growth and release of a truly vigorous smolt (young salmon matured for saltwater entry).

Also learned was the necessity for smolts to be grown to the right size, and planted at the right time in the right places. Any deviation doomed the effort.

This knowledge had been painfully acquired through trial and error. We, in Michigan, relied heavily upon this experience in the early phases of Great Lakes rehabilitation.

A formal request was made to the States of Oregon, Washington and Alaska for coho eggs. The first one million eyed coho eggs came from Oregon in 1964, and later additional coho and chinook eggs were received from Washington and Alaska.

In the spring of 1966, a total of 850,000 yearling coho smolts successfully reared in Michigan hatcheries from the million eyed eggs supplied by Oregon were released in three separate plants, two in Lake Michigan and one in Lake Superior. That fall about 8,000 fish returned as "jacks"—precocious males which mature a year ahead of normal—along with 50 to 60 entirely unexpected ripe females (females with eggs).

Jacks Thrive

These early developing fish weighed up to eight pounds after spending just six months in open waters of the Great Lakes. Pacific Coast jacks normally weigh 1½ to 2 pounds; thus the size of individual fish in this first return from the Michigan stocking effort gave reason for great enthusiasm. Obviously, the forage base was being utilized.

In the spring of 1967, nearly 2 million coho and 836,000 chinook salmon smolts were stocked. Chinooks have an advantage in hatchery culture in that they require a much shorter time to grow to smolting size than do coho.

During their four years of life in open water, chinook grow considerably larger than coho, commonly reaching weights of 60 pounds and more in the Pacific Ocean, and thus offer the sportfisherman the opportunity for a truly magnificent trophy. Coho weights seldom exceed 30 pounds, which is still a lot of fish.

Several cohos in the 30-pound class have been caught by Great Lakes sport anglers. One, captured at an egg-taking station, would have broken the world hook-and-line record for the species had it been landed by a fisherman. No chinooks of more than 50 pounds have been recorded from the Great Lakes.

'Salmon Fever' Erupts

During the fall of 1967, mature coho salmon started to congregate off the mouths of their home streams, and anglers began to find them. The news spread, and "salmon fever" gripped not only Michigan but also the entire Great Lakes area.

Public excitement was unparalleled in the history of Michigan sportfishing. Where before there had been no sportfishing activity worthy of being called such, there were suddenly concentrations of as many as 6,000 boats, ranging from canoes to ocean-size fishing cruisers.

No one, including Michigan's fish managers, had fully anticipated either the results or the impact of that first return of mature cohos. While warnings had been issued to "be prepared for success," the appearance of large numbers of big salmon caught everyone off guard.

Perhaps inevitably, there were problems—but they were problems associated with even greater than expected success, the kind of problems a fish manager enjoys having to deal with.

Anglers quickly found that the boats, motors and tackle available to them were often inadequate to meet the challenges posed by big lakes and big fish. Private enterprise responded quickly by producing and marketing sturdier, more seaworthy boats, more reliable engines, and new items of tackle.

An early and highly successful development was the "downrigger," a weighted device which allows a trolled lure to be placed at depths where salmon and lake trout congregate. This innovation has played an important role in the Great Lakes sportfishery ever since.

Small-Boat Harbors

Among important spinoff benefits of the 1967 success story was acceleration of Michigan's program to create harbors-of-refuge for small boats at intervals of 15 to 30 miles around the Upper Great Lakes shoreline. Locations of needed new harbors to fill gaps in the network were identified, sites obtained, and construction pushed.

The lesson for the fish manager is that public reaction to a highly successful result must be anticipated to the extent possible, and appropriate beforehand steps taken to solve "people" problems likely to arise.

To this point the story of Michigan's Upper Great Lakes rehabilitation program, with emphasis on the sportfishery, has been an almost uninterrupted tale of triumph. Let there be no mistake; there have been disappointments. No program of the scope undertaken could go for-ward as one constantly continuing success story.

A major disappointment has been failure, thus far, to reestablish natural reproduction of lake trout in Lakes Michigan and Huron.

Kokanee salmon introduction attempts have largely failed, and so have efforts to establish Atlantic salmon, undertaken after coho and chinook were successfully installed. A thriving population of Atlantic salmon in the Great Lakes certainly is still an objective worth striving for.

Chemical contamination of fish in the Great Lakes was initially a serious problem, with DDT and later PCB's. However, levels of chemicals found in Great Lakes fish have dropped steadily in the years since 1967 and now with very limited exceptions all will pass Food and Drug Administration standards.

Foul-Hooking Ban Set

To give the angling public a further opportunity to harvest salmon surplus to the open-water fishery, regulations were liberalized in 1966 on stretches of some spawning streams to permit retention of foul-hooked (snagged) fish. That was a controversial decision from its inception and it is gradually being reversed. There will be a total ban on foul-hooking in 1985. The ethic that good sportsmanship requires fish to strike a bait or lure and be hooked in the mouth runs strong and deep among Great Lakes anglers.

From an economic standpoint the Upper Great Lakes rehabilitation program has produced outstanding results.

By 1972, an estimated 300,000 sportfishermen were spending more than 2 million angler-days on the three Upper Great Lakes. Since then, economic studies have indicated that this sportfishery contributes between $350 million and $500 million to Michigan's economy annually. Catch figures for 1978—latest year for which reliable statistics are available—show these minimum numbers of high-value salmonids taken from Michigan waters and tributary streams:

Chinook salmon, 1,150,000; lake trout, 1,080,000; coho salmon, 968,000; steelheads, 718,000; brown trout, 422,000. These numbers add to 4,338,000 fish. Applying an average weight of 5 pounds per fish, which is very low, more than 20 million pounds of those highly prized and sought-after species were harvested.

Not least of the benefits realized has been reduction, almost to the point of elimination, of the alewife problem. No longer do these little forage fish die in the spring and pile up on the beaches in untenable hordes.

This mitigation of the alewife nuisance is perhaps the best evidence at hand to indicate a reasonable predator-prey balance has been restored in the Upper Great Lakes. It is a precarious balance, supported in large measure by a hatchery program and subject to upsets by events which are not foreseeable.

Sportfishing has come of age in the Upper Great Lakes. Highly prized species such as coho salmon, chinook salmon, lake trout, steelheads, and brown trout attract thousands of anglers to the Great Lakes and tributary streams.

Michigan Dept. of Natural Resources

Water, Water, Everywhere—for Americans at Play

By David W. Lime

As bees are attracted to flowers, we Americans are attracted to water. Water is essential to our basic physiological, spiritual, and emotional well-being: We cannot live without it. We drink it, build our cities along it, and transport our goods and ourselves on it.

And we play on it—using our rivers and lakes not only for water sports such as swimming, fishing, water skiing, boating, beachcombing, waterfowl hunting, and ice skating but as an important backdrop for camping, picnicking, jogging, photography, painting, hiking, driving for pleasure, and just plain relaxing. Sometimes referred to as "liquid gold," water is a vital element in a multi-billion-dollar recreation and tourism industry nationwide.

About a fourth of all outdoor recreation in the United States depends on water. Fortunately, Americans are blessed with a large number and variety of fresh and salt water resources. Nearly two-thirds of all public recreation areas have a body of water within their boundaries or are adjacent to accessible water.

The United States has about 110 million acres of water surface, including about 60 million acres of inland water and 50 million acres of coastal water.

Because these natural waters are so widely distributed geographically and since thousands of reservoirs and farm ponds have been constructed during the last four or five decades, just about every American lives

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within 50 miles of a public lake, river, stream, or coastal shoreline. About a third of us live within five miles of one of these resources.

Let's briefly explore some of these water resources to learn about their vastness and potential for outdoor recreation.

Rivers and Streams

The country has about 2 million streams totaling more than 3.2 million linear miles in the contiguous United States and another 365,000 miles in Alaska. There are nearly 30,000 miles of reservoirs along these rivers and streams.

Obviously not all waterways are available for recreation. Many are too small. Others are used for non-recreation purposes such as residential housing, industry, transportation, mining, and agriculture. Some rivers are far removed from population centers. Others, although near or in cities and towns, are virtually inaccessible.

Public concern over the plight of free-flowing streams that have scenic, recreational, ecological, and cultural values has led to special designation of selected rivers under Federal and state programs. The national Wild and Scenic Rivers Act of 1968 designated eight rivers (or portions of them) as the nucleus of a National Wild and Scenic Rivers System.

Today the system includes 61 rivers or river segments totaling nearly 7,000 miles. Other rivers—including the Current and Jack's Fork Rivers in Missouri and the Buffalo River in Arkansas—have been federally designated as National Scenic Riverways.

Besides Federal efforts to preserve rivers, 23 States have established river preservation programs. In 1965, Wisconsin was the first to establish a program. By 1980, a total of 19 States had designated more than 200 rivers or river segments, totaling nearly 6,000 miles. Unlike the Federal program, which is uniform in intent and purpose, state programs range from active, dynamic planning to less aggressive activities having minimal administrative responsibilities.

Our Varied Shorelines

The coastlines of the Pacific and Atlantic Oceans, Gulf of Mexico, and Alaska total more than 88,000 miles and an additional 11,000 miles border the five Great Lakes.

Together these coastlines represent diverse physical and biological environments such as the rocky shores of the Maine coast and Lake Superior, the sandy beaches of States bordering the Gulf of Mexico, and spectacular seacliffs of the Pacific coast in California, Oregon, Washington, and Alaska.

Efforts also have been made to preserve seashores and lakeshores with outstanding natural, historical, and recreational values. Today, the National Park Service administers more than a dozen national seashores and lakeshores totaling nearly one million acres.

Cape Hatteras National Seashore in North Carolina was the first area designated in 1950. Other well-known national shorelines include Cape Cod, Point Reyes, Padre Islands, Apostle Islands, and Indiana Dunes.

Despite efforts to preserve coastal land for public access, only 25 percent of this resource is accessible for recreation. Very little shoreline has been developed for recreation, and most land is privately owned. Less than 20 percent of private shoreline is accessible for recreation.

100,000 Natural Lakes

We have more than 100,000 natural lakes in America, both freshwater and saltwater. Natural lakes include a spectrum of water environments ranging from small prairie potholes and alpine lakes to the Great Lakes.

The largest of our natural saltwater lakes include the Great Salt in Utah; Pontchartrain in Louisiana; Salton Sea, Mono, and Eagle in California; Walker in Nevada; and Goose in Oregon and California.

Reservoirs expanded rapidly during the 1940's to the 1960's, and today total about 12 million surface acres of water—an area the size of New Hampshire and Vermont combined. Unlike most of our coastal resources, reservoirs generally are publicly owned. Primary developers are the Army Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and private power companies.

As one of the primary managers of reservoir recreation, the Corps of Engineers oversees nearly 450 lakes and 3,800 recreation areas nationwide with a total shoreline exceeding 50,000 miles. In the West, the Bureau of Reclamation works with State and other Federal agencies to provide recreation on about 180 water projects with a combined shoreline of over 12,500 miles.

Although reservoirs were originally built mainly for flood protection, power generation, irrigation, and navigation, most are used today for a variety of on-water and shoreline recreation activities. Many newer reservoirs have been constructed with recreation as an important objective, especially some built near metropolitan areas where the need for recreation and leisure services is greatest.

Untapped Opportunities

Municipal water supply lakes and reservoirs and their adjacent watersheds represent largely untapped opportunities for outdoor recreation, particularly in the Northeast and Far West.

Historically, recreation on these lakes and reservoirs was prohibited to protect public health and to ensure a continuous source of safe potable water. Today, however, improved water treatment technology and thoughtful planning should increase opportunities to use these water resources and their

H.R. Slayback

Throughout the United States, more than 2.5 million farm ponds are used for recreational activities.

These young anglers are trying their luck on a pond stocked with bass and bluegills.

shorelines for a variety of sports. Nevertheless, a stigma remains against such uses, especially for water contact activities like swimming and water skiing.

The more than 2.5 million farm ponds in the United States are a significant and growing resource for outdoor recreation. Ponds average about an acre in size, and nearly all used for recreation are located in the Northeast and Southeast.

A recent survey by the Soil Conservation Service, the agency primarily responsible for aiding farmers in developing farm ponds, estimates that about two-thirds of these ponds are actively used for fishing or other recreation activities.

Nearly three-fourths of the ponds are stocked with fish. One study estimates that farm ponds account for about 20 percent of the total warm-water angling each year in the United States.

Boat Ownership Grows

By almost any indicator, the pattern is the same—water recreation is popular and growing—not only the water sports but also those activities enhanced by water.

David W. Lime

Canoeing is one of the fastest growing water sports. Today about a million canoes are in use on the Nation's waterways.

A recent Coast Guard survey reveals that ownership of recreational boats in the United States continues to grow. In the contiguous 48 States more than 12 million boats are owned and used for recreation, an increase of 34 percent between 1973 and 1976. The Great Lakes and Pacific Northwest experienced the largest increases.

The number of kayaks and nonmotorized canoes owned by Americans has grown faster than any other type of watercraft. Between 1973 and 1976, for example, there was a 68 percent increase in the number of canoes and a 107 percent increase in kayaks.

The most rapid rise in canoe ownership occurred in New England and the Lake States. The New England, Mid-Atlantic, and West Central regions produced the most rapid growth in kayak ownership. Today, there are about 1 million canoes and almost 100,000 kayaks nationwide.

Water sports are among our most popular outdoor recreation activities. Swimming, fishing, river running, sailing, and other water sports grew as fast as or faster than other popular recreation activities during the last two decades. A third or more of Americans over 11 years of age swim and sunbathe, fish, and boat at least once each year.

Canoeing, kayaking, river running, water skiing, ice skating, waterfowl hunting, and sailing each attracts between 10 and 20 percent of the citizenry over 11 years of age at least once each year. Sailing, canoeing, and kayaking are among the fastest growing outdoor sports nationwide.

Boardsailing Boom

One of the newest and perhaps the most rapidly growing water sport in America is boardsailing. It was first introduced in California in 1969. Only recently has boardsailing caught on in a big way in the rest of the United States and business is booming.

In 1980, about 9,000 domestic and foreign-made boards were sold in the United States. Sales in 1983 are expected to exceed 45,000. There were only two American manufacturers in 1980, today there are more than 30. Many believe boardsailing has a bright future in the 1980's and beyond.

Water recreation use has been growing since the 1950's, but significant growth in river recreation did not occur until the 1960's. On many rivers the number of visitors increased during that time as much as 20, 50, or even 100 percent per year. Some of the most dramatic increases are on rivers nearest large population centers in the Midwest, East, and Far West.

Growing membership in water recreation organizations, increases in sponsored water sport events, and in circulations of magazines oriented to water recreation also point to accelerated interest in water recreation resources. The number of competitive paddlers joining the American Canoe Association increased about 25 percent between 1978 and 1982. Circulation of *Canoe Magazine*, which began publication in 1973, jumped from 5,000 that year to more than 45,000 in 1979.

In five years the number of rental agencies listed in some canoe rental directories soared more than 100 percent to over 1,000 entries. The number of outfitters and river guides also increased. In 1962, the Western River Guides Association had only 15 members; by 1982, membership had risen to about 700.

Demand to Stay High

Water recreation demand will probably remain high for several reasons. The reduction in pollution on many waterways—especially in and near urban areas—resulting from legislation such as the Water Quality Act of 1965 and the Federal Water Pollution Control Act Amendment of 1972 makes those waterways more attractive for recreation use.

A rapidly growing interest for challenging, even dangerous, recreation activities such as whitewater river running and scuba diving will thrust new demands on leisure resources.

The rising number of books, magazines, films, advertisements by commercial water recreation suppliers, and television programs on the outdoors and rivers encourage people to "give it a try."

More and more theme parks with special water attractions for boat and innertube rides and opportunities to "shoot the rapids" draw increasingly larger numbers of thrill-seekers annually. And, technological innovations in outdoor recreation equipment and related industries continue to provide new paraphernalia and playthings for an ever expanding water recreation market.

But despite the rosy outlook for increased interest and participation in water recreation and other pursuits, growth rates probably will not parallel those of the 1960's and 1970's. Some water activities may grow more slowly because the Nation's population growth will continue to decline and the population as a whole will age.

Since as people get older they tend to participate less in recreation activities—especially the more strenuous activities—providers of water recreation opportunities probably will serve a different and less rapidly expanding clientele with potentially new recreation needs and preferences as we move closer to the 21st century.

Costs May Affect Travel

Rising energy and transportation costs may reduce travel to more distant water recreation sites; and, visits to distant locations may last longer. In particular, day trips to water sites closer to home may become more prevalent. With greater demands placed on urban and suburban resources, efforts probably will intensify to curb water pollution and improve water quality.

Along with the increased popularity of water resources have come new and greater problems for outdoor recreation planners and managers—and for water recreationists, landowners next to these waters, and others.

Debates frequently center around the appropriate use of water resources; and increasingly, decisions are based partly on demands for recreation. Also common are the conflicts between recreation uses and nonrecreation uses over water issues such as commercial fishing and trapping, transportation, hydropower, irrigation, residential water supply, and waste-water treatment. Other conflicts among recreation uses and nonrecreation riparian uses take place over forest industries, mining, agriculture, and residential land use.

New problems, both social and environmental, have been created by the increased number of water recreation users. Many streams, lakes, and reservoirs are threatened by accelerated and unregulated shoreline development that could degrade water quality, restrict public access, and impair natural beauty.

Increased recreation use may adversely affect plants, birds, and animals. Erosion of banks, campsites, and public accesses is a common problem in some locations. Growing use also may result in more littering and vandalism to public and private property along waters. Problems of sanitation, maintenance of facilities, and law enforcement along the Nation's waterways may also be expected to rise.

Effects of Crowding

Periodic crowding on and next to recreation waters may lessen the enjoyment of some visitors. Even small changes in the density or kinds of use a site receives could greatly influence the quality of their experience. In fact, people seeking low-density use and contact with nature may be displaced altogether. Conversely, some water recreationists enjoy the sociability of crowds.

Recreation use often generates other conflicts besides crowding. Conflict has arisen between anglers and boaters, between water skiers and swimmers, between motorized and nonmotorized boaters, and between recreationists and landowners.

Before the 1960's, active water recreation planning and management were virtually unknown. Where activities were underway, most were accomplished secondarily to other practices such as watershed protection, irrigation, flood control, and hydroelectric production.

Some State and Federal agencies that owned land adjoining water resources did provide basic facilities, campsites, and picnic tables. Other activities usually centered on enforcing Federal and state water regulations and licensing requirements.

Through the 1960's, 1970's, and into the 1980's, water recreation planning and management grew from largely passive efforts to rigorous and innovative activities. Now, a generation of water recreation planners and managers is taking thoughtful steps to ensure that a rich and continuing mix of recreation opportunities is available for Americans.

Zoning, Other Curbs

Increasingly, restrictions have been imposed or are anticipated by many managers to control environmental impacts and to ensure that the types of opportunities sought by current and future visitors will remain available. These management restrictions include use rationing, limitations on camping and open fires, party-size restrictions, and limitations on lengths of stay.

Zoning techniques frequently are used to reduce conflicts among recreationists. On the portion of the Lower St. Croix River between Minnesota and Wisconsin, "no wake zones" have been established to lessen the conflict between canoes and motorized craft. On several trout streams in Michigan, anglers are encouraged to use the river during early morning and late afternoon hours when canoeing is prohibited.

Another use of time zoning is scheduling trip departure times from public accesses. On the Chattooga River, one of several rivers in the Southeast managed by the Forest Service, commercial outfitters are limited in the number of trips they can make on weekends and are assigned departure times at least an hour apart.

Potential visitors are being informed about past use in some places to reduce congestion and crowding. Brochures pinpoint heavily used locations so recreationists can avoid crowded areas and peak use times, if they desire.

Fishing is popular recreation activity, and in most areas—like this stream in Idaho—there

To control environmental impacts, party size is often limited. Campsites may also be assigned to give vegetation an opportunity to recover from previous use. For example, on the Middle Fork of the Salmon River in Idaho, another Forest Service-managed river, trips are scheduled so that a particular campsite is vacant at least 4 out of every 10 nights. In many locales either a ban on cans and bottles or a pack-in–pack-out policy is in force.

Despite these problems, our water resources are in capable hands, and management of most water recreation opportunities and resources is running smoothly—assuring all of us high quality water recreation for the future.

Donald C. Schuhart

is no conflict. But in areas where boating is also popular, there have been problems.

The Risk Factor From Acid Rain: All The Answers Are Still Not In

By William McFee, Ellis Cowling, and James Gibson

"April showers" water the crops, make the desert bloom, drive the earthworms up within the robin's hungry grasp, and fill our streams and reservoirs. How fresh and nice the air seems after the rain has scrubbed it clean. "April showers" bring "May flowers," but also much of the material suspended in the atmosphere.

Since the beginning of the industrial age, we have been releasing more and more gaseous and particle pollutants such as sulfur dioxide and nitrous oxides into the atmosphere. In the world's industrialized regions, including eastern North America and northern Europe, pollutants are so abundant in the atmosphere that the quality of the rain and snow is noticeably affected.

The cleansing effect of precipitation results in rain and snow that contain much of the impurities that were in the air. The phenomenon known as "acid rain" is one of the results. Precipitation that cleanses the dirty air brings down acidic materials, plant nutrients—such as nitrogen and sulfur, and many other materials, some of which may be harmful.

A network of acid precipitation collectors was established in 1978 using the regional research system of the U.S. Department of Agriculture and the State agricultural experiment stations. This network now includes many public and private organizations and is called the National Atmospheric Deposition Network (NADP).

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NADP has assembled information indicating that almost all the United States east of the Mississippi River and eastern Canada are receiving precipitation with an average pH below 5.

Clean air should produce rain with a pH of 5.6 due to natural levels of carbon dioxide, and air with the small amounts of pollutants that would be expected from natural sources would probably deliver rain with a pH slightly above 5.

50 Lbs. of Acid an Acre

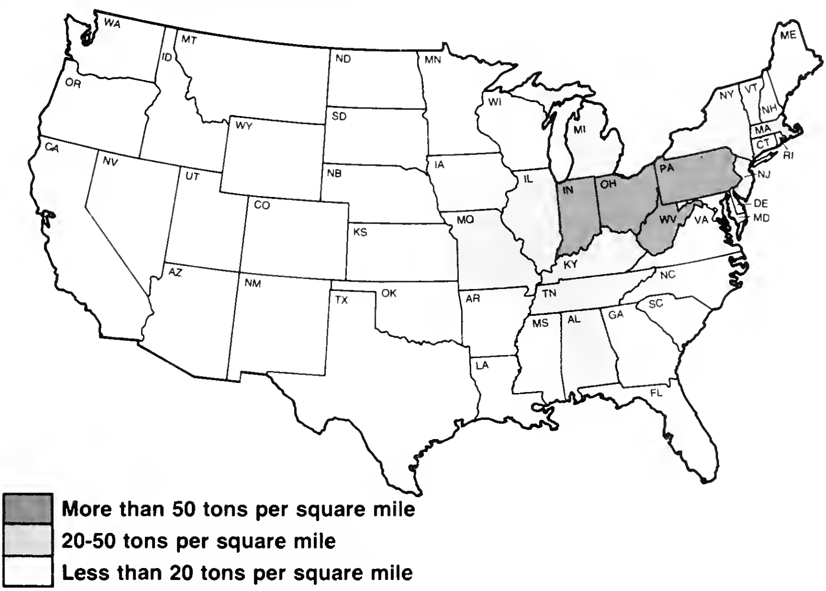
This large region of North America is receiving precipitation much more acid than would be expected under natural conditions. How much acid is this? In the regions receiving the most, the acid reaching every square yard each year is equivalent to that contained in about six quarts of lemon juice. In other terms, it is equivalent to a little less than 50 pounds of sulfuric acid per acre per year.

The region receiving acid rain roughly corresponds to the portion of the country that has high sulfur dioxide emissions.

It is clear that a large portion of the acid materials being deposited come from manmade sources, primarily from the combustion of fossil fuel materials—coal, gas, and oil.

Fossil fuels have sulfur impur-

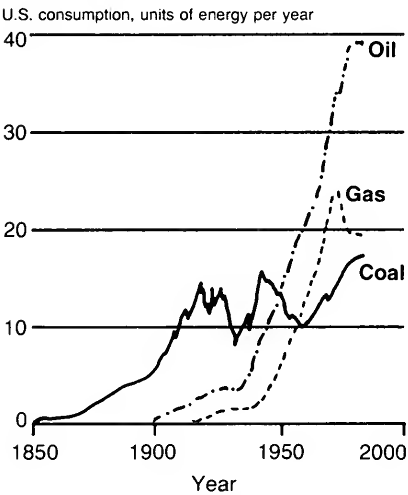
Density of Sulfur Dioxide Emissions in the United States Averaged Within Each State.



ities which are converted to sulfur dioxide during burning unless removed prior to combustion. If that sulfur dioxide is not removed, it goes into the atmosphere where it may be transported long distances, eventually converted to sulfuric acid, and become a major contributor to acid rain.

Likewise, most combustion processes produce some nitrogen oxides which are emitted into the atmosphere and converted to nitric acid. In the Eastern United States, the acid rain is made up of a mixture of dilute sulfuric and nitric acids in the ratio of about two to one.

Trends in Consumption of the Three Major Energy Sources in the U.S.



The big rise in coal energy consumption occurred early in this century, and the rapid increase in gas and oil use began in the 1950's. Similar to coal consumption, the total sulfur dioxide emissions, while higher, have not been changing very rapidly in the last few decades.

Acid Rain in 1850

We are not sure just how long acid rain has been with us. Some work in this country indicated that the rain pH in much of the Eastern United States had become more acid in recent decades, the 1950's to the 1970's, but other researchers claim that is unlikely considering the small amount of change in sulfur dioxide and nitrogen oxides emissions that occurred during this period.

We know acid rain has fallen in some localities for a very long time. Beginning about 1850, researchers became aware of acid rain around the industrial cities of England.

Regardless of the length of time acid rain has been occurring, it is clear that significant amounts of acids and other materials are being deposited over large portions of North America.

Almost everything that humans do on a large scale—burning fossil fuels for heat, power, or transportation; processing metal ores or other materials; intensive farming and forestry; and incinerating wastes—contributes to changes in the atmosphere.

Some of these changes provide additional nutrients for crops and forests, and accelerate the natural weathering or breakdown of soil minerals. Other changes may cause stress in plants and animals, alter water quality, aggravate nutrient deficiencies in soils, or accelerate the natural weathering or corrosion of structures.

Plants May Benefit

The nitrogen and sulfur brought back to the earth in acid deposition may be important in meeting the needs of plants in terrestrial ecosystems. Sulfur deposition in the Eastern United States, for example, is a significant portion of that needed by most plant communities. In non-agricultural systems, forests and wetlands, both sulfur and nitrogen may be having an important positive impact on the growth of plants.

The other plant nutrients being deposited—such as calcium, magnesium, and potassium—are probably in such small amounts compared to what plant communities need that they are not particularly important.

The consequences of acid rain on soils vary greatly depending on the type of soil, type of vegetation, and the rates of acid input. Effects of soil acidification are well known and generally result in a less productive soil. However, acidification is a natural process in humid climates where rainfall exceeds evaporation and the contribution of acid rain to that process appears relatively small.

Acid deposition can increase leaching of exchangeable plant nutrients such as calcium and magnesium. It also may lead to a reduction in nitrification rates and other changes in microbial processes near the surface. The greatest concern in soils, however, is the possible mobilization of aluminum.

Aluminum is toxic to most forest and agricultural plants when it is in high concentrations in the soil solution, and it becomes more soluble as the pH goes down.

Most soil scientists agree that acid deposition will have little or no harmful effects on agricultural soils because the impact of cropping, fertilization, and liming practices will totally overshadow any effects of acid rain on the soil.

Natural Ecosystem Concerns

In natural ecosystems, however, where soil amendments and cultivation are not practiced, there is concern that soils which do not resist change (poorly buffered)—such as extremely sandy soils—may be subtly affected over relatively long periods of time, a matter of decades.

Some of the effects will be additional nitrogen and sulfur, which in many cases may increase plant productivity; a slight increase in the rate of leaching of basic cations, such as calcium and magnesium, which may be offset by an increased rate of mineral weathering; and finally, an increase in aluminum availability to plants.

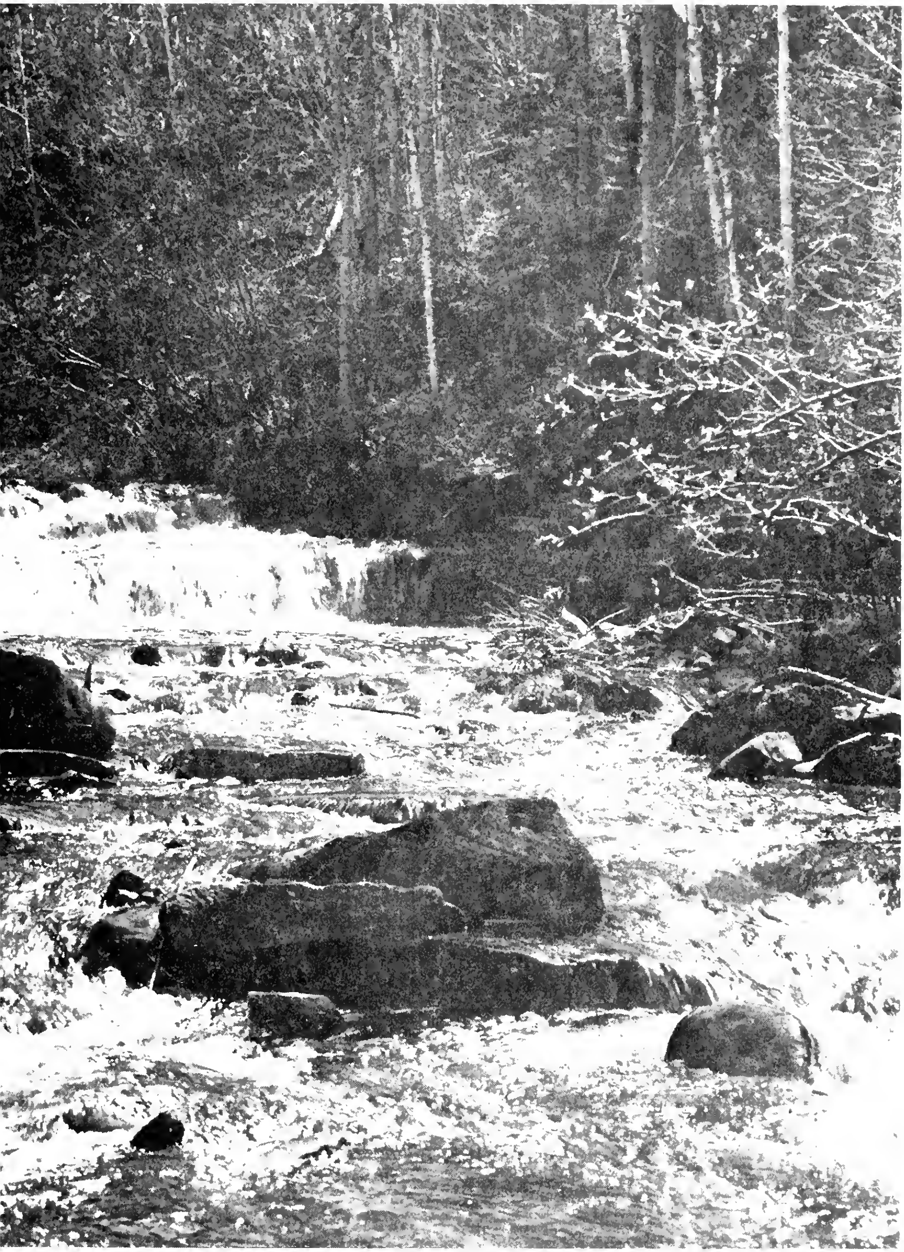
This increased aluminum may be detrimental to plants and also to waters receiving drainage from this soil.

The natural resource which seems most seriously affected, most at risk, is the aquatic system. Water bodies lack the buffering capacity, or resistance to change, that is common in soil materials. Acid precipitation can change the acidity or alkalinity of lake and stream waters from conditions favorable for fish and other aquatic organisms to conditions that inhibit reproduction or growth of fish and fish food organisms.

Interference with normal reproductive processes and reduction in fish populations is not necessarily due to the acidity itself, but may be due to increased concentrations of certain metals, particularly aluminum, in acidified lake and stream waters. There is evidence that ionic forms of aluminum can interfere with the operation of gills in very young fish.

Acidic materials that accumulate in snow in cool regions of North America may be released in large amounts during the spring snowmelt. This release of pollutants can cause major and rapid changes in the acidity and other chemical properties of streams and lakes. When this occurs at critical times in the reproductive cycle of the fish, the results can cause a dramatic decrease in the fish population.

Acid precipitation can change the acidity or alkalinity of lake and stream waters



Erwin W Cole

to conditions that are unfavorable to fish and other aquatic organisms.

Northeast Lake Acidity

As of 1983, relatively large numbers of lakes in New York State's Adirondacks region, New England, and various parts of southern Ontario and Quebec were showing evidence of diminished populations or extinction of certain fish due to increasing acidity. Lakes and streams in other regions of the United States and Canada may be vulnerable to stress by acid precipitation.

Such regions as northern Minnesota, Wisconsin, and Michigan, parts of the Southern Appalachians, and Florida have lakes with low alkalinity and are surrounded by soils that provide poor buffering capacity. Therefore they may be influenced by acid precipitation in the future.

Forest systems in the United States are very important to our economy, and a large portion of the eastern forests receive acid rain. Reliable evidence of economic damage to forests due to the atmospheric deposition that we are receiving is not available. However, specific biological effects of simulated acid rain have been demonstrated in controlled field and laboratory experiments.

Some of these experiments have shown increased leaching of nutrients from leaves, predisposition of plants to infection by pathogens, accelerated erosion of waxes from leaf surfaces, and inhibition of bud formation and increased mortality of pine seedlings. It must be pointed out also that treatments sometimes result in increased growth of tree species due to the fertilization effect of the nitrogen and sulfur in the acid rain, and some diseases are less likely under acid treatments.

Combination Cuts Growth

In certain industrial regions of the world, substantial damage to forests has been caused by ozone, sulfur dioxide, and oxides of nitrogen and fluoride. Recent experiments have shown that the combination of acid precipitation and some of these pollutants causes a greater reduction in growth than the air pollutant alone.

Experiments in Germany have indicated a relationship between soluble aluminum in forest soils, death of feeder roots in spruce, fir, and beech forests, and widespread decline in the growth of these trees. Acid precipitation and dry deposition of acid-yielding substances have been postulated as a probable cause for these effects.

Likewise, research in the eastern United States in the pine barrens of New Jersey has pointed to declines in tree growth that occurred during the same period that the streams became more acid, and acid precipitation may have become worse, pointing to a possible relationship between acid rain and declining tree growth.

The widespread dieback of red spruce at higher elevations in New England may be related to air pollutants, but the cause is not yet clear.

At this time, it is impossible to definitely conclude whether or not acid deposition is causing a problem with forest growth in the United States.

Agricultural crops can be affected by acid rain indirectly through additions to soils or directly by physiological changes in the aboveground portions. Field experiments with agricultural crops have shown a wide variety of responses, both positive and negative.

Physiological Effects

Many direct effects on physiology of the plants have been shown in controlled field and laboratory experiments. A number of the crops tested show leaf damage, changes in growth patterns, and reduction in yield if the pH is dropped to a very low value although treatment pH's—around 4.0 such as those that commonly occur in the Eastern United States—sometimes show small decreases in yield and growth.

We lack reliable evidence of economic damage to important agricultural crops from the acid rain currently received. A few reports indicate small reductions in soybean yields in experiments where they were treated with artificial rain no more acid than that sometimes experienced in the area, but other reports have indicated no effects at these same levels.

At the present time the bulk of the evidence indicates the effects on agricultural crops are relatively small, and additional research is needed to quantify the direction and magnitude of these effects.

Besides the concerns for lakes and streams, soils and crops, there is some worry about the effects of acid rain on ground water quality. The chemical composition of lakes and streams is determined in part by the chemical composition of precipitation, and acid water increases the solubility and mobility of many cations in soil. Therefore, some influence on ground-water chemistry seems possible.

Some ground waters are naturally acid, and there is evidence in Scandinavian countries of an increase in the acidity of ground water due to acid deposition. There is no evidence for such a change having occurred in this country, although the possibility of a subtle, long-term effect does exist.

Impact on Structures

There is little doubt that acidic materials—whether deposited dry or wet—increase the rate at which many building materials corrode or decay. Stone structures built of carbonaceous rock such as marble, limestone, and dolomite are directly attacked by any acid material, resulting in decomposition of the stone itself. The rate of breakdown of marble and limestone structures is directly influenced by the amount of acid that reaches them from the atmosphere.

Exposed steel and iron oxidize (rust) more rapidly in an acid environment than in a neutral one.

For that reason, certain increased costs in replacing and refurbishing metal structures is sure to be the result of acid deposition.

The total economic impact of acid rain on statuary, building faces, tombstones, structural steel and iron is difficult to estimate, but is certainly a significant amount when the whole of eastern North America is considered.

Acid rain is primarily the result of human activities. We are using the atmosphere as a disposal area for many of our gaseous waste and combustion products. The material released into the atmosphere ultimately returns to the lands, plants, and waters of the Earth. Such deposition cannot occur without some effect.

As more research is gathered on the effects of atmospheric deposition, we will be able to tabulate the costs—both in direct economic terms and in less direct, but equally important, costs to our quality of life.

Emission Curbs Costly

Costs of significant reductions in the emissions to the atmosphere are relatively large, easily amounting to billions of dollars in the Eastern United States alone. In some cases, these costs would include displacement of people or shifts in the economy as well as expenditure of large amounts of capital. However, the costs due to long-term effects of atmospheric deposition on materials, lakes, natural and managed ecosystems may be very large also.

The issue of natural resources at risk due to acid rain extends well beyond the United States. The atmosphere of North America does not respect national boundaries. Materials emitted into the atmosphere move freely across these boundaries.

So any effort to reduce the load of pollutants in the atmosphere must be international, perhaps even worldwide. Precipitation quality being measured in

Tim McCabe

Material released by human activities into the atmosphere ultimately returns, and quite often with ill effects.

recent years at some rather remote locations indicate man-made sources of sulfure dioxide are influencing the atmosphere thousands of miles away.

In Europe, multiple-nation conferences and international cooperation in measuring the quality of atmospheric precipitation are commonplace. In North America, the United States and Canada are cooperating in studying the problem and attempting to develop a common policy on acid rain.

Evidence is strong that acidic deposition has a harmful effect on numerous lakes and streams. Damage to some forest systems seems likely, and there may be some small risks to agricultural crops. Acidic deposition is one of the results of waste disposal into the atmosphere and should be a part of the larger concern for clean air.

East and West, Animal Waste Cleanup Pays

By E. Alan Cassell and John Van Calcar

In the northeastern United States, St. Albans Bay is polluted and a recreational resource that cannot be used. In the Northwest, Tillamook Bay is polluted and a shellfishing industry threatened.

Because St. Albans Bay is a prime recreational resource for Vermont, and Tillamook Bay is Oregon's largest oyster-producing area, local and State interest in cleaning up both bays has been high. Nitrogen, phosphorus and bacteria in cow manure and sewage pollute both bays, causing profuse algae and weed growths and making the water unsafe for shellfishing, drinking and swimming.

Through cooperative local-State-Federal efforts, dairy farmers in the St. Albans Bay and Tillamook Bay drainage basins have accepted the challenge to help achieve cleaner water. Everyone will benefit from this cooperation: The farmer because of better methods of manure management and soil erosion control, and users of the bay waters because of reduced pollution.

Each drainage basin has thousands of dairy cows. Since just one cow produces about 38,000 pounds of manure annually, an enormous amount of animal waste must be managed by the farmers. Traditionally, manure has been spread on farmlands with little knowledge of or regard to how it may pollute lakes, rivers and bays or what can be done about it.

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John Van Calcar is a Program Specialist, U.S. Agricultural Stabilization and Conservation Service, Portland, Oreg.

John Van Calcar

The largest oyster-producing area in Oregon is around Tillamook Bay. High bacteria levels in these waters have threatened the industry—and led to major efforts to improve animal waste management on dairy farms in the adjoining drainage basin.

Cleaner waters can be achieved if dairy farmers adopt soil erosion and manure management practices that keep soil on the land, and keep nutrients and bacteria from manure out of the water. Installing and maintaining these practices are costly, and require many farmers to change their traditional farming operations.

Voluntary Action

In 1977, an amendment to the U.S. Clean Water Act provided for voluntary action to address rural water quality concerns.

In 1980, as part of the U.S. Department of Agriculture (USDA) appropriations act, Congress authorized the Rural Clean Water Program (RCWP) to help farmers reduce water pollution by cost-sharing various onfarm techniques, called Best Management Practices (BMP's). For the dairy farmer these BMP's largely are associated with manure management, barnyard runoff control, milkhouse waste management and cropland erosion control. Examples include manure storage facilities with scheduled land application of manure, stripcropping, water diversion structures, and shifts in cropping patterns.

RCWP was designated an experimental program, since no one was certain how effective BMP's would be in reducing water pollution. USDA now has funded 21 RCWP projects across the Nation, including the St. Albans Bay and Tillamook Bay projects, in order to study how effective BMP's may be.

Years of cooperation and dialogue among local farmers, the Agricultural Stabilization and Conservation Service (ASCS), the Soil Conservation Service (SCS) and the Cooperative Extension Service provide a foundation on which RCWP can build.

Thomas Bushey—a dairy farmer from Shelburne, Vt., who recently adopted BMP's—expressed the views of many farmers: "I've been involved with ASCS for 20 years. I've been a county committeeman and over the years we've had many talks about manure management and pollution. I could not have been a participant without the cost-sharing of the manure management system."

Clean water and good farming go together. The St Albans Bay and Tillamook Bay RCWP Projects are showing that best management practices on farms can result in cleaner water. Their individual experiences follow.

Lake Champlain Study

Weed and algae growths and bacterial pollution of St. Albans Bay have existed for two decades. In 1963, residents formed the St. Albans Bay Association and since then have worked toward a cleaner bay.

In the late 1970's, a study of Lake Champlain found agricultural runoff an important pollutant of Lake Champlain, including St. Albans Bay. A little later the Vermont Department of Water Resources released its *State Water Quality Plan for Controlling Agricultural Pollution*. The St. Albans Bay Watershed emerged as Vermont's priority area to receive cost-sharing for BMP's.

In 1979, a Governor's Special Task Force recommended upgrading the St. Albans City wastewater treatment plant and reducing agricultural pollution in the drainage basin.

These studies challenged dairy farmers to help improve water quality in the bay. The agricultural community accepted the challenge and—with the support of State and Federal agencies—the St. Albans Bay RCWP project was underway by spring 1981.

The project has two parts:

1) A voluntary local program to prepare farm water quality plans and help install BMP's on the farm. Extension and SCS people provide information and technical assistance to individual farmers so all BMP's will meet RCWP goals as well as each farm's unique requirements. ASCS contracts with each farmer to share the cost of implementing the BMP's. The Franklin County ASC Committee and Franklin County Conservation District ranked farms in the watershed so the most critical situations could be addressed first.

2) A comprehensive monitor-

David Drew

Near St. Albans, Vt., dairy farmers are using best management practices to reduce water pollution. At this farm, manure is stored in the lagoon at left, to be spread on fields at times when the pollution potential is minimized.

ing and evaluation program aimed at answering the question: How will use of BMP's affect water quality in the bay? It may take five to ten years before a scientifically supportable answer will be available.

Within two years after the project began, 44 of the 98 dairy farmers in the watershed signed contracts with ASCS to cost-share implementation of BMP's. Another 30 farmers have signed up to participate since then.

Holding Facilities

Most farmers are installing some type of large holding facility to store manure over winter and during wet periods. Manure then can be spread on the fields when its fertilizer value is highest and the pollution potential lowest. The traditional practice of daily year-round spreading on frozen ground, on top of the snow, and during wet periods is being discontinued.

Hubert Rheaume of Georgia, Vt., has operated his management system for two years. "I spread manure daily all year-round for years," he says. "This program lets me get a liquid manure storage system years before I could have afforded it myself. I used to swim in that stream down there 20 years ago—I won't do it now. I hope this program will help clean it up. I've also cut my 'corn starter' (commercial fertilizer) in half and I'm saving on equipment maintenance and time."

Norman LaRose of Swanton, Vt., says: "This program has been expensive for me but I hope it will help solve the problem.

I've really enjoyed not spreading all winter and hope I get more benefit from my manure."

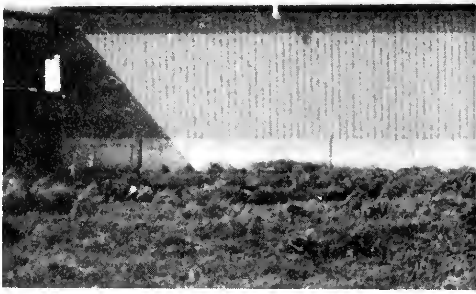
This kind of cooperation among individual farmers, local organizations and State and Federal agencies has made the St. Albans Bay and similar projects work extremely well. In Vermont's LaPlatte River Watershed, a Public Law 566 watershed protection and flood prevention project, 80 percent of the high-priority farms are installing the needed BMP's. *All* farmers in the Lake Parker drainage basin have installed BMP's.

Together they are helping assure both high-quality water and productive land for future generations—important goals for the Nation.

Oregon Control Program

How do you handle and dispose of 275,000 tons of cow manure from 118 dairies in an area where rainfall reaches 100 inches a year? This problem was posed to the Tillamook Bay area dairymen in 1980 by local people and State officials concerned about Tillamook Bay pollution.

An investigation by local citizens and State agencies, led by the Oregon Department of Environmental Quality (DEQ), showed manure in and around the barnyard and on the field during wet periods was the major Tillamook Bay polluter. It was through this investigation that State officials and dairymen came to a mutual understanding of the problem and its solution.



It took time, much talk, and many visits to the area by DEQ to convince dairymen their actions were the major cause of the pollution. Yet once convinced, the local agricultural community took the lead by applying for and then implementing the Tillamook Bay Drainage Basin RCWP Project.

Based on experiences with the ongoing Agricultural Conservation Program, a list of BMP's was developed that fit the climate and agriculture of the bay area. Some were unique, such as installing roofing over manure storage tanks and barnyard areas.

The key to getting participation was threefold: Local dairy industry support from the Tillamook Cooperative Creamery; support from local lending institutions; and a fear that if this opportunity to improve local waste management were missed, a much harsher regulatory system might be imposed.

Robert A. Pedersen

An unusual best management practice under the Rural Clean Water Program was installing roofing over manure storage tanks, such as this round one in the Tillamook Bay area.

The long-term cooperation among Federal, State and local people paid off too. A locally developed rating system was used to approve farmer applications for cost-sharing installation of BMP's. Later, as experience was gained, a group representing the County ASC Committee, the Conservation District, and the Local Coordinating Committee visited each applicant farm, and made a final priority listing.

After two years, 60 dairy farmers are under contract to install carefully chosen BMP's.

Flexibility Led to Success

RCWP worked well in Tillamook because it was flexible enough to provide adequate and reasonable solutions. It succeeded because local people worked as a team to solve problems and encourage participation.

In looking back, dairymen on local committees wonder why they had volunteered to be elected, and how they coped with all the pressures. But now they smile proudly as they can see their valley slowly being transformed into an area where water is losing its polluted appearance and green vegetation is increasing along the sloughs and marshes where manure once accumulated.

BMP implementation added many construction jobs to the economy during a time of high unemployment in Tillamook County.

What about the waters in Tillamook Bay? Extensive water sampling is planned for the next few years to determine effectiveness of the BMP's. In the meantime, dairy farmers and oyster growers are breathing a little easier. The RCWP project should bring an era when these two industries can coexist in harmony.

The St. Albans Bay and Tillamook Bay drainage basin experiences are proving that local, State and Federal cooperation can work to improve water quality by reducing agricultural pollution. The formula for this success has three ingredients:

1) Meeting local needs. Different localities in the United States have different water pollution problems and solutions
2) Involving the community
3) Nurturing cooperation.

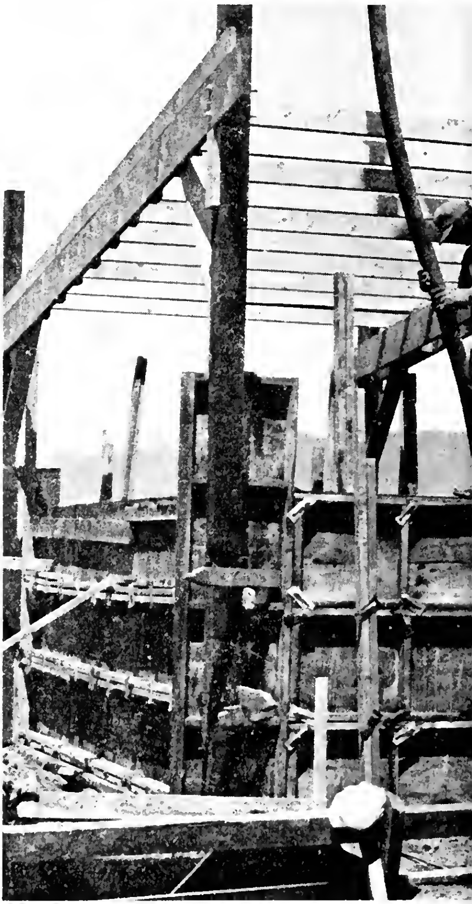
Clearly the definition of local agricultural pollution problems and actions to solve them are best accomplished by cooperatively involving farmers, citizens and their local institutions. Federal and State programs, to succeed, need to be highly flexible so they can meet local needs and attract acceptance and cooperation.

Cost-Sharing Important

Farmers cherish freedom and the independence to farm as they wish. Yet successful farmers understand the economic facts of life as well as their responsibilities to the community. If farmers perceive the RCWP or any other program to be beneficial, it will succeed. If farmers see it as a threat or just an added cost, it will fail. Cost-sharing is an important element in RCWP.

Local, State and Federal agency personnel must be dedicated to making the program work—not merely acting to administer some preconceived program or set of regulations.

Many others in the community need to be involved as well: People who use the water, people simply concerned about their community. In Tillamook, it was the oyster growers and private citizens. In St. Albans it was shore-front property owners on the bay, State Park users, and



citizens in general. Local participation and acceptance of the program are the key to its success. But there is no single best way to develop and nurture the needed cooperation.

Viable cooperative actions among local, State and Federal agencies and individual farmers do not develop spontaneously or rapidly. Unless viewed by all participants to be mutually beneficial, effective cooperative ventures will not be formed.

The old motivations to "go by the book," "protect turf," "build an empire," must be overcome first. It takes a lot of hard work, time, imagination, give and take—more than many people are willing to exert—to maintain and nurture a successful continuing cooperative spirit.

But cooperation has led to excellent success in St. Albans Bay and Tillamook Bay, where good farming and clean water will truly mean that everyone wins.

Robert A. Pedersen

Construction jobs were yet another benefit of the Rural Clean Water Program in Tillamook County. Here, carpenters build a dry manure storage structure that will have a roof to deflect the high annual rainfall in the area.

Harnessing Water for Electricity—One More Time

By Charles M. Payne

Water. Electricity. The creation of electric power through the transformation of energy present in falling or moving water is not a new idea. At the turn of the century, a large proportion of the electricity produced in the United States was hydroelectric power.

After a period of decline in relative importance in the Nation's overall electric energy supply mix, hydroelectric power is once again under active consideration as a potential partial solution to the national energy supply problem.

Basically, the dynamics of hydroelectric power are simple and well-understood concepts. Water is diverted through a conduit to turbine blades. The blades spin the turbine shaft which in turn spins a generator shaft. A spinning, copper wire-wound generator armature creates the magnetic field recognized as electricity.

Advantages of hydroelectric power are many, not the least of which is the nonconsumptive use of a naturally occurring renewable resource. Water is diverted from a stream or other water body, used to generate electricity, then discharged back into the stream. Other public benefits may also be present.

Flood control, fishery enhancement, streamflow augmentation and regulation, and recreational opportunities are usually associated with hydroelectric projects. Dams are also constructed to provide water supplies for crop irrigation, and for

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municipal, industrial, and manufacturing purposes. Hydroelectric generating plants can be installed at many of these water supply dams without interfering with the purposes for which the dams were constructed.

The key element in any hydroelectric project is a dam which may impound a reservoir, or a diversion structure with no impoundment. The latter is referred to as "run-of-the-river." Public benefits may be incidental to the production of electricity or they may be purposefully designed into the project.

Pros and Cons

More specifically, hydroelectric power offers many advantages from the electric power production standpoint.

- The equipment has a long operating life, generally a minimum of 50 years. Operation and maintenance costs are low. Hydroelectric power is readily amenable to remotely controlled operation. It can be brought on-line within minutes; no lengthy warmup or startup time is required.
- Hydropower is combustion free; thus, it is free from air pollution problems. Operating efficiency is high: 85 percent or more. Once installed, a hydro project is virtually inflation proof. It is not subject to escalating fuel costs. And if it is remotely controlled, there are no direct labor costs.

There are major drawbacks, as well as advantages, to hydroelectric power.

- It is capital intensive at the front end, resulting in negative cash flow in the early years of a project; thus, the profit break-even point may be extended for several years. It is site specific; therefore, standardization of equipment is difficult. Because of variations in terrain, construction techniques and the electric plant to be installed usually will have to be customized.
- If the project involves a new dam, expensive fish passage facilities may have to be provided. Variations in streamflow may create problems in assigning dependable generating capacity values to a project. Minimum streamflows may have to be released at the dam to prevent dewatering immediately below the dam; this may result in loss of power generation.
- Hydroelectric power is heavily regulated. There are at least 17 Federal laws that impinge on hydropower development. The major laws involved are the Federal Power Act, the National Environmental Policy Act, and the Fish and Wildlife Coordination Act.

These drawbacks will cause rejection of some sites for development. However, careful planning and design can usually offset most disadvantages. In addition, mitigation measures can sometimes be provided to make development of a particular site acceptable. Many hydroelectric plants constructed during the 1920's and earlier are still operating as environmentally and economically sound ventures.

History of Hydropower

The earliest known hydroelectric generating plants were placed in operation in 1882 at Niagara Falls in New York and St. Anthony Falls in Minnesota. The first commercial application of hydroelectricity was street and business lighting for the City of Minneapolis. The first central station hydroelectric plant appears to have been a 25-kilowatt plant on the Fox River at Appleton, Wis.

Early in this century, hydroelectricity played a major role in the Nation's burgeoning industrial and economic base. By the mid-thirties, however, discovery of vast oil, natural gas, and coal fields had produced huge stocks of cheap fossil fuels.

Consequently, very large fossil fuel fired central generating stations were constructed to take advantage of the economies of scale afforded by these low priced fuels. Hydroelectric power started to decline as a percentage of the Nation's total energy supply—to about 30 percent by 1935, 20 percent by 1965, and about 12 percent at the current time.

It is estimated that by the early seventies, about three-quarters of all hydroelectric generating plants of 5,000-kilowatts or less had been abandoned, dismantled, or simply not repaired or replaced as they became inoperable.

Rural Electrification

Plentiful, low-priced fuel, coupled with large central station generating plants, resulted in virtually complete electrification of the Nation's larger cities and urban industrial centers by 1935. But this was not the case for rural areas.

Only about 11 percent of the Nation's farms had access to central station electricity in 1935. At that time, it appeared it would never be economically feasible to provide electricity to the sparsely settled and remote areas of the country. There was no profit to be made in constructing electric distribution lines many miles long to serve very few customers.

Legislation enacted in 1936 made it possible for the Federal Government to make low interest long-term loans to groups of farmers banded together into rural electric cooperatives for the purpose of helping them to electrify rural America. These loans, along with financial and technical advice, were (and still are) provided through the Rural Electrification Administration, an agency within the U.S. Department of Agriculture. That the program has been successful is attested by the fact that today almost all farms and rural areas in the United States have access to electricity.

The rural electric cooperative system has become a vital part of the nationwide electrical supply system. The amount of electricity consumed represents less than 10 percent of national consumption; however, the cooperatives serve about 70 percent of the land area of the United States.

Continued success of the rural electrification program will depend on ability of the cooperatives to modernize and maintain their existing systems, and to expand to accommodate a growing rural population. This is particularly true in view of the latest census data which indicates large population shifts from urban areas to the countryside.

Use of hydroelectric power by the cooperatives parallels that of the industry at large. That is, during the early fifties, rural electric cooperatives had 43 hydroelectric power plants in operation. By 1980, only 18 of these plants were still in service.

Changing Events

Events of the past 10 or so years promise to reverse this downward trend in hydroelectric plant development. The national electrical load growth pattern has dropped dramatically from 6 to 7 percent annually in the early seventies to less than 2 percent in the early eighties. Sharply escalating construction costs and interest rates have caused constricted cash flows for the electric industry all across the country.

Load growth uncertainty, and the long lead times and high costs of large generating plants, have prompted the industry to take a new, hard look at new power plant planning. Smaller generating plants located closer to load growth areas lessen many of the risks associated with large-scale generating plants. Hydroelectric power plants, especially small-scale ones, fit well into this concept.

The single most important event affecting the national energy supply during the 1970 to 1980 time frame was probably the oil embargo.

The Arab oil embargo of 1973, and subsequent skyrocketing of petroleum prices, sparked nationwide interest in a search for domestic energy supplies sufficient to foster energy independence for the United States. Oil prices were shocking enough, but long-term availability became an even more serious concern as political confrontations among the oil-producing Mideast nations and their neighbors escalated into armed conflicts.

Renewed Interest

In part, the search for energy independence has focused on the prospect for development of renewable energy resources—water, wind, solar, tidal, geothermal, biomass. Interest in these resources is self-evident, for they are naturally occurring resources and thus can be assumed to be, collectively, a virtually unlimited domestically available source of energy.

Many of these renewable resources are currently in the process of research and development. Some have advanced to the stage of demonstration projects. For the most part, however, full scale commercialization—and hence long-term availability—of these energy sources lies many years in the future.

The one exception is hydroelectric power. Hydropower is available now. It is an industry with proven reliability over more than 70 years. The technology behind the industry is well established and widely known. No research and development effort or demonstration projects are required, except possibly to improve upon the already high operating efficiencies of the generating equipment.

The magnitude of renewed interest in hydroelectric power can be illustrated by information available from the Federal Energy Regulatory Commission

In the early 1950's, rural electric cooperatives had 43 hydroelectric power plants in operation. By 1980, only 18 were still in service. One of those is the 15,000-kilowatt Flambeau Station operated by Dairyland Power Cooperative on the Chippewa River in Rusk County, Wisconsin.

(FERC), the agency responsible for licensing non-Federal hydroelectric projects. Applications for preliminary permits (prelicensing feasibility study authorizations) numbered 36 in fiscal year 1976, and 70 in fiscal year 1977. During fiscal years 1981 and 1982 these filings increased to 1,859 and 944 respectively.

The great majority of the hydroelectric power plants under study are proposed for installation at already existing dams. A survey conducted by the Army Corps of Engineers in 1979 indicated there are about 50,000 existing dams scattered through the country. These dams serve a multitude of purposes—such as flood control, navigation channels, irrigation, municipal water supply, and industrial and manufacturing process water supply.

Many existing damsites are amenable to hydroelectric power plant installation without impinging upon the purposes for which the dams were created.

Co-ops Seek Hydro Sites

Renewed interest in hydropower on the part of rural electric cooperatives mirrors that of the electric industry at large. During fiscal years 1976 and 1977, two applications for preliminary permits seeking authorization to study hydro sites were filed at FERC. In fiscal years 1981 and 1982, 70 such applications were filed.

Many of these sites have since proved not to be economically feasible. Some were lost to other applicants competing for particular sites. Nevertheless, at the current time, 23 preliminary permits are in effect and applications are pending for another 9 sites.

Issuance of a preliminary permit by FERC establishes and reserves to the permittee certain priorities for a subsequent license application. Issuance of a license authorizes construction of a hydro project.

Over the past 2 years, 8 licenses (or amendments to existing licenses, or exemptions from FERC licensing) have been issued to rural electric cooperatives, and 15 applications for licenses are presently pending.

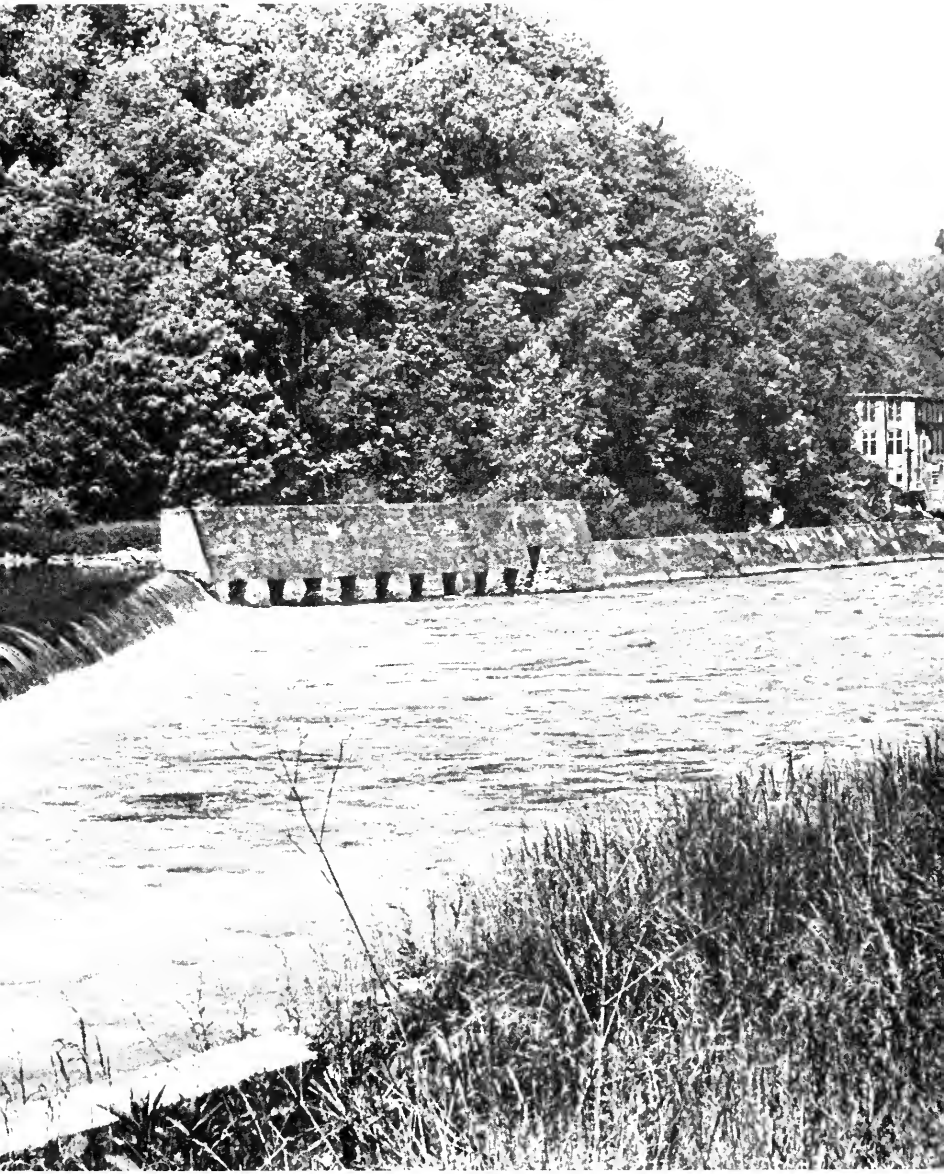
Development of the hydroelectric power potential in the United States certainly cannot be said to be a panacea for the Nation's energy supply problems, nor will it solve all the energy problems of rural areas.

Shortfalls Predicted

Some industry experts have recently begun to predict national electric generating capacity shortfalls for the nineties. It appears likely that continued development of all forms of generation will be required to meet the Nation's future electric energy needs. Nuclear energy, coal, oil, natural gas, synthetic fuels, renewable resources—all will be needed.

And just as certainly as hydropower played a major role in the past development of electric energy in this country, it can and should play a significant part in the future national energy supply mix. To ignore this hydroelectric power potential would be to ignore a naturally occurring, renewable, nonconsumptive energy resource.

Most of the hydroelectric power plants under study are proposed for installation at already existing dams, such as the Capitola Dam on the French Broad River in Madi-



Richard Thomason

son County, North Carolina. The French Broad Electric Membership Corp. has started construction of a 3,000-kilowatt plant.

Wilderness, Natural Areas and Other Wild Lands

By Laurence R. Jahn

The landscape mosaic of rangelands, farms, forests, aquatic areas and urban-suburban areas so dominant today is the product of our ever-expanding human population, technological developments, and open economic competition to convert the resource base to a variety of uses.

Less than 500 years ago, the United States was a 1-billion acre wilderness consisting of a broad spectrum of deserts, grasslands, woodlands and water areas. With the exception of relatively minor and local modifications by native Americans, the landscape was shaped by natural forces and in various stages of ecological succession.

Mature or climax vegetative stands were intermixed with those recovering after disturbance by such natural forces as wildfires, floods, volcanic eruptions, hurricanes, and tornadoes.

Plant-consuming wildlife played an important role in shaping vegetative communities. Most important was the foraging by millions of bison, pronghorn, deer and elk.

Coupled with lightning-caused and Indian-set fires, fire-dependent plant communities were perpetuated.

As human settlements progressed northward from Mexico and westward from the East Coast, the landscape was changed dramatically, and vast areas were altered and converted to other uses, largely on a permanent basis. By the 1880's, settlement of the conterminous 48

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Yellowstone National Park was 61 years old when these horseback riders stopped along canyon rim near Point Lookout in 1933. Yellowstone was the first national park.

States was virtually complete and land-use patterns established. Concurrent with this massive conversion of wilderness to other uses, values associated with wilderness grew.

Catlin and Wild Lands

Among the first observers to call for maintaining some wild lands as a distinctive quality of American culture was George Catlin, painter and student of American Indians. Following a series of trips through the northern Great Plains, Catlin concluded that the rapid slaughter of bison, deterioration of Indian cultures, and overall disappearence of the pristine landscape were losses America could ill afford.

In the mid-1800s, he called for establishing "A Nation's park containing man and beast, in all the wild and freshness of the Nation's beauty." The first national response—likely independent of Catlin's call—to set aside undeveloped land to maintain natural landscape features and associated wildlife occurred in 1872 when Congress established Yellowstone National Park.

This initial action for maintaining wild areas was reinforced by others, including Henry David Thoreau, Robert Marshall, Arthur Carhart, and Aldo Leopold. Nevertheless, another 50 years passed before the unique values of wilderness became recognized more widely.

In 1924, the U.S. Forest Service administratively designated the Gila Wilderness Area in New Mexico, consisting of some 750,000 acres. Leopold outlined a concept of wilderness for the Southwest, with several objectives, one of which was to prevent annihilation of rare plants and of animals such as the grizzly bear.

Despite this pioneering action and growing public awareness of the need for wilderness areas, it was 1964 before the first Wilderness Act was approved by Congress. It expressed the enlarging citizen concern to maintain a well-distributed system of wild areas, managed to promote and perpetuate the wilderness characteristics of solitude, physical and mental challenge, inspiration, primitive recreation and scientific study.

Pressures on Wilderness

Satisfying these goals was recognized as a major challenge. By the 1960's, in all areas of the United States but especially the populous eastern half, wilderness areas were threatened increasingly by pressures of a growing and more mobile population, large-scale economic growth, and developments and land uses inconsistent with protecting, maintaining and enhancing the region's wilderness.

Relatively few remnant wilderness areas, covering entire watersheds, remained. Outside of Alaska, few existing or proposed wilderness areas contained mature vegetative communities, since all or parts of them were in varying successional stages following human-induced or natural disturbances.

Consequently, no two wilderness areas are exactly alike. Each has different geological and human-use history, soils, waters, plants, and fish and wildlife. This variation among wilderness areas is what prompted specific language in the Wilderness Act of 1964 and the Eastern Wilderness Act of 1975. The acts were designed to salvage remnants of the rapidly diminishing natural landscape.


Donald C. Schuhart

The Wilderness Act of 1964 defined the basic values embraced within a unit of the landscape designated a wilderness area. "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."

It's not hard to spot a wilderness area, such as Crater Lake in the Cascade Range in Oregon. Wilderness areas typically have a rich diversity of landforms and plant and animal life, as well as opportunities for primitive recreation and solitude.

Naturalness and solitude are distinguishing qualities of wilderness as defined by Congress. Maintaining these qualities, as demands for using the areas continue to increase, requires careful evaluation of candidate areas, delineating boundaries and setting up sensitive guidelines for managing them.

Rigidity Avoided

In defining wilderness, Congress recognized that some human activities likely would be encountered in candidate wilderness areas. Therefore, it did not rigidly forbid any impact of people inside wilderness areas.

Debate over interpretations of the 1964 Act was reconciled considerably with enactment of the 1975 Eastern Wilderness Act, in which new admission criteria for areas east of the 100th meridian were established. Congress recognized that many lands in the East have been impacted substantially in the past by human activities, and that many of these impacts have been minimized by rapid recovery of vegetation in this humid region.

Areas recommended for inclusion in the National Wilderness Preservation System are to have rich diversity, including a wide variety of landforms, plant and wildlife species, as well as opportunities for dispersed primitive recreation and solitude. In reviewing an area proposed for wilderness designation, however, Congress attempts to balance wilderness values with economic values.

Where boundaries of a proposed wilderness area encompass a "checkerboard" pattern of landownerships, Congress provides for exchanges of private lands within the proposed wilderness area for lands outside the area. Likewise, blocks of cutover lands or short stretches of roads that constitute wilderness intrusions are permitted to revegetate.

In reviewing candidate wilderness areas and when making final designations, Congress recognizes existing and future land uses. Boundaries have been drawn for each area to provide exclusions for established activities, case-by-case on the basis of need. Exclusions have included rustic cow camp facilities, motor vehicle access to inholdings, roads, corridors for power and transmission lines, existing and potential ski developments, potential reservoir sites, and forest stands with commercial timber values.

Provisions for Hunting

Congressionally designated wilderness areas are administered so as to maintain most existing management practices. For example, management of wildlife populations through hunting is not changed by wilderness classification. If an area, such as in a national park, was closed to hunting before wilderness designation, it remains closed after establishment. Similarily, if it was open to hunting, such as in a national forest, it would remain so after being designated a wilderness area.

In 1983, the National Wilderness Preservation System consisted of 268 separate wilderness areas located in 42 States and totaled almost 80 million acres. Eighty-four percent of the acreage entered in the wilderness system in the lower 48 States is administered by the Forest Service, with the remaining 16 percent administered by the National Park Service (13 percent), Fish and Wildlife Service (2.8 percent), and Bureau of Land Management (0.1 percent).

In Alaska, the National Park Service and Fish and Wildlife Service administer 90 percent

Management of wildlife populations through hunting continues today in many National Forests after they have been designated wilderness areas.

of the 56.5 million wilderness acres, much of which is accessible only by aircraft or boat.

Additional areas under study or to be reviewed in the future will be considered by Congress as potential additions to the wilderness system. Inventory, classification, review and designations of candidate areas will continue as part of the resource planning exercises underway in the four Federal agencies mandated to identify potential wilderness areas. It is doubtful, however, if more than 2 percent of the Nation's land area will qualify and eventually be designated as wilderness.

Although Congress may exclude facilities and activities inconsistent with wilderness areas, uses within designated wilderness areas are prescribed by the Wilderness Act. With but

Number of areas and acreages in National Wilderness Preservation System, 1983

	Lower 48 States		Alaska		Total	
Federal Agency	*No.*	*Acreage*	*No.*	*Acreage*	*No.*	*Acreage*
Forest Service	150	19,799,417	14	5,453,366	164	25,252,783
National Park Service	27	2,988,322	8	32,355,000	35	35,343,322
Fish and Wildlife Service	44	652,184	21	18,678,232	65	19,330,416
Bureau of Land Management	4	12,206	0		4	12,206
Total	225	23,452,129	43	56,486,598	268	79,938,727

Wilderness areas, such as Mt. Baker Snoqualmie National Forest near Glacier in the State of Washington, total almost 80 million acres in 42 States. In the lower 48 States and Hawaii, 84 percent of the acreage is administered by the Forest Service.

few legal exceptions, ". . . wilderness areas shall be devoted to the public purposes of recreational, scenic, scientific, educational, conservation and historical use."

Certain uses are prohibited, with the exceptions stated in the Wilderness Acts (1964 and 1975), especially those dealing with existing private rights. Prohibitions include commercial enterprises and permanent roads.

B. Moser

Managing Fire

Uses established before Congressional designation of a Forest Service Wilderness Area may continue to be subject to agency administrative guidelines. Steps may be taken, where held necessary, to control fire, insects and diseases.

Mineral prospecting and mining is permitted in National Forest Wilderness Areas through Dec. 31, 1983, except where Congress specifically acts to curtail activities before that date.

Similarly, within National Forest Wilderness Areas the President—in a specific area—may authorize evaluations for water developments, including reservoirs and associated service roads. Livestock grazing, where established before 1964, is permitted to continue, subject to reasonable regulations.

Use of motorized equipment normally will be permitted in those portions of a wilderness area where it occurred before that area's designation as wilderness, or was established by prior agreement. Commercial services may be performed within the wilderness areas to the extent needed for activities appropriate for realizing recreational or other wilderness purposes. States retain jurisdiction and responsibilities for fish and wildlife.

All these provisions were set up by Congress to permit flexibility in tailoring management to the unique characteristics of each designated wilderness area. Necessary management facilities and activities are not prohibited, but the test is whether they are needed to meet the *minimum* requirements for administering an area. Management guidelines are set forth as Congress responds to specific areas and their particular situations on a State-by-State basis.

In considering management of wilderness areas, it is essential to recognize that these wild landscape remnants are "islands" of various sizes in a sea of intensively used lands. Fre-

Some former uses, such as grazing livestock, are permitted to continue in wilderness areas.

Frank M. Roadman

quently what takes place outside a wilderness area boundary can have impacts within the area. Likewise, actions and activities within a wilderness may impact on adjacent lands.

Historically, management of wilderness areas consisted of "drawing a line around it and leaving it alone."

Early leaders of the wilderness movement were concerned with keeping out development. They assumed that prohibiting road construction, logging and similar activities would perpetuate wilderness characteristics.

Loving It to Death

That approach was reasonably successful—until the volume of users began to reach overwhelming levels. Now, people are threatening to love wilderness to death.

Denuded vegetation, compacted soils and people-wildlife conflicts signal resource managers that more sensitive management actions are needed. Congestion in some wilderness areas reminds both visitors and managers that visits need to be timed and spaced to satisfy the objectives for naturalness and solitude. Continuing high demands for using these wild areas make their management ever more essential.

Studies in the last two decades show we must manage human uses and influences to perpetuate natural processes and satisfy specific wilderness objectives, and use only the minimum tools to achieve those objectives. Congress directed that common sense be used in applying management measures. Sensitive management for specific wilderness areas and situations is the continuing challenge for resource managers.

Just as Congress considers candidate wilderness area proposals State-by-State, so the four

Federal administering agencies must consider management measures case-by-case for each designated wilderness area. The agencies are doing this through established planning systems for forests, parks, refuges and national resource lands. Inputs from State fish and wildlife agencies, as well as from citizens, play a major role in assigning management objectives and methods.

Debates among State and Federal agency representatives on management practices, especially aerial fish planting in landlocked lakes, prompted the International Association of Fish and Wildlife Agencies in 1976 to develop *Policies and Guidelines for Fish and Wildlife Management in Wilderness and Primitive Areas*. This statement covered fish and wildlife research needs, facility development, habitat alteration, threatened and endangered species, and management of fish, wildlife and recreationists.

The goal was to develop policies and guidelines for fish and wildlife management in wilderness areas that would unify management among Federal agencies. States, particularly those in the West, that used the policies and guidelines found them useful in developing wilderness management plans. Some Eastern States, however, have identified needed modifications to make the statements more suitable for wilderness areas in their region. These needs have prompted preparation of a revised set of policies and guidelines that encompass all geographic areas. It is pending completion.

Grazing Review

In 1980, Congress mandated a review of all policies, practices and regulations of the U.S. Department of Agriculture (USDA) regarding livestock grazing in National Forest wilderness areas nationwide. USDA's Forest Service was instructed to implement new policies and practices where needed to conform livestock-grazing management in wilderness with the intentions of Congress.

Congress directed that wilderness designation not prevent maintenance of existing fences or other livestock management improvements, construction and maintenance of new fences, or improvements needed to prevent range deterioration. Increased grazing use can be permitted if the land management plan shows it will not adversely impact wilderness values. Decisions for managing grazing are to be based on a rule of practical necessity and reasonableness.

Within these Congressional guidelines, the four Federal agencies administering wilderness areas have flexibility to manage grazing in a site-specific fashion.

Similar practical guidelines for wildlife management are being developed by Congress. During reviews of proposed wilderness areas, it became obvious that certain fish and wildlife management activities were compatible and sometimes essential for managing native fish and wildlife as integral, natural components of remaining wilderness areas.

For many fish and wildlife species, wilderness areas are a source or reservoir for restoring populations to suitable habitats in other locations.

Wilderness areas are important to fish and wildlife. But large areas are required to perpetuate anadromous fish such as salmon, and wide-ranging carnivores such as the grizzly bear and wolf.

Spawning Streams

In the lower 48 States, wilderness areas sometimes are the last retreats for fish and wildlife populations. For example, in California's Central Valley, no more than 300 miles of an original 6,000 miles of salmon and steelhead trout spawning streams remain.

In a 1983 review of this and similar situations in California, Congress tentatively accepted recommendations for maintaining key drainages in their undeveloped state by including them in proposed wilderness areas. Wilderness designation was considered the only reasonable option to increase protection for fish that depend on these drainages for survival.

Pending action by Congress will help perpetuate water flows, fish populations, and primitive recreational values. Positive impacts on jobs and future revenues in fishing guide and outfitter services and tourism are anticipated. In addition, visitors will continue to have opportunities for primitive recreation such as hiking, camping, hunting, and photography. This recognition in California of the multiple values of outdoor recreation, both economic and those beyond dollar expression, deserves wider application.

To maintain and restore native wildlife populations, it is recognized that seasonal and annual habitat (space, food, water and shelter) requirements must be met. Thus, wilderness managers must consider fish and wildlife needs and not limit management considerations to recreational uses alone. Their challenge is to meet the mandate of the Wilderness Act to maintain the wilderness character of an area, including its native fish and wildlife populations, through using the minimum needed management tools.

Administrators are charged with maintaining natural habitats of all fish and wildlife, whether year-long residents, migratory species, or occasional visitors. Habitat needs of threatened and endangered species or populations are to be given priority attention.

The overall approach is to 1) Identify those habitat elements that are limiting fish and wildlife, and 2) When they are critical to animal survival, initiate actions to augment or restore them. A few examples illustrate types of situations requiring the attention of resource managers.

Bighorn Sheep

Historically, desert bighorn sheep ranged over a large part of southern California. Human settlement and expansion have confined the bighorn population to a fraction of the total area used formerly. Within the available range, a permanent supply of water is needed to support bighorns.

Maintaining existing water supplies is an accepted practice in wilderness areas, and developing additional supplies is permitted to enhance range use by bighorn, but only when essential to their survival. Use of mechanical equipment by resource management agencies to provide critical water for bighorns is permissible, but should be the minimum tool needed, as required by the Wilderness Act.

Awaiting further attention by Congress are such things as use of aircraft, motorboats and motor vehicles in wilderness areas for research and management; manipulating vegetation to provide essential foods and habitats for threatened, endangered and other species; use of prescribed burning—including allowing wildfires to burn under controlled conditions; and identifying procedures to avoid excessive human intrusions into wildlife habitat, to prevent wildlife displacements.

With many wilderness areas near human population centers, and visitor use increasing, it is paramount that guidelines for such use be completed immediately—particularly for those periods of the year when wildlife needs are most critical.

Research Natural Areas

Related efforts seek to establish a system of Federal Research Natural Areas, as well as a system of State Natural Heritage Programs. The Federal Research Natural Areas were initiated by the Forest Service in 1927, with the Santa Catalina Natural Area on the Coronado National Forest in Arizona. In the subsequent 56 years, additions to the national system were made and now total 441 areas administered by eight Federal agencies and the Nature Conservancy.

As originally conceived by the Forest Service, Research Natural Areas are established to:

"Permanently preserve in an unmodified condition areas representative of the virgin growth of each forest and range type within each forest region so far as they are represented within the national forests, to the end that its characteristic plant and animal life and soil conditions, the factors influencing its biological complex, shall continue to be available for purposes of science, research, and education."

Likewise, lands held by other Federal agencies and organizations were examined to identify qualified natural areas. These frequently occur as delineated parts of designated national wilderness areas.

Despite continuing efforts since 1927, the Federal Research Natural Areas System remains incomplete. For example, only 80 of 145 forest cover types identified by the Society of American Foresters in 1980 are represented in the Forest Service's Research Natural Areas network. Finding samples of those forest cover types absent from the network, and that will meet the "virgin" condition requirement, is becoming more difficult as people's activities continue to spread and impact the resource base.

Nevertheless, the value of using natural areas as controls to make comparative studies of developed areas grows in importance. Results of such research are critical to help design intensive management systems, which are required to yield multiple benefits, including satisfying increasing demands for fiber and food for expanding human populations.

Number of Federal Research Natural Areas, 1983

Agency or Organization	*No. of Areas*
Fish and Wildlife Service	194
Forest Service	148
National Park Service	64
Bureau of Land Management	23
Tenessee Valley Authority	4
Department of Defense	4
Department of Energy	2
Bureau of Indian Affairs	1
Nature Conservancy	1
Total	441

Nature Conservancy

In a complementary national effort, the Nature Conservancy has been working with the States since 1974 to develop a network of State Natural Heritage Programs. There are 28 programs in effect now, with about half housed in a State agency.

Through State agencies and its own efforts, the Nature Conservancy seeks to protect habitats for those wild species and ecosystems not protected adequately in national wilderness areas, Federal Research Natural Areas, or similar areas. The overall goal is to maintain viable examples, in adequate numbers, of all wild species and natural community types present in the United States.

Action centers on

1) Identifying the wild species and natural communities requiring protection,

2) Protecting the best examples through land acquisition and voluntary cooperative agreements,

3) Managing those lands where it is deemed necessary to do so, and

4) Raising funds to carry out these actions.

The basic premise is that, by maintaining examples of different natural communities, most wild species will be perpetuated. For example, protecting an oak-hickory forest will help ensure that oaks, hickories, robins, earthworms and all other associated wild creatures are sustained.

Citizen support for the Nature Conservancy has grown substantially since its first natural area, the Miannus River Gorge, was established in New York State in 1953. In the subsequent three decades, 1,700 areas encompassing nearly 2 million acres have entered the program. It now is the largest system of private natural areas in the world, harboring at least 80 plant and 56 animal species that the Federal Government considers threatened or endangered.

Natural Area Guidelines

Although areas included in the National Wilderness Preservation System, Federal Research Natural Areas System, and State National Heritage Programs maintain remnants of our precious natural heritage, it is their tremendous potential for yielding new knowledge to improve management of the total resource base that needs better recognition and understanding.

Guidelines for both Federal and State natural areas call for maintaining natural diversity, monitoring environmental changes, protecting from adverse environmental disruptions, conducting research, and permitting only compatible educational and recreational activities.

These areas are the best and least disturbed units of the landscape remaining for use as baseline controls in research. Studies of nonmanipulated natural areas and manipulated communities can provide the insight to improve understanding of successional changes and impacts of disruptions. Findings from such comparative studies can yield the insights required to develop management practices needed to yield sustained, multiple benefits, whether within wilderness areas or on intensively managed lands.

Further Reading

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Outdoor Recreation on Public Lands: Opportunities for Everyone

By Roy W. Feuchter and George H. Moeller

The outdoors have long held an attraction for Americans. The beneficial effects of outdoor recreation encompass many aspects of our lives. Individually we are enriched with physical and psychological well-being. Society as a whole benefits by the resulting increased productivity and better social interactions.

Economically, outdoor recreation supported by public land resources contributes to a $250 billion recreation and travel industry, the creation of jobs and demand for goods and services.

Our Nation possesses a vast public land base capable of serving a broad array of outdoor recreation interests. Nearly all Federal lands—755 million acres included in National Forests, parks, wildlife refuges, and public domain—are capable of supporting some form of outdoor recreation. Some 375.3 million acres are designated especially for recreation uses: as National Forests, parks, recreation areas, and other special areas.

The Nation has made remarkable progress in increasing the supply of publicly owned outdoor recreation resources over the past two decades. But use of public lands has increased proportionally faster than we have added acres. While Federal park and recreation acreage increased 3 percent over the past 20 years, recreation use has increased 138 percent.

Many Federal, State and local agencies manage for public recreation. The private sector adds many complementary opportuni-

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ties and services not available on public lands.

10 Agencies Involved
At least 10 Federal agencies are specifically mandated to manage land for public recreation. In the Department of the Interior, the Bureau of Land Management, National Park Service, and Fish and Wildlife Service provide a wide range of public recreation services. The Army Corps of Engineers manages a nationwide system of reservoirs and recreation-related facilities. The Forest Service, in the U.S. Department of Agriculture (USDA), provides more recreation than any other Federal agency: 43 percent of the total.

Agencies in USDA have programs directly related to enhancing opportunities for public recreation, through education and extension programs, technical and financial assistance programs, and actual supply and management of recreation facilities and services. Their various activities are carried out by three agencies: The Cooperative Extension Service, the Soil Conservation Service, and the Forest Service.

The Cooperative Extension Service provides a wide range of educational programs in outdoor recreation. Firms and individual entrepreneurs in the recreation and tourism industry receive marketing and management education and technical assistance, thereby improving their individual business income and adding to the overall economic viability of the outdoor recreation industry.


USDA

Through 4-H, young people acquire a variety of outdoor recreation skills.

Individual landowners learn to manage resources in ways that enhance wildlife and fisheries habitats. This, in turn, improves recreational opportunities for hunting, fishing, and other activities that increase potential profitability.

State and local government officials are assisted in setting up natural resource management plans that support outdoor recreation activities, and in developing local parks and recreation management programs. Through Extension's 4-H youth recreation programs, thousands of volunteer adult recreation leaders are trained, over 330,000 youths participate in camping experiences, and outdoor recreation career skills are learned through special interest projects.

SCS Contributions

Another USDA agency that contributes to the Nation's recreation facility supply is the Soil Conservation Service (SCS).

Since 1962, SCS has authorized nearly 500 public recreation developments under provisions of the Small Watershed Act. This legislation provides for technical and financial assistance to project sponsors that are non-Federal land agencies in acquiring land rights and developing public recreation facilities as integral parts of such projects.

Similar assistance is provided under SCS's Resource Conservation and Development program, in which needed conservation measures are applied to alleviate erosion problems on intensively used recreation areas, school playgrounds and athletic facilities.

Through its Conservation Operations Program, SCS each year provides technical assistance to individuals, groups, and units of government to help develop conservation plans that include recreational use.

154 National Forests

The 154 National Forests provide a delightful change from the sights, sounds and smells of the city, and from the sameness of an automated world. Whether or

not you have ever visited one, National Forests spread out a lush green carpet welcoming you to come share in their recreational enjoyment.

Recreational opportunities abound in these majestic woodlands that sweep the length and breadth of the Nation: 191 million acres, adapting chameleon-like to the varied climes and terrains through which they pass.

Far from the urban scene in mood, National Forests are within a day's drive of almost any starting place in the United States except Hawaii and Alaska.

Beverly Miller

Near Provo, Utah, a multipurpose reservoir provides flood control, irrigation water—and recreational opportunities. It is one of nearly 500 public recreation developments under the Small Watershed Act administered by USDA's Soil Conservation Service.

Even in Alaska, the railroad takes visitors daily from Anchorage to the Chugach National Forest.

Making National Forests available to all the people is central to national recreation policy. Congress, acting on recommendations from Federal and State agencies and outdoor enthusiasts, established a National Trails System that would be, "primarily, near the urban areas of the Nation."

Initial components of this trail system are the Appalachian Trail, a 2,100-mile journey from Katahdin, Maine through 14 States to its southern terminus at Springer Mountain, Georgia. Its western counterpart, the Pacific Crest National Scenic Trail, traverses the Sierra and Cascade Mountains on a 2,600-mile pas-

Leland J. Prater

Recreational opportunities abound in the 154 National Forests. Here, visitors enjoy Sliding Rock in the Pisgah National Forest in North Carolina.

sage through 23 National Forests between Canada and Mexico.

350 Recreation Trails

Over 350 National Recreation Trails on National Forests are another important part of the system.

A dazzling variety of recreational activities is represented by the 105,000 miles of trails, streams and woodlands on National Forests, 6,000 campgrounds and picnic sites, 300 swimming areas, 1,000 boating sites, and 250 water sports sites. Some of the most popular National Forest recreation is focused on snow-blanketed mountains, or on the tree-fringed lakes and rushing streams.

Last year 233 million recreation visitor days were recorded, or the equivalent of every person in the United States spending one 12-hour day in the National Forests.

Some of the most famous ski areas in the world are on National Forests—among them Vail in Colorado, Sun Valley in Idaho, Heavenly Valley and Alpine Meadows in Lake Tahoe, California, and Waterville Valley in New Hampshire. These are all private enterprises, operating as concessions on National Forests under special use permits which require payment of fees to the Federal Government for use of the public lands.

Urbanized recreation is the exception rather than the rule on National Forests where most people go "to get away from it all" and enjoy the pleasures of nature. Sunlight that must stream through a canopy of green to reach you— that is one of the charms of camping or hiking in a National Forest.

"The woods are lovely, dark and deep," and you can enjoy solitude on many, many acres of the National Forests in addition to the 25 million acres of wilderness areas. Established by Congress in 1964, wildernesses are areas touched only by the forces of nature, where people just visit and do not remain.

Million-Acre Canoe Area

A unique wilderness is the Boundary Waters Canoe Area, 1 million acres of water-linked land in the Superior National Forest in Minnesota. Criss-crossing the region are 1,500 miles of canoe routes on lakes that were formed millions of years ago out of volcanic depressions and filled with meltwater from retreating glacial ice. It is a journey that takes you beyond civilization.

The exhilaration of walking in a National Forest can be further heightened by taking self-guided tours down interpretive paths which describe the natural history and ecosystems of where you are.

Forest Service archeologists have opened a window on the world of the past by preserving the fragile traces—pottery shards, carvings—of ancient peoples who once inhabited parts of what are now the national forests.

Not being a hardy hiker need

not deter you from enjoying National Forests, since most have facilities modified for the benefit of the disabled. One example is an interpretive exhibit in the White Mountain National Forest in Colorado. It is designed to accommodate the blind and features an obstacle-free Braille trail that uses raised symbols to describe the area.

Year by year, recreation use on the National Forests has increased. In the past, camping was most popular while rugged mountain climbing and backpacking were relegated to derring-do outdoorsmen. In the last decade, there has been general participation in all forms of outdoor recreation.

Cross-Country Skiing

The most rapid growth has been in snow and ice activities, especially cross-country skiing. Dramatic increases in sales of boats and marine equipment have accompanied a surge in water sports—canoeing, sailing, rafting.

Studies have shown steady increases in wilderness recreation, and a recent Nielson survey indicates similar rises in campground and trail use for hiking and horseback riding.

Within the National Forest System, the National Grasslands also provide recreational opportunities. There are 19 National Grasslands comprising 3.8 million acres of Federally owned land intermingled with privately owned land.

The large open areas demonstrate sound practical grassland management that has multiple use applications including recreation—especially fishing, boating, hunting, camping, hiking, and in winter, snowmobiling. Brief excursions by local area residents and by those living in outlying metropolitan areas account for most of the visits. Recreational use is increasing as more people become aware that the National Grasslands are open to public use.

Future Demands

There is no precise way to project future demand and needed supplies of outdoor recreation facilities and opportunities. It is clear, however, that the public supply now available for outdoor recreation will have to be greatly expanded if even low levels of projected growth in demand are to be met.

Increased demands for some kinds of activities can be easily satisfied. For example, the Nation's forest and range lands and inland waters surely have the capacity to meet any foreseeable growth in demands for natural resource based outdoor recreation. This will, of course, require additional facilities in some cases, such as other trails, roads, access points, and campgrounds.

Meeting the prospective growth in demand for some activities may present special problems. As a case in point, it is becoming increasingly difficult to develop winter sports complexes, especially on public lands, due to the high costs of planning, mitigating environmental impacts, and providing for expanded needs for community services.

It seems evident that future demands for the use of unique and popular areas cannot be met in ways that have worked in the past. There is a similar situation in many wilderness areas. Wilderness use must be kept at low density levels if unmodified natural conditions are to be protected and if "outstanding opportunities for solitude" as described in the Wilderness Act are to be maintained.

As population has grown and public use has increased, adverse impacts from littering, trampling, and damage to structures also have risen. These problems are likely to grow more severe in the future.

In most densely populated regions, only limited land and water areas are available for many kinds of public outdoor recreation. In such cases the outlook is for overcrowding and declines in the quality of the recreation experiences.

Private Sector Aid

Intensive use of finite resources poses challenges to manage the recreation resource to achieve high quality recreation, equity in use, protection of the resource, and at the same time cost-effectiveness.

To provide sufficient recreational opportunities may require further private sector participation in furnishing public facilities on public lands. It will mean continued cooperation with private and volunteer organizations such as trail user groups in maintaining facilities, and the help of individual volunteers in accomplishing many needed tasks.

Many factors will influence outdoor recreation needs in the future. Increasing urbanization is creating the need for more areas of contrast. Being analyzed through research to provide background for future recreation management are social changes affecting family life, lower birth rates, longer lifespans, more leisure time, rising automation, different interest trends, added disposable income, changing ethnic populations, and shifts from one section of the Nation to another.

The growing importance of outdoor recreation to the American public, and associated problems that must be overcome to meet growing future demands, has been recognized by the Outdoor Recreation Policy Review Group in its report, *Outdoor Recreation for America—1983.*

Central finding of the policy review group is that ". . . outdoor recreation is more important than ever in American life—as a fundamental expression of our national character, for its benefits to individuals and to society and its significant contribution to the Nation's economy. It has become a major component of the health and fitness movement and remains a powerful force in the drive for environmental quality."

Keeping the Wild in Wilderness Recreation

By Robert C. Lucas

Robert C. Lucas is Project Leader, Wilderness Management Research, Intermountain Forest and Range Experiment Station, U.S. Forest Service, Missoula, Mont.

Wilderness! A word that stirs strong feelings which vary widely from one person to the next. But wilderness also has a particular, legal meaning, stemming from passage of the Wilderness Act by Congress in 1964.

The Wilderness Act created the National Wilderness Preservation System. Almost all the original wilderness areas were in the western United States. Only four were east of the Rockies, and not one was in Alaska. These first areas were all in National Forests and had been managed as wilderness since the 1920's and 1930's.

Many more eastern wilderness areas were added by a second Wilderness Act in 1975, and vast tracts of Alaskan wilderness were added in 1980. Other areas have been established in less spectacular spurts from year to year, including areas in National Parks, Wildlife Refuges, and National Resource Lands administered by the Bureau of Land Management.

In 1983 the National Wilderness Preservation System consisted of 268 areas in 43 States, with a total of almost 80 million acres. Four Federal agencies are responsible for protecting and managing parts of the system. Three agencies of the Department of the Interior—National Park Service, Fish and Wildlife Service, and Bureau of Land Management—care for 104 areas and almost 55 million acres. In the Department of Agriculture, the Forest Service has responsibility for 164 areas and over 25 million acres.

More than 70 percent of all wilderness acres are in Alaska, and cover 15 percent of the State. In contrast, only about 1 percent of the area in the lower 48 States (and Hawaii) is in the wilderness system. In Alaska, 57 percent of the wilderness acreage is in National Parks and 33 percent in National Wildlife Refuges, while in the rest of the country, 84 percent is in National Forests.

Enjoyment a Key Goal

What are the main purposes for which these 80 million acres have been placed in the National Wilderness Preservation System? The Wilderness Act's overriding objective is "to assure that an increasing population, accompanied by expanding settlement and growing mechanization, does not occupy and modify all areas within the United States. . ." The act goes on to direct that wilderness lands "be administered for the use and enjoyment of the American people" in such a way as will leave the lands "unimpaired for future use and enjoyment as wilderness. . ."

To meet this management challenge, a definition of wilderness is essential. The Wilderness Act's definition stresses preservation of natural conditions and natural ecological processes, essentially unmodified and uncontrolled by humans, and opportunities for solitude or primitive recreation.

Wilderness recreational opportunities fall toward the primitive end of a broad range of recreation. Wilderness recreation is characterized by nonmechanized access—foot, horse, boat; very little development, except trails; and relatively light use, in a generally natural unmodified environment.

The recreation settings vary enormously in many ways; size is one. Wilderness varies from

National Wilderness Preservation System, January 1983

Agency	*No. of areas*	*Percent of areas*	*Million acres*	*Percent of acres*
National Park Service	35	13	35.34	44
Fish and Wildlife Service	65	24	19.33	24
Bureau of Land Management	4	2	.01	—
Forest Service	164	61	25.25	32
Total	268	100	79.93	100

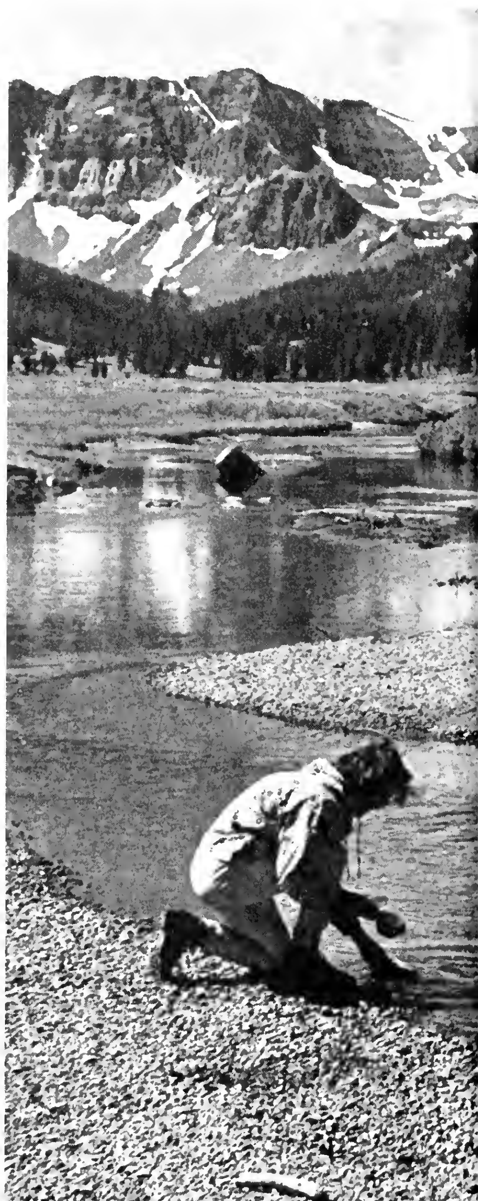
small islands with just a few acres to 8.7 million acres in the vast Wrangell-St. Elias National Park in Alaska. The average wilderness is about 300,000 acres in size (equal to a square about 21 miles on a side), but most are smaller than this. The larger areas provide more opportunity to experience remoteness from civilization, and often better preserve complete functioning ecosystems.

Mountains to Swamps

Wilderness also varies in ecosystems and landscapes. High mountain country is most common, but there are deserts, swamps, and tundra. Grasslands and lower-elevation deciduous forests are particularly scarce, mainly because they were so economically attractive that few remained undeveloped into this century.

Different policies among the four wilderness managing agencies also create diversity in recreational opportunities. For example, most National Park wilderness (except some in Alaska) is closed to hunting, while almost all National Forest and Bureau of Land Management wilderness is open during State hunting seasons. (About 17 percent of all wilderness visitors hunt, primarily for big game such as elk and deer.)

A few wilderness areas are closed to recreational use. These are small Wildlife Refuges, where managers have decided that protecting the natural ecosystem, and particularly shore birds and



Wilderness areas offer solitude and primitive recreation in natural settings—and challenge managers to keep it that way.

marine mammals, is not possible with recreational use. The "use and enjoyment" must be from afar or based on the knowledge that the areas exist.

These closed areas emphasize that a wilderness is *not* simply a recreational area, but rather a special, natural area which usually provides a particular type of recreational opportunity that both depends on and is consistent with preserving natural conditions.

5 Million Visits in '83

In the rest of the wilderness system, many visitors seek their own type of experience. Estimated recreational use of wilderness in 1983 totaled nearly 5 million visits and almost 15 million visitor days (one person present for 12 hours equals one visitor day). Two-thirds of all recreational use occurs on just 10 percent of the wilderness acres—excluding Alaska, where most areas are lightly used.

The most visited area is the Boundary Waters Canoe Area Wilderness in Minnesota, with about 1.4 million visitor days of use on its one million acres. However, other wildernesses are more intensively used on a visitor days per acre basis.

A few areas average almost 20 visitor days per acre per year; most are in California and North Carolina. At the other extreme, some wilderness averages less than one-tenth a visitor day per acre (200 times less intense use).

Variation in the intensity of use is also great within each wilderness. Typically, a few popular places account for most use, while other large sections are very lightly visited.

The most-used 20 percent of the trails in most wilderness account for two-thirds to three-fourths of visitor use. A few access points generally have a majority of all use, while many more trailheads are lightly used. In most areas visitors stick to the trail system, with few exceptions, and areas reached by cross-country travel are often almost empty.

Wide Range Offered

For visitors, this uneven distribution of recreational use provides a wide range of conditions to choose from, as well as keeping most of the wilderness free of the impacts caused by recreational visitors.

Depending on the visitors' preferences for solitude or social contact and for degree of evidence of other visitors, there usually are areas to suit them. For managers, however, this concentration of use may create problems of excessive impacts at popular places. The proper balance is not easy to find.

Hiking is the most common way people visit wilderness. Over three-fourths of all wilderness visitors are on foot. About one-tenth of wilderness visitors ride horses. Canoeing and rafting are other common ways of visiting wilderness, accounting for over one-tenth of all use.

Lake travel is most common in Minnesota's Boundary Waters. River travel is prominent in other wilderness, including the Salmon River in the River of No Return Wilderness, Idaho, the Snake River in Hells Canyon Wilderness, Oregon and Idaho, and the Flathead River in the Great Bear and Bob Marshall wilderness areas, Montana.

Wilderness visitors are a cross-section of America. Younger adults and college-educated people are most common, but all age groups are represented. Incomes are average to moderately above average. Most visitors are with family members. Most visitors come from the region near the wilderness, and over 90 percent travel on their own—without the services of outfitters or guides.

1-Day Trips Common

Most visits are not long, challenging treks. About half of all wilderness visitors make 1-day trips. But camping out on a longer trip is the adventure many dream of and seek when they enter the wilderness. Typically, campsites are isolated and undeveloped. Skill is required to camp with pleasure while minimizing impacts on vegetation, soil, and water at the campsite.

Management is difficult and complicated, but essential if wilderness values are to be preserved. Three types of management challenges stand out.

The first is to allow natural ecological processes to work throughout the wilderness with as little human interference as possible. This is essential to achieve the basic goal of the wilderness system as mandated by the Wilderness Act.

An important ecological process in most areas is also the one that modern humans usually have altered the most—natural fires. Most forests and many other vegetation types in wilderness have been shaped over the ages largely by periodic natural fires, generally caused by lightning.

Some plant communities—such as open ponderosa pine and grass types—had light fires frequently, sometimes as often as every 8 or 10 years. Others had severe fires once in several centuries.

Fires influenced the types of forests, meadows, and other plant communities in each wilderness, their distribution and size, and the sort of habitat available for wildlife.

Fire control began early in this century and became very effective. Natural fires were controlled most of the time and the ecological role of fire was sharply curtailed. As a result, landscapes may look different. For example, in some places trees have filled openings.

Fire Management Plans

In the last 15 years, park and wilderness managers recognized the inconsistency of excluding fire from natural ecosystems, and developed fire management plans in many wilderness areas that allow fire to more nearly play its natural ecological role.

Values outside wilderness need to be protected and risks to life and property minimized. This requires careful planning to specify the conditions under which a fire will be permitted to burn or will be controlled.

Wilderness fire management is quite new, although a number of fires have burned in wilderness—most small and a few large—as part of such programs. So far, only about 1 percent of the acres covered by wilderness fire management plans have burned.

Visitors usually have shown good understanding and acceptance of fire management. In the future, they will be able to see and experience more truly natural wilderness landscapes and ecosystems as a result of the return of natural fires.

The second management challenge is limiting the impact of recreational use on the wilderness environment. Visitors can trample vegetation to death, especially at campsites. More fragile plant species can disappear and tougher plants, often nonnative weeds, become more common.

Campfires can use up wood supplies, sterilize soil, and leave piles of ashes and blackened rocks. People and horses can cause soil erosion at camps and on trails. They can pollute water. They can disturb wildlife and interfere with their feeding and reproduction.

Growing recreational use poses the potential for increasing these visitor impacts. Since 1964, wilderness recreational use has more than doubled, with an average annual increase of about 5 percent.

Minimum Impact Camping

Managers deal with these problems in a variety of ways, but one of the most promising is a "minimum impact camping" education campaign.

Visitors and potential visitors—for example, a group of explorer scouts—are made more aware of the impacts they can cause and taught how to camp with as little impact as possible. They are encouraged to follow such practices as choosing campsites on higher, drier ground, camping in small groups, not ditching tents, not staying for long times in one place, cooking with campstoves instead of a fire, carrying out all trash, burying human waste well away from water, and—if horses are used—following special procedures.

Visitor education seems to be reducing impacts without some of the negative effects on visitors' experiences that may result from managers relying heavily on regulations. In some very heavily used places, the numbers of visitors have been limited, at least partly to keep impacts from becoming too numerous and too severe, and causing wilderness characteristics to fade away.

USDA

Visitor impact on the wilderness is apparent at this camp: Horses tied to the trees have compacted soil, exposed tree roots, and wiped out vegetation; campers have cut down trees. Careless or unskilled wilderness visitors pose serious problems in wilderness areas, problems that may grow as recreational use increases.

The third major management challenge is providing visitors opportunities for high quality wilderness recreational experiences.

Many things contribute to a good wilderness experience. Some of the most important are the number of other parties that visitors encounter, where they meet others, how the others behave, adequacy of the information visitors have about the area, the kinds of evidence of other visitors that they see (litter, bare ground at campsites, remains of numerous campfires), the degree of freedom available to visitors to explore and experience the area, the number and type of regulations imposed on visitors, and how regulations are explained and enforced.

"Minimum impact camping" is one of the most promising education campaigns used by wilderness managers. This well-chosen campsite in the Absaroka-Beartooth Wilderness in Montana minimizes impacts. It is on hard, dry ground, away from the lakeshore. A campstove is used rather than a wood fire.

Visitor Preferences

Managers try to provide for high quality experiences in many ways. In a number of places, managers limit the number of visitors, not only to control impacts but also to keep congestion and loss of solitude from detracting seriously from visitors' experiences.


Robert C. Lucas

A majority of wilderness visitors prefer to camp out of sight and sound of other campers. This leads to managers limiting the amount of use allowed in some places; trying to inform visitors of crowded and uncrowded places and times; encouraging people to choose campsites farther back from shorelines, screened by trees or terrain; and suggesting that campers be reasonably quiet.

Most managers try to allow visitors as much freedom as they can while still protecting precious wilderness conditions. And managers strive to use education and information as management tools where feasible, limiting regulations to only those that are essential.

In the 20 years since passage of the Wilderness Act in 1964, managers have gained experience in wilderness management. Research has improved knowledge of visitor motivations, satisfactions, and factors related to the severity of the environmental impacts caused by recreational use. Visitors have increased greatly in numbers, but also seem to have improved their wilderness ethics and skills.

The overriding challenge is to accelerate improvements in management, the knowledge base it depends upon, and visitor skills, so wilderness will truly be an enduring resource for present and future generations.

Further Reading

Wilderness Management. By Hendee, John C., Stankey, George H., and Lucas, Robert C. For sale by Superintendent of Documents, Washington, D.C. 20402.

Wilderness U.S.A. National Geographic Society, Washington, D.C. 20036. $10 per copy.

Surface Mining Areas Can Be Restored, or Left to Ugliness

By E. Wayne Chapman

E. Wayne Chapman is a Soil Conservationist in the Land Treatment Program Division, Soil Conservation Service.

A power shovel big as an office building bites into the earth, piling up row on row of rock and soil to get at a vein of coal . . . An auger with a 7-foot bit bores into a hillside, and coal works its way out like wood shavings . . . A floating barge dips its big chain-bucket into a streambed for a load of sand and gravel . . . An ore-laden train snakes its way out of a giant open pit.

Through these and other operations, surface mining is carried on. From this activity we get many minerals, fuels, and building materials that help our Nation grow and that provide energy and jobs. In the process, the land is changed—laid bare, rearranged into parallel ridges, or scooped out like a soupbowl.

Properly treated and managed, the land can be returned to safe and productive use, can even become a greater asset to the community than it was before mining. Left untreated it may produce only stream-fouling sediment, acid and ugliness.

For many years the U.S. Department of Agriculture (USDA) has been helping private landowners and mine operators restore their surface-mined land. This has been done as part of the landowner's regular conservation program of wise land use and conservation treatment in cooperation with local Soil and Water Conservation Districts. USDA also has done restoration work and research studies on the national forest land that it administers.

The Department's experience and skills range from preplanning mining so that offsite damage is prevented, to designing and supervising specific practices needed to reclaim the land after mining.

Federal law requires all coal-mined land to be properly reclaimed and provides an incentive for reclamation of the abandoned land mined before 1977.

This chapter provides information about the amount of land disturbed by surface mining, where it is located, and what is being done to reclaim the land after mining. It discusses the Rural Abandoned Mine Program (RAMP) administered by USDA, including examples of successful reclamation projects.

Early Mining Cave-Ins

Near the turn of the century, there were 14 coal mines near the small east Texas towns of Hoyt and Alba. Lignite coal from the mines furnished fuel for steam-powered locomotives for the Texas and Pacific Railroad and for a Morton Salt Company plant at nearby Grand Saline. Today the once-bustling mining area, which in its heyday supported about 3,500 people, has a population of around 500. Dairy and beef farms occupy the area where mining took place from 1860 until the last mine closed in 1946.

As was the case in many other mined areas in the United States, the approximately 1,000-acre area affected by these 14 mines was not properly reclaimed. In fact, the landscape resembled an area raked with heavy artillery fire.

The coal was mined by the "pillar and room" method. Miners dug a long tunnel all the way to the end of the vein, which was 20 to 120 feet below the surface. They then mined the coal in room-sized sections off the main tunnel, leaving a pillar of coal between the main tunnel and the room. After the room was mined, they dug the coal from the pillar.

Many years later the rooms began to cave in, causing deep holes and presenting a safety problem for area residents. One of the main highways built over the mined area caved in and had to be closed while being repaired.

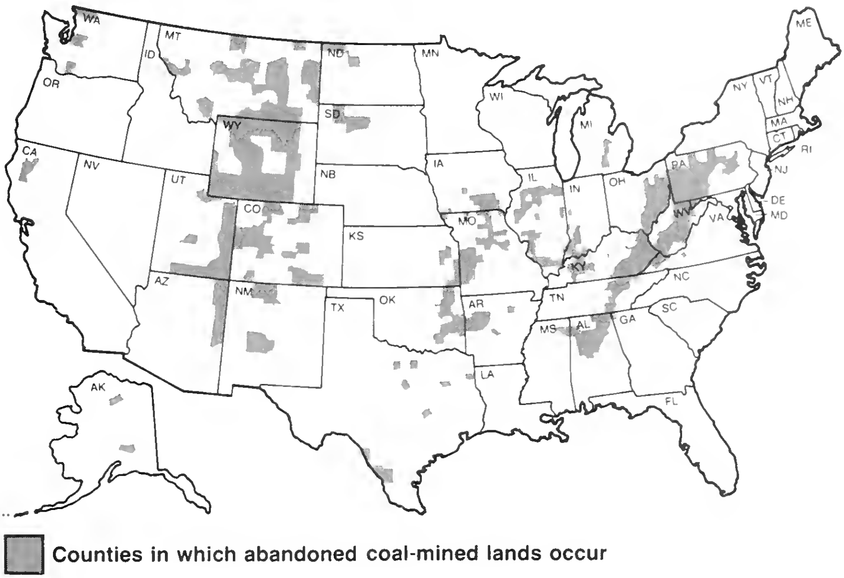
Problems other than dangerous sinkholes or mine shafts include polluted air and water caused by acid runoff and sediment from mined areas. Fires in coal refuse piles (gob), surface mine spoil, and some abandoned coal mines cause a safety and health hazard as do crumbling highwalls and old mining structures. (A highwall is a vertical cutbank 50 to 100 feet high that remains after mining operations.)

Large Expanses Affected

Surface mining occurs in all States and affects a wide range of soils, vegetation, ecosystems, and climatic zones. The acreage disturbed is a small percentage of the Nation's total land area, only about .25 percent of the land mass of the United States.

Although only a small percentage of the Nation's land area is disturbed by surface mining, its effects extend far beyond the land actually damaged.

Land Distributed by Surface Mining as of 1977



Because mining is concentrated in a few areas, however, it totally devastates those environments. These changes, in turn, often affect a larger expanse than the area physically disturbed.

USDA'S Soil Conservation Service (SCS) made a county-by-county inventory of mined land in 1977. As of July 1, 1977, the mineral industry had disturbed 5.7 million acres in the United States—an area about the size of Vermont. Some 3 million acres of this land have been reclaimed by the mining companies, landowners or naturally. About 2.7 million acres still need reclamation.

Coal mining accounts for about 1.1 million acres of the unreclaimed areas, sand and gravel pits for about 800,000 acres. All other types of mining—including stone, phosphate, iron, clay, and gold mining—account for the remaining 800,000 acres.

In 1977, after more than a decade of public debate about the best way to deal with the environmental damage caused by mining, the 95th Congress enacted the Surface Mining Control and Reclamation Act. This act, which is administered by the Department of the Interior, has two major objectives: To ensure that all land mined for coal in the future is adequately reclaimed, and to reclaim abandoned coal-mined lands that pose a hazard to the public and to the environment.

The act established an Abandoned Mine reclamation Fund

High Priority Reclamation Funding

Primary Problem	Number of Projects	Reclamation Grant
Fires	75	$ 28,091,600
Subsidence	241	27,390,800
Slides	86	11,636,800
Shafts	152	6,614,500
Refuse Piles	11	2,829,300
General	110	36,744,900
Total	675	$113,307,900

into which all active miners pay at the rate of 35 cents per ton of coal mined from surface mines and 15 cents per ton of coal produced by underground mining. These payments represent income to the Government of about $200 million per year. At least half of the reclamation funds collected in each State must be returned to the State for use in its reclamation program.

The Office of Surface Mining Reclamation and Enforcement (OSM) of the Department of Interior, in conjunction with States, provides funds for emergency and other high-priority reclamation projects. As of January 31, 1983, OSM had provided $113 million from the reclamation fund for 675 such projects.

Rural Projects Set Up

Up to 20 percent of the abandoned mine reclamation funds may be transferred to the Secretary of Agriculture for use under section 406 of the act. This section authorizes the Rural Abandoned Mine Program (RAMP), which is administered by SCS.

The first RAMP contract was signed in 1978. As of Jan. 31, 1983, SCS had signed 322 RAMP contracts with individual landowners for reclamation projects. These projects are located in 18 States—Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Maryland, Missouri, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Virginia, West Virginia, and Wyoming. Reclamation cost of the projects is about $34.6 million.

RAMP projects are in rural areas. After reclamation the land is expected to be grassland, forest land, wildlife habitat, or have other noncommercial uses. RAMP projects are not of an extreme emergency nature.

Solving mine problems involves three primary actions:

- Correcting the hazard. This includes closing shafts and adits (mine entrances), burying acid materials, stopping the slide, quenching the fire, and creating a stable condition.
- Reconstructing topography and a soil material that will maintain stability and support the planned use. This includes a safe water removal system including practices such as terraces, underground outlets, and grassed or stone-lined waterways.

- Establishing vegetative cover that will protect the area from erosion and support the planned use.

Mine reclamation sites are much more fragile than ordinary farmland and require careful monitoring for several years. Excessive settlement, acid spots, and failure of installed erosion control practices are all hazards of mine reclamation and must be corrected promptly for a successful project.

Completed projects eliminate hazards and improve environmental quality for residents of the surrounding area, as well as returning the land to a useful condition for the landowner. Examples of some completed projects follow.

Lake, Airport Improved

Residents of the subdivison around the 588-acre Wee-Ma-Tuk lake near Cuba, Ill., are proud of the Thompson RAMP project that has improved water quality of their lake. Runoff from a large acid "gob" pile, left when the coal mine above the lake site was abandoned over 20 years ago, was polluting the lake. Besides being the recreational hub of the subdivision and the golf course, the lake serves as a water supply.

Current owner of the farm where the abandoned site was located is Ronnie Thompson, a livestock and crop farmer. Under his RAMP contract, he reclaimed the site by burying the acid "gob" material in a pit and covering it with four feet of good topsoil. The area was then planted to grasses and legumes to serve as hayland and wildlife cover . . .

"November 3151 Whiskey. Left downwind. Preparing for final approach, runway 1 at Brazil."

Chances are this pilot will land safely at Arthur Municipal Airport near Brazil, Ind. At one time, though, dangerous crosswinds caused by gaps in the mine spoil adjacent to the runways would have made landing hazardous.

A huge spoil bank, 20 feet high with two big gaps in it, has been reclaimed under RAMP.

Fish, Wildlife Benefits

Fish and wildlife have an improved home as a result of the Bethel Burdine RAMP project in Pulaski County, Kentucky. Before the project was undertaken, an estimated 350 tons of toxic-laden silt per year ran into nearby streams from the eroding abandoned coal-mined site.

The ugly, eroding roadbank along the main highway has been eliminated. A dangerous pit has been filled and grasses, legumes, and shrubs planted to provide food and cover for wildlife . . .

Work is underway on the Snowville, Ohio, project to reclaim 700 acres of abandoned coal-mined land that scar the rolling grassland farms surrounding this Meigs County community.

Many streambeds in the area, and much of the adjacent valley farmland, are completely filled with acid sediment from the abandoned mined land. Flooding of roads and farmland is common because of the sediment.

Work will be done in seven phases. Phase I, which included 90 acres of the most erodible areas in upper reaches of the watershed, was completed in 1982.

Other Case Histories

A reclamation project adjacent to the rural Appalachian village of Morris Run, Pa., illustrates the conversion of eroding mine culm (spoil) banks and abandoned coal company buildings to a green hillside. Another RAMP project to reclaim a 25-acre site near the northeast edge of town is being completed.

This still leaves an open shaft, more mine spoil, a highwall, and some mine subsidence for future reclamation. When reclamation is finished, the 150 families of Morris Run—who are celebrating their 150th anniversary this year—will be able to enjoy a safer and a healthier environment . . .

Ten of the landowners who farmed about 400 acres of the 1,000 acres of abandoned mine land near the east Texas towns of Hoyt and Alba, mentioned at the beginning of this chapter, have recently reclaimed their land. They filled in the holes and planted the area to grass and trees and established a loblolly pine plantation. Special plantings such as wild plum, autumn olive, fruit, and mulberry trees were made to benefit wildlife . . .

In 1982 the NCAA semifinal soccer game between two small eastern colleges—Bethany and Scranton—was played on a reclaimed coal mine site in West Virginia.

Before reclamation, an unsafe coal dam was impounding 2 million gallons of water—threatening downstream homes and property along Buffalo Creek. This hazard, along with a 40-foot highwall adjacent to nearby housing subdivisions and Bethany College, created a real potential for loss of life.

Part of the highwall was backfilled to form a flatter slope and planted to grass and trees. The remainder was fenced to keep small children from falling over the highwall into the creek. The reservoir behind the unstable dam was filled with earth, creating a 2-acre area for a soccer field and leaving a new safe fishing pond and surrounding recreational grounds.

Active Mining Aid

USDA technical assistance is available to help land users, State reclamation agencies, and mining companies develop and apply reclamation plans for new mining. The Surface Mining Reclamation Act requires certain USDA involvement. Some of the major requirements are:

- The State regulatory authority

Under the Rural Abandoned Mine Program (RAMP), this site, adjacent to Morris Run, Pa., was reclaimed to eliminate the eroding mine spoils and old buildings.

Tim McCabe

is to consult with the SCS state conservationist to ensure that a reclamation plan is developed which will return the land to its premining level of production if prime farmlands are within a mining permit area.

- The Secretary of the Interior is to solicit USDA views before approval of the State reclamation program.
- USDA is to determine whether or not mining will be permitted in national forests in the western part of the Nation.

Plants for Reclamation

SCS began testing plants for reclaiming mine spoil in the 1940's. Since then the agency has released more than 40 varieties for this use. Among them are 'Tioga' deertongue, 'Arnot' bristly locust, 'Lathco' flatpea, and 'Appalow' sericea lespedeza.

One plant currently being evaluated is smooth sumac, Rhus *glabra*. To select a superior smooth sumac, a shrub that grows well on shallow soils and has leaves that turn a beautiful red in fall, SCS compiled one of the broadest collections of the plant ever made. The collection covered 41 major land resource areas in Missouri, Iowa, and Nebraska, and the 18 States east of the Mississippi River and north of Tennessee.

Over 200 different plants selected by SCS personnel because of superior characteristics are being evaluated at the SCS Rose Lake Plant Materials Center near East Lansing, Mich.

USDA's Soil Conservation Service provides assistance to land users in developing and applying reclamation plans for mined lands.

John Massey

How Farmers Affect Natural Resources

By Sandra S. Batie

Many of our natural resources are either owned or influenced by farmers. Our 2.4 million farms occupy over 900 million acres. Use of these lands influences the appearance of our Nation's rural landscape, the quality of our water and air, as well as the amount and type of our wildlife.

In short, farms are an important part of the ecosystem we depend on. Not only do farmers influence our natural resources; the quality, quantity, and price of natural resources influence farmers' profits and ultimately their ability to continue in farming.

The farm sector is extremely diverse. A tobacco farm in the Virginia Piedmont bears little relationship to an irrigated vegetable farm in California's Imperial Valley or to a dryland wheat farm in the Palouse country of Washington State.

A 65-cow dairy farm in New York may scarcely resemble a corporation-owned drylot enterprise with 10,000 cows in Arizona.

Still, each of these farms influences and uses our Nation's resources: Agricultural land, water, energy, and wildlife.

Beliefs and Practices

To a farmer, agricultural land is an input in a production process; land is needed to produce crops or graze animals. Yet the meaning of land to many farmers—perhaps most—transcends its production capacity. The land is a storehouse of wealth, a heri-

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Earl R. Baker

Farming in the United States is extremely diverse. A dryland wheat farm here in the Palouse of Washington State, for instance, bears little relationship to an irrigated vegetable farm in the Imperial Valley of California or to a tobacco farm in the Piedmont of Virginia.

tage from the previous generation, and a bequest to the next. To many farmers, land is something special and precious.

But farmers have to be business-minded to succeed. Thus farmers may hold strong beliefs on the wisdom of land stewardship and also farm in such a way as to cause considerable soil erosion.

Erosion remains a national problem despite a half-century of government programs to combat it. The U.S. Department of Agriculture estimates that cropland erosion still occurs at an estimated rate of 2 billion tons of soil a year. Although measuring soil loss is difficult, widely used tools show that four regions have severe water-caused erosion problems:

1) The Palouse and Nez Perce areas and the Columbia Plateau of western Idaho, eastern Washington, and north-central Oregon

2) The cropland soils of Nebraska, Kansas, Iowa, and Missouri

3) Uplands of the southern Mississippi Valley, and

4) Cultivated areas in Aroostook County, Maine.

Furthermore, almost 70 percent of the erosion exceeding 5 tons per acre is on less than 8.6 percent of the total cropland acreage.

Erosion Can Cut Yields

Erosion reduces the depth of topsoil, impairs the soil's capacity to retain water, and thwarts infiltration of water and air into the soil. As a result, soil erosion can ultimately reduce crop yields.

But measuring yield reductions due to soil erosion is difficult because, over time, farmers may substitute increasing amounts of fertilizers or use other technologies to enhance the soil's natural fertility. Also, erosion effects on crop yields differ by soil type, crop, and management practices.

Studies indicate, however, a relationship between erosion and reduced yields on many soils. If erosion has reduced the soil's water-holding-capacity, the rooting depth available to the plant, or the water infiltration rate, adding fertilizer may not offset the yield-reducing effects.

Erosion also affects air and water quality. Agriculture is considered the main source for that part of the Nation's water pollution that comes from diffuse (nonpoint) sources. Sediment in water runoff carries along fertilizer residues, pesticides, dissolved minerals (such as salts), and animal wastes (with associated bacteria).

Excessive sedimentation can clog navigation channels and can dirty drinking water, adding costs to rectify both, and can reduce recreational opportunities. Also, in some areas, sediment is rapidly filling inland lakes and reservoirs.

Soil erosion is considered a problem because it can ultimately reduce crop yields. The sediment in water runoff is

no less of a problem—contributing substantially to the Nation's water pollution problems.

The Profit Factor

If erosion reduces yields, water, and air quality, why don't all farmers practice conservation? A major reason is many conservation practices do not pay for themselves. However, this is not because the practices are ineffective.

Farmers can choose among many soil conservation techniques such as changing the characteristics of a field's topography with terraces, planting only the least erosive lands, rotating crops, stripcropping, planting on the contour, retaining crop residues on the field surface after harvesting, constructing waterways, or using methods such as no-till.

No-till is a technique that eliminates almost all tillage, and chemicals—rather than conventional plowing—are used to control weeds. On some croplands this can reduce erosion rates 60 to 95 percent.

Many of the techniques are not profitable, however, or not perceived to be so. A business-minded farmer—who must be competitive to remain in farming—is not interested in practices that don't pay. Even a farmer with a strong land ethic and a desire to practice soil conservation may find it financially impossible to do so.

Mining the Soil or Not

For the business-minded farmer, a decision to maintain, improve, or deplete soil is largely an investment decision.

For some tracts of land, conservation may be economical for the farmer when the land is first cultivated. This might be true on fairly flat land where the topsoil is shallow but highly productive, and the subsoil of substantially poorer quality. In this situation, losing an inch of topsoil could reduce yields dramatically. Erosion could be reduced inexpensively if, for example, contour plowing or residue retention were used.

On other tracts where conservation requires major land-moving technologies to form terraces and where straight-row, highly erosive cropping patterns can bring a high dollar return, private economics may dictate mining the soil. This is particularly true where the original topsoil is very deep.

Other financial factors also influence the farmer's decision on conserving soil. The lower the price of soil substitute, such as fertilizers, the less likely the farmer is to conserve. Also, the lower a farmer's current net income, the less likely he or she is to conserve, since substituting future income for present income is financially impossible.

While many soil conservation practices may not be economical investments for farmers, there are exceptions, such as conservation tillage, contour plowing, and leaving residue on the field after harvest. In some areas these practices are effective in reducing erosion and may even increase profits.

Farmers can choose among many soil conservation techniques. On this cropland in southwestern Iowa, the farmer has chosen to plant on the contour and use conservation tillage. These practices are effective in reducing erosion and in some areas of the Nation may even increase profits.

The Nation's policymakers currently are considering changes in conservation programs to make them more effective in reducing soil erosion on croplands. If incentives are provided so farmers will conserve the soil when and where it is appropriate, substantial progress can be made in both retaining soil for future production and improving water and air quality.

Cropland in Use

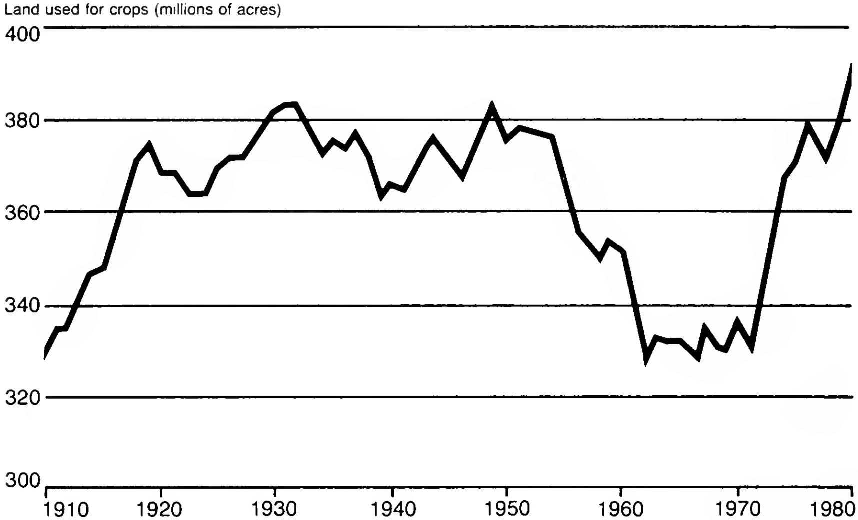
Erosion influences the quality of our farmland. Another dimension is the quantity of farmland.

The amount of land in crops was relatively stable from 1920 through 1950, varying between 360 to 380 million acres. That was followed by a decline to a 1962 low of 331 million acres, mainly due to tremendous advances in yields per acre during the 1950's.

Next there was a relatively stable period when land used for crops averaged about 330 million acres until 1972. Then the land used for crops began to increase, reaching a new high of 391 million acres in 1981.

Considerable regional shifts occurred in the use of cropland. Over a third of the cropland decline took place in the Northeast, Southeast, Appalachia and the southern Plains. Other regions increased their cropland acres. Recent rises were mainly in the Mississippi Delta States, the northern Plains and the Corn Belt.

Cropland in Actual Production



Source: USDA

Land Shifts Too Big?

These trends and changes have led many to question whether too much land is being converted from agricultural to nonagricultural uses.

Numerous studies have been made of the physical adequacy of our total cropland base relative to future land requirements. Many researchers concluded there will not be land shortages endangering food and fiber production, although there may be some increases in the real costs of production.

These aggregate statistics do not mean there should be no concern about conversion of agricultural lands to nonagricultural uses, however.

First, many communities enjoy the visual, cultural and financial benefits from a viable agricultural industry. Thus, some communities are willing to forego benefits from whatever alternative uses would have replaced agriculture in the region. Therefore they are interested in reducing the incentives for farmers to sell their land to nonagriculturalists.

Second, some farmlands have unique characteristics for producing specialty crops—such as cherries in the Great Lakes States; citrus in the warmer regions of California, Texas, and Florida; or wine grapes in the coastal States.

If these lands are converted to nonagricultural uses, replacing their production within the Nation could prove expensive. More controlled environments might have to be provided, production costs could rise, or yields decline. Furthermore, producing these specialty crops may give a region a unique cultural attribute the community wishes to preserve.

Agri-Urban Patterns

Thus many communities are looking for techniques providing farmers with incentives to continued farming. The search for viable techniques is not easy since frequently the communities most interested in retaining agricultural land already have a land-use pattern best described as "agri-urban."

Agri-urban is an intermixture of farm and rural residential uses with no clearly defined boundaries for either use. This usually means the demand for land for development and recreational purposes is strong, property taxes are high, and friction between neighbors over normal farm practices and suburban uses is great. Therefore, farmers may have many incentives to sell their land.

Irrigation Use

Use of water for irrigated agriculture has tripled since 1940. This growth has been possible in part because of low energy prices for water pumping and Federal subsidies that have kept the cost of water low. Irrigation now accounts for over a fourth of the value of the Nation's crops.

Much of the growth in water use has been concentrated in the midwest, in States overlying a vast underground lake—the Ogallala Aquifer. Farmers have used wells to raise water from the aquifer to grow sorghum, corn, and alfalfa, some of which has been fed to cattle.

However, the era of both low cost water and low cost energy appears over. Where farmers rely on ground water such as the Ogallala Aquifer, declining ground-water tables coupled with rising pumping costs make irrigation water more expensive.

High energy costs make it less attractive to pump surface water over long distances as in transferring water from one river basin to another. Also, western surface water sources are, for the most part, already fully appropriated, so new users increasingly will have to bid water rights away from present users.

This combination of falling water tables and rising energy costs means, long term, that ground-water irrigation will decline. Farmers are adjusting to higher irrigation costs by adopting water conservation measures; still, the relative profitability of irrigated farming to dryland farming has dropped.

Salinity Problem

Increased irrigation not only impacts on water supplies, but may result in rising soil and water salinity. Some researchers estimate that as much as 25 to 35 percent of irrigated lands in the West have a salinity problem.

Maintenance of wetlands, careful application of chemicals, and maintenance of border strips at the edges of fields are all measures farmers can—and do—take to provide the quality of habitat necessary for wildlife.

Salinity can result in significant loss in yields and profits, and farmers are seeking ways to reduce the problem. One way, drip-irrigation, reduces the amount of water needed to irrigate effectively. Another involves recirculating water. The least salty water is used first on the crops most adversely affected by salt. As the water gets saltier, subsequent uses are on less sensitive crops.

Role of Chemicals

Most farmers rely on chemicals to raise crop yields: fertilizers, herbicides, and insecticides. While these chemicals have many beneficial effects, some—if they find their way into water bodies or the food chain—have been implicated as posing threats to human or animal health.

Chemicals are very expensive inputs, and farmers do not like to see off-farm chemical losses any more than the general public. The problem exists in part because stopping the movement of chemicals to inappropriate places is also expensive.

Techniques exist for curtailing use of chemicals without cutting


Erwin L. Cole

yields. One—integrated pest management—in some cases substitutes biological and other methods for chemical control. In other instances it involves using chemicals as effectively as possible so not as much is required. Organic farming methods may cut chemical needs without reducing net farm income.

Energy, Wildlife

Historically, the farm sector has responded to relatively low energy prices by substituting chemicals and fuel for labor and land. Fuel, for example, can be used to irrigate crops and offset vulnerability of the harvest to bad weather. Energy—through chemicals—can protect crops from pests.

Energy has been used not only to improve yields, but to curb crop spoilage risks after harvest—by drying or refrigeration.

Still, energy is a small proportion of total production costs; 3 percent of total energy use in 1974 was for food production. So farmers do not make dramatic adjustments to rising real costs of energy. Changes are occurring, however, to reduce the use of energy for irrigation via water conservation measures such as irrigation scheduling, or reducing chemical use with more fertilizer-sensitive plants, recycling animal wastes, or integrated pest management.

Besides producing food and fiber, cropland, pastureland and rangeland are—if managed correctly—excellent habitat for many wildlife species. Border strips at the edge of fields, carefully applying chemicals, and maintaining wetlands can provide the quality of habitat needed.

In contrast, converting wetlands to cropland, planting fence row to fence row, and removing windbreaks all may have harmful effects on wildlife. What's more, irrigation expansion can bring river systems below the water level needed to support fish and other water-dependent species.

While in some cases protecting wildlife habitat will mean tradeoffs in agricultural production, often relatively minor changes in farm operations can avoid detrimental wildlife impacts or increase positive effects.

Family Farming: Corn, Cattle, and Conservation

By Mary M. Cressel

"I never wanted to do anything but farm," says Jim Martin of Decatur County, Indiana. For the Martins, farming is a family business—and conservation farming a way of life.

Martin and his son Jon, 23, own and operate Coffee Tree Farm, a general livestock and grain operation on 659 rolling acres in the southeastern part of the State. The land was first farmed by Martin's grandfather.

Jim and Jon Martin do all the farm work themselves, except for specialty work such as fertilizer spreading and some repairs. Another of Martin's sons, Ric, 27, helped run the farm until recently when he joined the Army.

"If we really need help," says Martin, "we wait for my two daughters, Pam and Jan, and their husbands to come home for the weekend—then we put them to work." Other helpers include Martin's wife Lou, who teaches third grade, and his father, Donald C. Martin, who at 83 still helps keep an eye on the cows.

Why the name, Coffee Tree Farm? There is a stand of coffee trees, but there's more to it than that. "We have a soft spot for the coffee trees," explains Martin. All the Martin children grew up tackling various 4-H conservation projects. For one forestry project, the whole family gathered leaves—but the coffee leaf, which was more than two feet long, was too big to fit on the display board. So the leaf itself

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was used as the subject of yet another 4-H demonstration project.

The coffee leaf project won a statewide 4-H contest, and several other 4-H'ers borrowed it and used it in surrounding counties.

What's Best for the Soil

Coffee Tree Farm is a productive operation because land-use decisions have always aimed at what's best for the soil. "We looked at the land," says Martin, "saw that some of it was rolling enough to erode, and decided a cattle operation was best."

The farm produces mostly corn and cattle, but hogs, soybeans, and a few acres of woodland complete the operation. Diversity of land use is matched by diversity of conservation practices. These include conservation tillage, terraces, woodland improvement, pasture renovation, and wildlife habitat development.

Jim Martin's awareness of conservation began in high school. There, in vocational agriculture classes, he learned about terraces and other conservation practices. But the Martin family has long been conservation-minded. In the early 1940's, Donald Martin got guidance on efficient farm management from Extension specialists at Purdue University.

"Dad used a five-year crop rotation system and put land in pasture that was too steep to use for cropland. We knew we had to manage our land to control erosion if the farming operation was to survive."

Crooked Terraces

So in 1944 the Martins installed one of the first gradient terrace systems. Some people call them "crooked terraces" because they closely followed the land's contour but were not parallel. The distance between each terrace could vary considerably. This made them somewhat inconvenient to farm.

"Those old crooked terraces were the first practice we built to control erosion," recalls Martin. Much later, in 1970, Coffee Tree Farm would have a complete conservation plan. The plan was prepared with the help of the U.S. Department of Agriculture's Soil Conservation Service (SCS), and Martin continues to update it.

Following the plan, Martin has installed a grassed waterway, grade stabilization structure, and sediment control basins. The waterway carries excess runoff off the field, the grade structure lets it down a steep drop so a gully won't form, and the sediment basins allow sediment to settle out before the runoff leaves the farm and heads for a nearby stream.

Martin is well known as an innovator in Decatur County, and his use of no-till is one of the main reasons why. With no-till, crops are planted directly into the residue from the previous crop. The residue protects the soil from erosion, conserves moisture, and adds organic matter.

When Martin began using no-till, in 1974, he was one of the first farmers in the county to do so. His neighbors watched closely for the results.

Martin bought a four-row no-till planter to plant corn in red clover sod. "We learned a lot that first year," Martin remembers. "The second year was more successful. We're pleased with our no-till corn and doublecrop no-till soybeans after wheat."

Sprays When He Plants

The no-till soybeans weren't too successful at first, because of weeds. SCS district conservationist Ersel Rogers recalls that spraying for weed control wasn't effective because Martin was spraying at the wrong time. "Jim found a solution," says Rogers. "He mounted saddle tanks on his tractor and sprays at the same time he plants. And that is his last field operation until harvest."

Because of the Martins' diverse farm operation and willingness to try new conservation techniques, other farmers pay close attention to Coffee Tree Farm.

"When we started farming," explains Martin, "our land was right next to the country church, so everyone saw what we were doing. Dad always said, 'If you're going to flop, you may as well flop *big*.'

"One year we sprayed a hayfield by that church to get the field ready for no-till corn. One Sunday, long enough after spraying that the field had turned brown, no one at church could imagine what we had done to the hayfield. I told them it wasn't a hayfield—it was a cornfield.

"We didn't have a very good stand of corn that year, but folks told us later that we'd proved we were right—it *could* be done."

The no-till corn is always the Martins' best, thanks to their experience and patience. Their land has been the center of attention for many no-till tours and demonstrations. Martin talks to farmers all over Indiana about conservation tillage, and has helped many get started themselves. He even hosted a group of Brazilians who were interested in conservation farming.

Neighbor Switches

Bill Reichenbach, SCS area conservationist for southeastern Indiana, says it's important to have people like the Martins in the community, people who don't mind having their farms used as conservation showcases.

"I asked one of the Martins' neighbors," recalls Reichenbach, "why he finally changed to no-till. He said he'd been watching the Martins real close for about four years because he didn't think no-till would work. When he realized it did, he switched."

Jon Martin says, "We're better off no-till farming than fall-plowing with a moldboard plow. No-till and parallel terraces are re-

Dewey Bearl

SCS district conservationist Ersel Rogers (left) discusses Jim Martin's conservation plan that was developed in 1970. Under the plan Martin has installed a grassed waterway, terraces, and sediment basins to control erosion. He started no-till farming about nine years ago.

placing the old crooked terraces. We've got only one terrace left that was built in the 1940's."

The Martins have begun installing parallel terraces with underground tile outlets. The parallel terraces and the outlets control runoff from the field and make it easier to farm. Jon has a bulldozer, so father and son will do most of the work themselves. The tile is in place already, although the terraces aren't built yet.

Waste management is a high priority for the Martins, who own 125 Angus cows. With cost sharing from USDA's Agricultural Stabilization and Conservation Service (ASCS) and planning help from SCS, they have installed a manure pit made of precast concrete. The pit is 80 feet long, 35 feet wide, and 8 feet deep. It is located directly below the slotted floor of the cattle barn.

Rainwater that runs off the barn roof is channeled into the pit to make the waste fluid enough so it can be removed by a pump. It is then spread on the cropland as a fertilizer.

Rotation Grazing

The Martins use rotation grazing on their 170 acres of pasture. They use a no-till seeder to fertilize and renovate the pastures. Always looking for a new approach, the Martins are trying the Savory method of rotation grazing. This method was first used on wild game farms in South Africa.

The Martins' 28 acres of fenced pasture have been divided into five parcels. Electric fences maintain the respect of the cattle for the boundaries of these parcels. The shock doesn't injure the cattle, but they only brush against it once.

"The cows come running when I call them to switch fields," says Jim Martin. "They've learned that the grass really is greener on the other side. With the Savory method, I'm able to run more cattle on a smaller area, and it should eliminate damage to the soil and plants that overgrazing and trampling can cause."

The Martins grow grain sorghum to supplement forage supplied by the pastures. They green-chop the sorghum and feed it to the cattle. They have

Martin feels that pasture management is very important. These cows are on a rotation grazing system in which they are put on a fresh pasture every three to four days. This enables him to carry more cattle per acre.

also developed three springs and two ponds to provide water for the beef cows.

Son Ric started the Martins' hog program before he joined the Army. He worked hard renovating old buildings to cut expenses, and by the time he left for boot camp the sow herd had grown to 18. Jim and Jon miss Ric's help with the hogs, but they don't mind the extra income that the hogs represent.

Woods and Wildlife

Trees have always been plentiful on the Martins' property, and woodland management and wildlife habitat are their newest areas of conservation work. The forestry division of the Indiana Department of Natural Resources (IDNR) prepared a management plan for 11 acres of black walnut and other hardwood trees to be managed for timber production. With the right mulching, thinning, and pruning, the Martins hope the walnuts will be more productive.

Two acres of open land have been planted to walnut. Between these trees the Martins planted European black alder. The alders will keep the black walnut growing straight and tall, and the shade they cast will naturally "prune" lower limbs of the walnut trees. The alders also supply the soil with nitrogen, which the walnuts need for good growth. The woodland is fenced to keep out livestock.

The IDNR conservation officer helped the Martins stock fish in the two ponds, which were originally built for livestock water and recreation. The newest pond has been fenced and turned into a haven for wildlife. IDNR supplied the Martins with wildlife seed packets. The packets contain seed of white and red pine, 'VA-70' japonica lespedeza, redbud, 'Cardinal' autumn-olive, and a mixture of dogwoods. Ducks, quail, raccoon, and songbirds—including at least one Baltimore oriole—use the habitat area.

Martin's activities in conservation and agriculture extend far beyond his own farm operation. He is a past president of the Decatur County Beef Cattle Association and a member of the National Cattlemen's Association.

He also is current president of the Indiana Beef Cattle Association. "Many people connected with the association," says Martin, "are concerned about soil conservation as well as environmental controls. Being president is an endless job of promoting the industry and making it easier for cattlemen to make a better living."

Farmer of the Year

For 9 years Martin served as district supervisor for the Decatur County Soil and Water Conservation District (SWCD). During part of that time he was district chairman. He has also served with the Indiana Association of SWCD's as Area 7 chairman and chairman of the Forestry Committee.

Martin and his family were proud when in 1982 the Indiana Farm Bureau named him Conservation Farmer of the Year in recognition of his conservation work and his dedication to wise land use and efficient farm management.

But the Martins are prouder still of the legacy that conservation will provide for future generations at Coffee Tree Farm.

This open area planted to walnut and alder trees is part of Martin's woodland management development which

Dewey Bearl

was planned by the Indiana Department of Natural Resources. The soil is excellent for timber production.

Specter of Another Dust Bowl Seems Laid to Rest

By J.D. Schwien, W.O. Willis, and A.R. Grable

The Dust Bowl of the 1930's is probably the most widely discussed and analyzed drought in the history of the United States. Impact of that drought on the land and the people who lived there was catastrophic.

Driving across the Great Plains today, however, one can see few after-effects of the drought. The once-ravaged land now produces an abundance of wheat, sorghum, corn, and forages and range for livestock. Huge feedlots dot landscapes where dust clouds rolled 50 years ago. Center-pivot sprinkler systems create a mosaic of greenery over much of this same land during the driest of summers.

But can this bounty be sustained? Drought is a frequent visitor to the Great Plains. And tree-ring studies show that the one in the 1930's was not the worst in either duration or intensity. We know we can expect the visitor again; we just don't know when.

Farming, especially dryland farming, is a risky business in the Great Plains. Drought is not the only threat. Hail, insects, and crop diseases cause severe damage periodically. Blizzards and severely cold temperatures are not uncommon during the winter. Hot, dry winds are particularly damaging to crop growth during some stages of plant development. And the decline of ground water levels compounds the problem in some irrigated areas.

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John White

The once-ravaged Great Plains now produces an abundance of wheat, sorghum, and corn, as well as forages and range for livestock.

In response to the Dust Bowl, Congress enacted legislation to start or accelerate programs to restore soil and crop productivity in the Great Plains. A variety of programs provided technical and financial assistance to farmers and ranchers.

Windbreak Plantings

For example, the Agricultural Conservation Program provides assistance to install conservation practices through long-term agreements. Other programs were added over the years to help farmers guard against return of the Dust Bowl. The Great Plains Conservation Program provides technical assistance as well as cost-sharing to landowners to minimize the hazards of recurring drought and wind or water erosion.

Ranchers and farmers who manage rangelands have received assistance in designing planned grazing systems for better soil and water conservation and plant and animal production. Through rural development programs, rural communities have gained municipal and industrial water supplies, irrigation water, and recreational areas.

The Resource Conservation and Development Program, led by the Soil Conservation Service (SCS), helps residents to improve the condition and use of natural resources and environment and to provide economic, cultural, and recreational opportunities. Through cooperative State and Federal programs, an

Farmers and ranchers receive technical and financial assistance from USDA for a variety of conservation efforts. Here, a South Dakota farmer

Gene Alexander

discusses stubble-mulch tillage with the district conservationist from USDA's Soil Conservation Service.

estimated 2,500 miles of field windbreaks are planted annually by landowners to protect cropland from wind erosion, save energy, and provide wildlife habitat.

By targeting funds and technical expertise to the Nation's most serious natural resource problems, U.S. Department of Agriculture agencies such as SCS and the Agricultural Stabilization and Conservation Service are helping to reduce soil erosion and save water where losses have been extremely high.

Stubble-Mulch Tillage

Supporting those action programs in the efforts of individual farmers are research and education programs in the different States. During the 1950's, research led to the development and wide-scale adoption by dryland farmers of stubble-mulch tillage. This practice leaves residues on the soil surface to protect against erosion and reduce evaporation of soil water. Stripcropping also helps to reduce erosion.

Concurrently, scientists developed improved crop varieties that withstand drought, insects, and diseases. Improved farming equipment became available along with farm chemicals of various kinds.

Farmers in eastern Colorado who use herbicides to control weeds can save from 5 to 9 trips over a field with a cultivator. Controlling weeds is important because they can consume 2 to 3 inches of soil water and up to 30 pounds of available nitrogen per acre—the equivalent of several bushels of wheat.

The combined effects of all these programs, plus the stewardship and hard work of many farmers, have eliminated in most people's minds the spectre of another Dust Bowl.

Wheat Yields Soar

In the central Great Plains, during the past 50 years, yields of winter wheat have more than doubled, from about 15 to 35 bushels per acre. The acreage of abandoned wheat plantings declined from 28 to 10 percent.

The region now produces a significant part of the wheat that is exported to overseas markets. The yield increases are worth over a billion dollars per year to the U.S. economy. And these increases occurred during a period in which precipitation actually declined by about 2.5 inches per year!

Recent assessments by researchers and others have attributed yield increases to improved cultural practices that store more water (40 to 45 percent), more productive wheat varieties (35 to 40 percent), improved equipment for planting and harvesting (15 to 20 percent), and improved fertilizer and herbicides (5 to 15 percent).

Scientists and farmers feel that higher yields can be produced in the future, even under less than optimum conditions. Wheat varieties will continue to improve gradually in productivity and tolerance to drought and other stresses.

The number of effective herbicides will increase, thereby making no-till and chemical fallow practices more practical and reliable. This will reduce both soil erosion and energy consumption. Careful use of fertilizers will help to maintain soil fertility for future generations of farmers.

In the northern half of the Great Plains, using grass barriers and terraces to capture and hold snow on the fields holds promise for both reducing wind erosion and snowmelt runoff.

Water Use Efficiency

The key to farming successfully in the uncertain conditions of the Great Plains now and in the future is the integration of all these factors into practical farming systems that use water efficiently.

Stopping the evaporation of water from bare soil, which accounts for 50 to 70 percent of the precipitation received, could increase yields dramatically in good years as well as help to ensure at least adequate yields when drought occurs. But no effective or economical method for doing this has been discovered. At present, the best way to control evaporation is to keep crop residues on the soil surface with no-till, eco-fallow, and other conservation tillage practices.

These practices will be the foundation of dryland farming systems for the future. They may also be useful, along with other techniques, for conserving water in irrigated areas and thereby extending the life of ground-water reserves and making the transition from irrigated to dryland farming easier.

Plains Farmer's Story

An increasing number of farmers in the Great Plains are using and perfecting conservation tillage, including no-till systems, and related technologies. Virgil Kochis, for example, farms 2,000 acres of wheat near Limon, Colo., on the High Plains.

"When I started the eco-fallow or reduced tillage program in 1976, after a dry winter that caused high wind erosion and low yields, I treated 400 acres with ½ pint paraquat and 1 quart atrazine per acre. Results were satisfactory, so the next year I doubled the acreage treated," says Kochis.

"By the end of the second year, which was very dry, I was convinced that eco-fallow was the type of farming I wanted to pursue."

Now Kochis' total wheat acreage, 2,000 acres, is in the reduced tillage program. He averages two sweep plow operations on the land, one in early July when the atrazine begins to dissipate from the soil and the second late in August before seeding the wheat.

"My goal in using eco-fallow is to increase yields, reduce wind erosion, conserve moisture, and reduce production costs," says Kochis. "My records for the past six years show that I have made money by changing from a tillage method that required four to seven tillage operations to one that requires two tillage operations and has produced higher yields.

Fuel, Tractor Savings

"I figure I save $8,000 in tractor fuel alone with my eco-fallow program," he says. "With conventional tillage, we put 2,000 hours per year on three tractors. With reduced tillage, we only need one tractor and we only used it 261 hours last year."

Kochis sees several other advantages in conservation tillage. Crop yields have increased by eight bushels per acre and soil erosion has been reduced. Equipment inventory has been cut from three tractors, four one-way plows, two springtooth harrows, two rodweeders, and four drills to only one tractor, one sweep plow, and four drills.

"The new tractor we purchased in 1980 may last throughout my farming career because fewer tillage operations are required in eco-farming," Kochis says. He also claims that weed populations are considerably reduced and problem weeds like pigweed and purslane virtually eliminated. Finally, the ground left with stubble retains more soil water near the surface, resulting in a fuller stand of wheat.

Kochis says that eco-farming requires fine-tuned management—precise application of herbicides, soil testing, proper fertilization—and the desire and dedication to make the program succeed.

In 1982-83, Kochis tried no-till on 300 acres. This wheat averaged 61.6 bushels per acre. He was so pleased with the results

Kochis' tillage schedule for the 3 tillage systems, and yields per acre for each

Month	*Conventional tillage*	*Eco-fallow*	*No-till*
July	sweeps	chemical application	chemical application
Sept.	sweeps	—	—
May	sweeps	—	air application
July	rodweeder	sweeps	—
Aug.	crustbuster	sweeps	air application
Sept.	—	rodweeder	—
Yield Per Acre	28 bu	35 bu	*40 bu

*No-till yield is a projected average, since there is only one year to base yields on.

that he drilled 1,200 acres of wheat into no-till residues last September.

Brothers Use No-Till

Dee Neiman and his brother Ed from Haxtun, Colo., have been farming no-till for 4 years. "We've made a 16-inch rainfall zone into the equivalent of 27 inches," says Neiman. "No-till is very effective in conserving soil moisture."

Neiman believes that if farmers can get good enough prices for their crops, in the next few years many will buy new equipment and switch to no-till.

Darryl Smika, with USDA's Agricultural Research Service at Akron, Colo., agrees that no-till is the very best system for producing wheat in eastern Colorado.

"You get greater water storage in the soil profile and correspondingly higher yields," says Smika. "Wheat yields increase on the average by 5 to 8 bushels per acre for each additional inch of available water above 10 inches."

Other benefits include reduced soil erosion and improved soil tilth, which provides a better seedbed and allows the seed to be drilled shallower.

With farmers now applying the results of extensive research, chances of another Dust Bowl seem very small. Only with extreme disregard for the soil, such as massive plowouts of fragile grasslands, could we conceivably set ourselves up for another Dust Bowl. We don't foresee this happening.

All aspects of dryland farming, especially water-conserving practices and drought-tolerant crop varieties, have been improved during the past 50 years. Further increases in the production of crops and soil-conserving residues are possible by integrating all these improvements into efficient and reliable farming systems.

As shown by research and practical farm experience, keeping crop residues on the soil is the most critical step in developing those systems. Even during drought, residues will protect the soil from erosion and help conserve rainfall.

With continued innovation by farmers and ranchers, and support for research and action programs, the demise of the Dust Bowl should be fact rather than fancy.

A Good Life for Wildlife on the Farm

By Edward C. Soutiere

I first hear them during the night. Mid-September and the first of the Canada geese are arriving. Honk! Honk! Honk!

Family groups of four or five break off from the small flock of a dozen or so and settle onto the 17-acre refuge pond across from the office. By tomorrow a hundred geese will be on the pond, resting after their 1,500-mile flight from the breeding grounds in northern Canada.

Arriving flocks will become larger and more numerous over the next few weeks. By late October there will be 15,000 geese and again as many ducks on this one pond. That is a sight we never tire of seeing. But it hasn't always been like this at Remington Farms.

Remington Farms is located on Maryland's Eastern Shore, across Chesapeake Bay from Baltimore. This is prime farmland: Dairy farms, truck farms, even a few horse-breeding farms, but mostly large cash-grain farms growing corn, soybeans, and small grains. The generally flat fertile landscape is much like the rich agricultural Midwest.

Remington Farms is unique among agricultural operations, in that its prime objective is to demonstrate how farming and wildlife management can coexist in harmony, each complementing the other. But at the same time its farming methods typify those in general use by other cash-grain farms.

Wildlife, like the crops, is a product of the land. Good soils

Edward C. Soutiere is Assistant Manager for Wildlife Management, Remington Arms Co., Inc. His office and home are at Remington Farms, Chestertown, Md.


Tim McCabe

Remington Farms manager Hugh Galbreath (left) reviews the farm conservation plan with Ralph Timmons, district conservationist for USDA's Soil Conservation Service. Remington Farms has had a conservation plan for 27 years.

produce good crops—and good wildlife. It behooves us all therefore, to manage our lands wisely. And wise land use is what we are demonstrating at Remington Farms. It all began 27 years ago with a plan.

Conservation Plan

Working with scientists and technicians at the local office of the U.S. Soil Conservation Service, we developed a conservation plan for Remington Farms. The plan has changed many times over the years to reflect new farming methods, and new knowledge, but our goals remained: Protect the soil, raise good crops, provide a good life for wildlife.

Food, water, shelter and adequate living space are the basic requirements of all living creatures, man and wildlife. Satisfying these basic requirements of wildlife during all seasons on today's modern farm is a challenge. But fortunately most farms have odd areas, varying in

size and topography, which are unsuited for agricultural crops and can be managed in simple ways to benefit wildlife.

Come along, and we will join the 30,000 people who take the Self-Guided Habitat Tour of Remington Farms each year. We'll make a few stops and examine how wildlife management can be integrated into the modern farming operation.

First stop, the crop fields. Corn, soybeans, and winter wheat provide the farm income. In spring, the fields are planted using conservation tillage, including "no-till" methods. Crop residue and trash left on the soil surface by these tillage methods reduce soil erosion and help keep the ponds and streams free of silt. The cover provided by last year's stubble in the "no-till" fields even attracts a few nesting pairs of bobwhite quail and of field sparrows.

Food for Wildlife

In fall and winter, after harvest, the fields are left covered by the stubble and crop residues. A fortuitous byproduct of

Canada geese and ducks arrive by the thousands each fall at Remington Farms on Maryland's Eastern Shore. The farm is managed to demonstrate how farming and wildlife management can coexist in harmony.

today's mechanized farming, the waste corn kernels and soybeans spilled by the modern combine feed huge flocks of wintering Canada geese, snow geese, mallards and pintail ducks.

Deer, doves, rabbits and a host of other wildlife join the ducks and geese in gleaning these waste grains left in the fields.

Ahead, a hedgerow of autumn olive separates the field edge from the county road. Over the years we've planted various kinds of fruiting shrubs to supplement both the wild plant foods and the waste grains.

In fall, songbirds and game birds alike harvest the fruit of amur and tartarian honeysuckle, autumn olive, and silky and gray dogwoods. Planted along farm lanes, field edges and around the farmstead, these shrubby hedgerows provide nesting cover to a dozen species of songbirds, and in the depth of winter, provide invaluable shelter to some 30 kinds of mammals and birds.

For the farmer, the hedgerows reduce soil erosion, and add beauty and privacy to the farm lanes and homesteads.

An immature bald eagle searches for food in a natural wetland area on the farm.

Grassy Cover

Proceeding to the more hilly upland part of the farm, we see the danger of soil erosion is greater. Grassed waterways, roadside filterstrips, and diversion terraces collect rainwater from the adjoining cropfields and move the water gently down the slopes.

Planted to cool- or warm-season grasses and lespedeza, these strips produce food for wildlife. Their edges shelter nesting quail, mallards, and several ground-nesting songbirds. The white-tailed doe also finds the dense grassy cover an excellent location to hide her fawns.

We mow every other year, and then only after the nesting season is complete, to control the invasion of unwanted trees into the strips.

The farm pond ahead is just one of several built on Remington Farms over the past 27 years. The Soil Conservation Service provided engineering and design help. Cost-sharing was available from the county office of the U.S. Agricultural Stabilization and Conservation Service.

This pond is a deep, steep-sided pond managed for fishing. Stocked with bass, bluegill and catfish, the pond provides hours of fishing and swimming fun for the farm's employees and their children. Other ponds on the farm are managed for ducks.

Built shallow, 24 inches or less deep, the duck ponds are drained and planted to Japanese millet in late July, and then reflooded in October to provide a

For the benefit of wildlife, nest boxes are used in many of the ponds and wetlands on the farm.

watery duck pasture. Thousands of ducks are attracted to the ponds, providing excellent hunting opportunities in the surrounding area.

Farm ponds provide water for livestock, conserve and replenish the ground-water table, and can serve as a source for irrigation water. Located near the farm buildings, they provide fire protection and can result in lower insurance rates.

Waterfowl Rest Areas

Besides the pond by the office, we set aside several other ponds on the farm as waterfowl resting areas. Because waterfowl concentrate in such large numbers on their wintering grounds, undisturbed rest areas are essential to good management. Such rest areas hold ducks and geese in the area and result in a more even hunting opportunity over the season.

Pond margins are planted to perennial grasses and legumes.

A shrub border separates the grassy edge from adjacent crop fields. Like the grassed waterways, this margin filters water entering the pond, extending the pond's life. Rabbits, quail, mallards and songbirds use the margin for nesting and escape cover.

The variety of fish, insects, amphibians and turtles that make a farm pond home provide an excellent food source for other wildlife that hunt at the ponds—osprey, great blue and little green heron, egret, tree swallow, and raccoon are but a few. What better place to spend a moment or two, binoculars in hand, watching wildlife?

Driving on, we pass a crop field put into the 1983 cropland retirement program, PIK. Planted to a clover and grass mixture to provide protection and nitrogen-fixing for the soil, these fields will be excellent nesting areas. Also, good "bugging" areas for the quail and wild turkey chicks—where they eat insects.

Timber Improvement

Returning to the flatter bottom land, we pass one of the several woodlots on Remington Farms. Most of our trees are young, 5 to 10 inches in diameter. The forests on the farm were cut for timber repeatedly by the previous owners.

The trees are too small to harvest for lumber, and too young to produce many fruits and acorns for wildlife, so we are improving the timber stand in these woodlots with the advice of the State forester. Cutting firewood, we remove poorly shaped trees, freeing better quality trees for faster growth—and greater future income.

This thinning lets in more sunlight to the forest floor. Succulent grasses and herbs, berry bushes and seedling trees grow in the sunlight, providing food and shelter to white-tailed deer, wild turkey, and woodcock.

These young trees lack the cavities, usually found only in more mature woods, that are the homes of squirrels, bluebirds, screech owls and other cavity-nesters. So each winter we build a few nest boxes, and erect them in the woods and on the woodland edges.

Last stop on the tour is my home. The homestead site is the one location where every farmer can fit wildlife into the farming operation. Using a variety of flowering and fruiting shrubs and deciduous and conifer trees, we've made our home more attractive not only to ourselves, but to wildlife. The mockingbird wakes us in the morning and the mourning dove puts us to sleep at night.

Falcons Move In

The nest box I put up in the rafters of the pole barn was intended to attract a barn owl. They are rare here. But a pair of kestrels (falcons) moved in. That's OK, I'll just put another box up this winter for a barn owl.

The spruce and fir tree windbreak on the northwest side of the lot deflects winter winds.

Crop fields are tilled using conservation tillage. Crop residue left on the soil surface reduces erosion and holds moisture for the new crop.

The experts tell me a well placed windbreak can reduce the winter fuel bill as much as 30 percent. I do know the windbreak is the nesting site preferred by mourning doves.

Doesn't integrating wildlife into the modern farming operation take time and generate added costs? Yes.

The question of time is easiest to handle. Plan ahead, and do a little each year. The well-managed farm is a lifetime's work, frequently the lifework of several generations. It is amazing what can be accomplished in just 27 years.

Hunting Offsets Cost

The question of cost is more difficult. Deer damage corn and soybeans, geese graze the winter wheat. And despite my best efforts at fencing, rabbits eat the green bean plants in my garden each year.

But the damage is not excessive. Allowing hunting on the farm serves to keep the wildlife populations in check, and can generate added income. In portions of the United States, hunting is a major industry.

Here, on Maryland's Eastern Shore, waterfowl hunters pay as much as $100 a day for the privilege to hunt. Farmers commonly earn $10 to $15 an acre per year on leases for hunting rights.

The cost of developing and setting aside wildlife habitat can be kept low. Use the free technical assistance available from the State fish and wildlife agency and the local office of the Soil Conservation Service.

Identify the critical areas on your farm that are subject to excessive soil erosion. Consider growing wildlife, not crops, on these acres.

Take advantage of the cost-sharing available for many conservation activities through the county office of the Agricultural Stabilization and Conservation Service.

Make sure these conservation practices are designed to do double duty. Frequently the benefit derived from a practice that reduces soil erosion is sufficient justification for its cost. The added benefits that accrue to wildlife can be free.

Then every farm will provide a good life for wildlife.

No-till planting—a form of conservation tillage—reduces soil erosion while providing

Tim McCabe

cover for ground-nesting wildlife.

Irrigating Better With Less Water: Small Watershed Success Story

By Douglas A. Bishop

The critical natural resource of the 1980's may well be water. Will there be enough to sustain irrigated agriculture in the West? Will farmers be forced to return to dryland farming? Or, can they irrigate better by using less water more effectively?

In Oregon, a group of farmers are irrigating the same or more crops with less water. This is their success story.

Before 1977, the Wolf Creek watershed in northeast Oregon was typical of many small watersheds in the Western States. Today, it has reached the potential that exists for many western watersheds. The difference is the completion of a federally assisted small watershed project authorized under Public Law 83-566 (the Watershed Protection and Flood Prevention Act of 1954).

To irrigate the same or more crops with less water, an irrigator must have better control and better management. That means storing excess runoff to provide a dependable water supply, having an efficient system to deliver water from the source to the farm, and applying water to crops more efficiently.

The technology to do this is available, but cost—especially the cost of energy—holds back many farmers. Irrigators who use water supplied by the Wolf Creek project have eliminated energy cost by harnessing gravity. The result is an enclosed, completely controlled system to deliver

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water to the farm and a highly efficient pressurized sprinkler system, with no cost for energy.

If gravity-pressure water is what made the Wolf Creek project technically feasible, assistance from the U.S. Department of Agriculture (USDA) helped make it happen.

USDA's Soil Conservation Service assisted with project planning and design, provided roughly 50 percent cost-share on project construction, and helped with conservation planning and designing irrigation systems on individual farms.

Powder Valley Water Control District, the primary project sponsor, financed its share of the costs with a USDA Farmers Home Administration loan. USDA's Agricultural Stabilization and Conservation Service made cost-share funds available to individual farmers for installing on-farm sprinkler main lines and other practices.

Community Benefits

The entire community has benefited from the Wolf Creek project. Although irrigation is the main purpose, the project provides multipurpose benefits including flood control, fish and wildlife habitat, and water-based recreation.

The Wolf Creek project provides water to 30 farmers who irrigate about 13,000 acres. About 8,700 acres are irrigated with gravity pressure sprinkler systems, and 4,500 acres are flood irrigated.

Before the project, Wolf Creek water users did not have a reliable water source. They diverted water from Wolf Creek and other small streams in the area. Precipitation there totals only 10 to 12 inches annually. Most of that falls as snow; only a fraction comes as mid-to-late summer rainfall. Often the farmers were flooded in the spring, then had too little water for irrigation during the summer growing season when they really needed it.

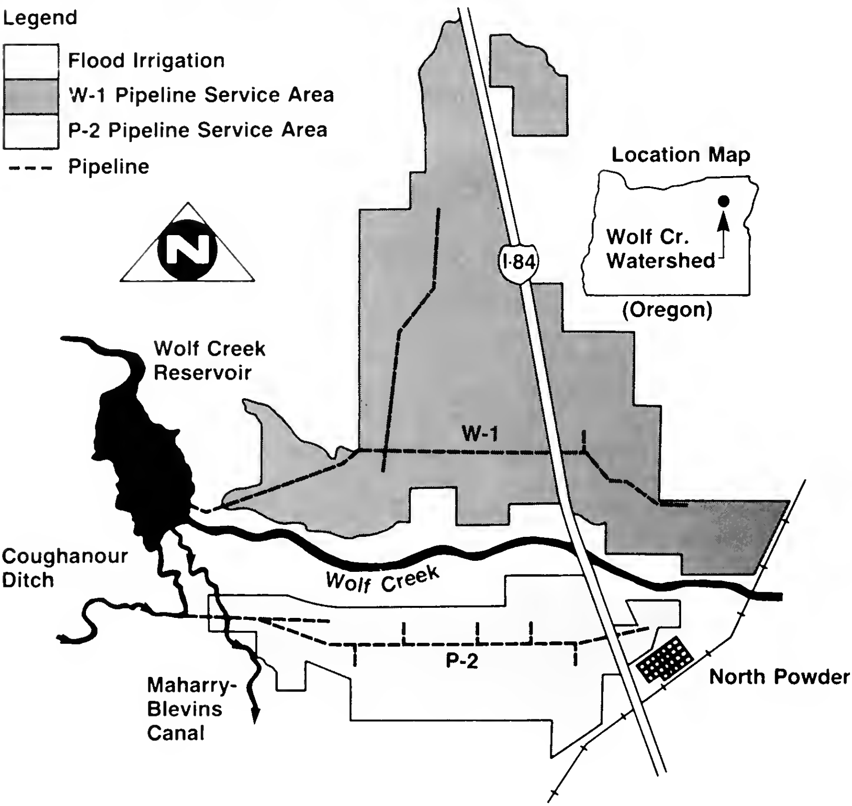
Open canal delivery systems conveyed water from the source to the farms. These long canals lost more than half their water to seepage, and their banks were eroding badly. A stream of water turned in the canal at the source did not always come out the other end at the farm.

On the farm, irrigators were plagued with problems. Field application efficiency was low. (Application efficiency is the percentage of water applied that is actually used by plants.) Upland areas were eroded by uneven amounts of irrigation water on the rolling land. Water had to be applied when it was available—too much too early in the spring, and not enough during the growing season. Because flooding and irrigation runoff from upland fields caused bottom lands to stay wet too long, crop yields suffered.

Dam Built

Directors and water users of the Powder Valley Water Control District turned to the Union Soil and Water Conservation District

Wolf Creek Small Watershed Project



and the Soil Conservation Service for help with their problems. Working together, they developed ideas and plans for a federally assisted small watershed project. Construction began in 1972, and the project became fully operational in 1977.

To gain control over their water source, the water users built a dam that stores a little more than 10,000 acre-feet of snowmelt runoff from Wolf Creek and other nearby drainages.

They replaced the troublesome canals and ditches with buried pipelines that deliver gravity-pressure water to every farm in each of two pipeline service areas. The service areas are separated by 4,500 acres of bottom land adjacent to both sides of Wolf Creek. The bottom land is still flood irrigated from stream diversions, canals, and ditches.

With the project, the Wolf Creek water users solved two of their three major problems—the

Ron Pratt checks an irrigated hay field on his farm, which is one of 30 farms benefiting from the Wolf Creek watershed project. He irrigates more than 1,200 acres of land in Union County, Oregon.

unreliable water source and the inefficient method of delivery to the farm. They also provided the opportunity for solution of the third problem, low efficiency of on-farm field application. Improving on-farm efficiency was up to the individual farmers, who wasted little time making some big changes.

Ron Pratt, Wolf Creek water user, explained how the project has affected his farming operation:

"My ranch is the last outlet on the 'W-1' pipeline, and I can tell you one thing for sure—being last on a pipeline is a whole lot better then being last on a ditch."

Just Turn a Valve

"Before we had the project, I was using diesel pumps to pressurize my water for sprinklers. I would spend at least half my time just chasing water around to make sure I had enough to keep the pumps running. Now all I have to do is turn a valve and the water's there, already pressurized by gravity.

"I'm irrigating about 1,280 acres the hard way, using a lot of 'hand moves' and some 'wheel lines'. But the thing I am able to do now, that I couldn't do before, is put the right amount of water where I need it, when I need it.

"I think the biggest thing the project did for me was give me the flexibility to change my operation. We've had a hay, grain, grass program. We're going to an intensified grazing program with more grass—in fact, all grass.

"Our goal is to split the place into 50-acre units and pasture at least three head per acre on a 25-day rotation. My hope is to be able to irrigate twice and fertilize during the period when the cattle are in a different pasture.

"I really think grass is the way to go on this ranch. This whole area has a fairly short growing season, but where our place is located—at the north end of the project—we're just enough higher that we're a little more susceptible to frost. Grass can handle that better than some of the other crops.

"I couldn't make this kind of change in my operation without the project water," Pratt concluded.

Fred Colton, another farmer in the project area, is also a director of the Powder Valley Water Control District and chairman of the Wolf Creek subdistrict. His headquarters farm is situated along Wolf Creek about a mile below the dam, in the part of the project area that is still flood irrigated. He also farms land in both areas served by a gravity pipeline. Colton made these observations:

"I guess you would call mine a diversified farming operation. I raise cattle, wheat, hay, and a little barley. That's the way we've operated it for years, long before the Wolf Creek project. But the project has definitely made it easier."

Sprinkle Irrigating

"It has done away with a lot of flood irrigating, and we're sprinkle irrigating ground now that we had given up flood irrigating—our steeper ground, where we couldn't spread the water uniformly. The water would just concentrate and run off. Erosion was terrible. Now, with sprinklers, I'm raising pasture up there that you just would not believe.

"We didn't have much of an erosion problem on our bottom land along Wolf Creek, and we thought we were doing a pretty good job of irrigating. But we can sure do it with less water now. My situation is definitely better because of the project. I irrigate more land, get bigger yields per

acre, and use only half the water I used to."

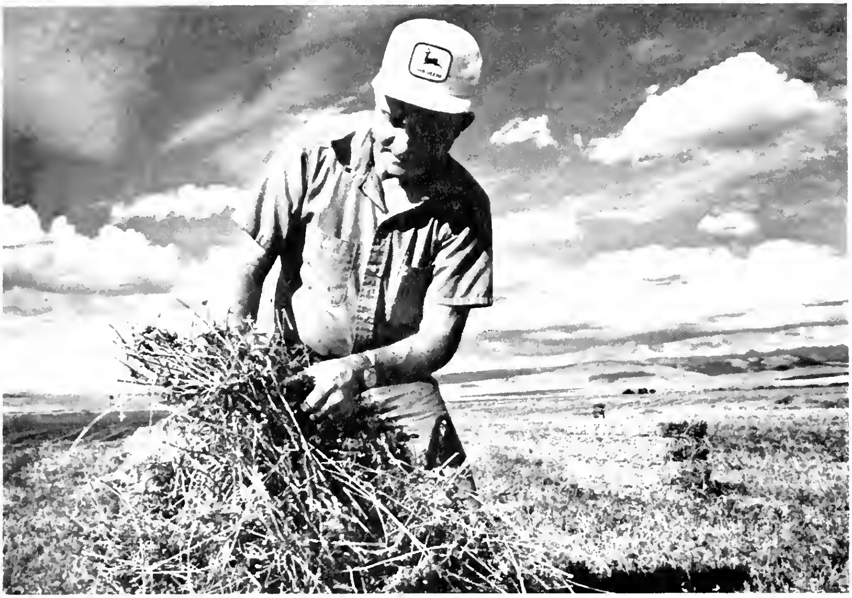
Another Powder Valley Water Control District director, Bill Lewis, farms about 2,200 acres, of which 1,400 acres are under sprinkler. Lewis told about the major differences the project has made in his operation:

"I guess the biggest single advantage the project has given me is a way to irrigate my rolling land. There was no way we could flood irrigate those 3-percent slopes without causing erosion. With the gravity sprinkler systems, we can set our water and know the crop's going to be irrigated right, and with no erosion.

"I've always had plenty of water. I had a good water right, even before the project. But we always had a stress factor in the crops when we were trying to flood irrigate. Now that we're using sprinkler irrigation our crops are doing fine."

With the new, dependable source of irrigation water, Fred Colton has been able to switch from flood irrigation to sprinkler with a savings in both manpower and water.

Douglas Bishop



Douglas Bishop

Bill Lewis has been able to increase his crop yields and cut his irrigation water consumption by more than 60 percent since the Wolf Creek project was completed.

Real Labor Saver

"I decided to go to center pivot sprinkler systems, and they have proved to be a real labor saver. When I was flood irrigating, it would take 10 or 12 of us to get everything done. Now my son and I pretty well take care of the irrigating. We hire a couple of others to help with haying and wheat harvest and other chores.

"Our yields are better now than they used to be. I think the reason is that our management is so much better. We can get our hay off and immediately get the water back on. We can irrigate our grains, or any of our crops, when we need to irrigate them—and not saturate the soil or cause erosion.

"I know the project has really helped in the management of our water. I know that it's helped us save a lot of water because we used to just run it off the end of the field. We had so much waste. We do a better job now and probably only use one-third—maybe even one-fourth—of the water we used to use. I would hate to think of not having the project."

Pratt, Colton, and Lewis agreed that the most difficult obstacle faced by those who signed up to go with the project was the commitment to change. They all knew they would have to adapt their individual farming operations to fit the new water system. That transition was gradual, but for many it was difficult. It meant changing crop rotations and learning a new way to irrigate. It meant higher risks with big investments in sprinkler equipment and higher fertilizer bills.

As Fred Colton put it, "It was tough on people like me, who had been doing things the same way for so many years, to just jump in and start buying sprinkler systems. It was a big step to take."

According to Ron Pratt, a key to the success of the project was the willingness of everyone involved to cooperate and to make small individual sacrifices for the benefit of the group. Pratt cited an example:

"Some of us had ditches that delivered water to our farms. We had private use over the water in that ditch, and nobody else touched it. It was like part of our family tree! Well, we were willing to give up those ditches and store that water in the reservoir."

End of 'It's Mine' Attitude

"Everyone benefited. We got over the 'it's mine' attitude. We realized that 10 percent of something good was going to be better than 100 percent of nothing."

The summer of 1983 marked the seventh irrigation season for the Wolf Creek project. In that time, project water users have withstood the rigors of drought and economic recession.

During their first irrigation season, they were faced with the 1977 drought, one of the worst ever. Although the skimpy snowpack yielded a water supply only 68 percent of normal, everyone in the project had enough water to get through the season. Before the project, only those few who had the very best water rights would have had enough water even in a good water year.

The economic picture since the late 1970's has been a concern to farmers across the country. It is a concern to Wolf Creek area farmers as well. But because of the project, they are at least making their payments.

Showcase Project

An economic evaluation published in 1981 by Oregon State University labeled the Wolf Creek project "a showcase agricultural development project."

Farmers like those at Wolf Creek who have already taken the first difficult steps away from tradition make it easier for others to follow. They have demonstrated it is possible to make a fickle water source predictable. They have shown that substantial amounts of water and soil can be saved by increasing the efficiency of delivery and field application. And they have proved, with better crop yields, that it is economically sound to do so.

The Wolf Creek project water users don't claim to have achieved the ultimate in water management. But they are pleased with the changes they've made, and what those changes have done for them. Ron Pratt, Fred Colton, and Bill Lewis are proud of what they and their Wolf Creek neighbors have accomplished—and they should be.

Our Underground Water Supplies: the Sometimes Dry Facts

By Herman Bouwer, Dale F. Heermann, and Bobby A. Stewart

"Meditation and water are wedded forever." When Herman Melville wrote these words, he was not thinking about ground water—the invisible water source which not so long ago was still considered an occult and secret substance emanating from the bowels of the earth.

Now we know, of course, that ground water simply is rainwater which has seeped underground and is stored in geologic formations. If the formations are permeable enough so they yield adequate flows to wells, they are called aquifers.

Most aquifers consist of sand and gravel deposits. Cavernous limestones, sandstone, and fractured basalt or other rock also are good aquifer materials. Aquifers can be quite extensive and underlie several States, like the Ogallala Aquifer in the central and southern Plains of the United States.

Some aquifers are sandwiched between impermeable formations and the ground water is under pressure. Water in wells in such artesian aquifers rises above the aquifer itself, so that pumping lifts are less than depths to ground water. There also are artesian aquifers where the ground water has enough pressure to flow all the way to the surface, yielding free-flowing wells.

Some aquifers are hundreds of feet underground and require deep wells for ground-water pumping. Others are near the surface.

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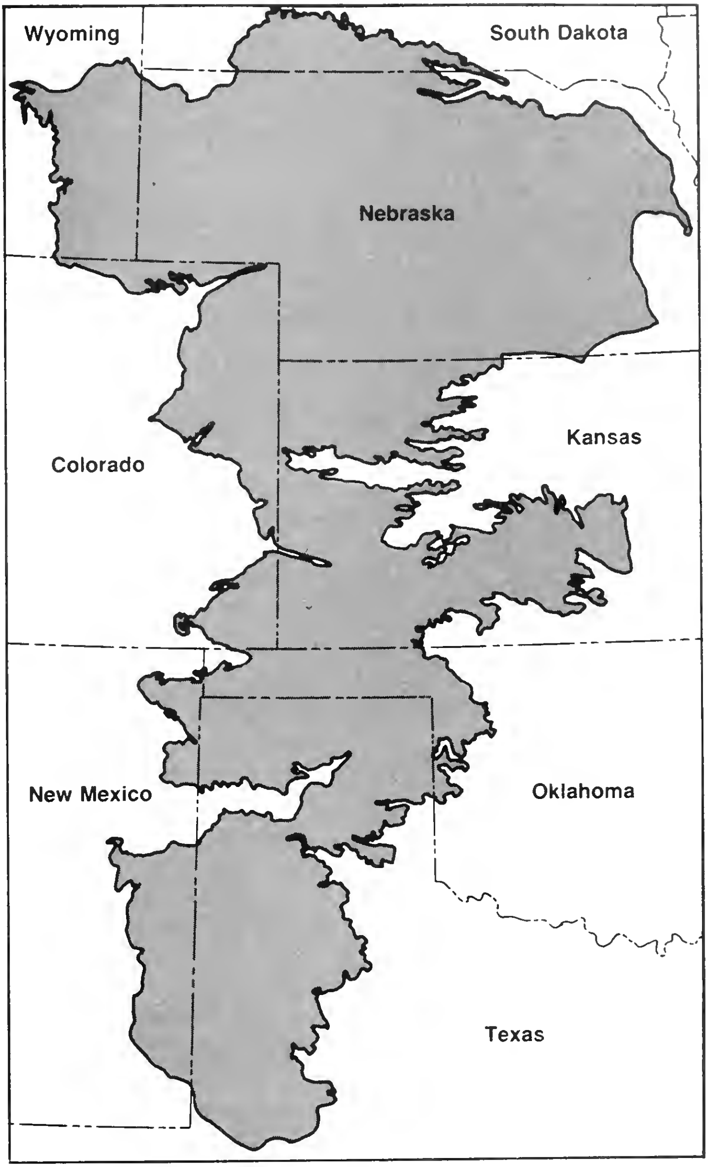
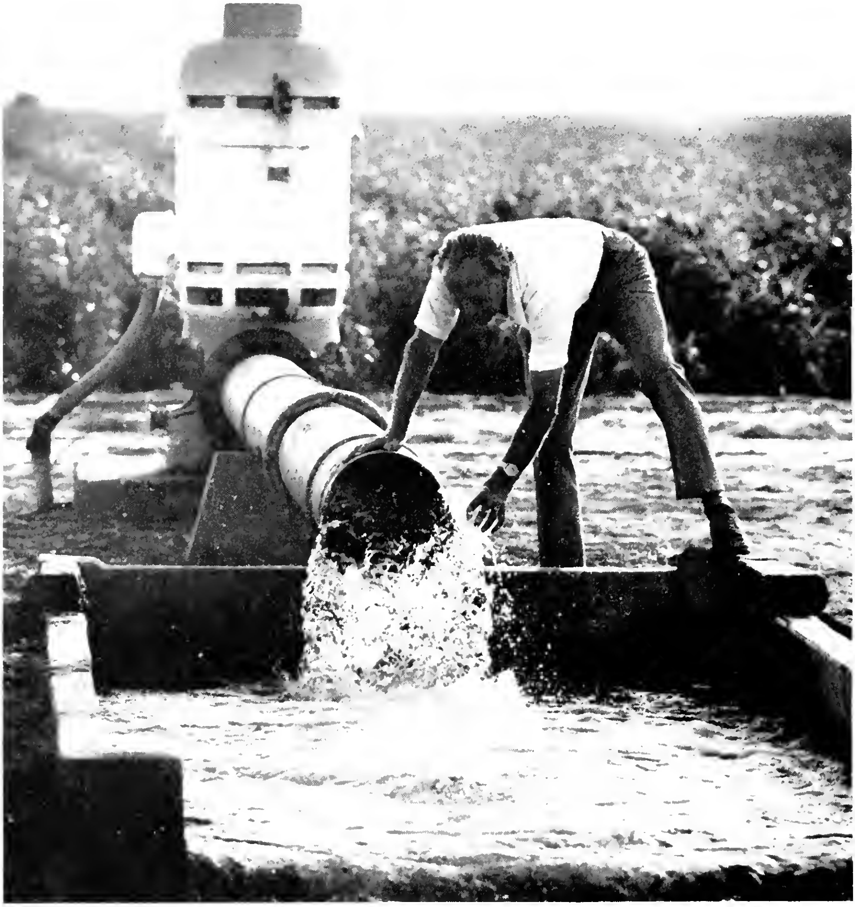
Ogallala Aquifers



Aquifers can be quite extensive and underlie several States. The Ogallala aquifer covers parts of eight States in the central and southern plains of the U.S.



Pete Mortimer

Some aquifers are hundreds of feet deep and require deep wells for ground-water pumping. In contrast, there are artesian aquifers where the ground-water has enough pressure to flow all the way to the surface, yielding free-flowing wells.

Average Age 150 Years

Average time the water has been underground, or average "age" of the ground water, in the United States is about 150 years. Some ground water is much younger, and some is older than 20,000 years. Most ground waters move horizontally but their velocities are small, often between 10 and 100 feet a year.

About half the population in the United States depends on ground water for drinking. In rural areas, the figure is close to 100 percent. Ground water supplies 25 percent of all water used in the United States and about 40 percent of all irrigation water.

Worldwide, about 30 times as much freshwater is stored within drillable distance underground as there is freshwater in all the lakes and streams. Ground water and springs have provided water for people throughout history and have made deserts bloom.

In arid and semiarid areas and in industrial or densely populated regions there is a tendency to overexploit the ground-water resource, pumping it out faster than the natural recharge or replenishment rate. This results in a decline of ground-water levels, which in turn increases pumping costs, requires deeper wells, causes some wells to go dry, and produces land subsidence.

A case in point is the Ogallala Aquifer, which underlies about 220,000 square miles in the Great Plains and is used extensively for irrigation.

Agriculture in the Great Plains originally was based on dryland production. The soils are among the world's most fertile, with inadequate moisture the principal factor limiting plant production. Rainfall ranges from 10 inches a year in the driest parts to more than 30 inches in the wettest areas. The variations from year to year can be very great. It is not unusual for annual precipitation to vary between 50 and 200 percent of the average.

Irrigation Pushed in 1950's

Irrigation in the Ogallala region began in the early 1900's, but did not accelerate until the late 1930's following the major drought responsible for the Dust Bowl era. After World War II, and particularly during the drought of 1951-1956, irrigated acreage expanded rapidly. The rapid conversion to irrigation provided much more consistent production for the farmer and reduced the extreme variation in production due to normal climatic variability.

The first irrigation developments took place in Texas and in the southern High Plains, followed by Colorado, Kansas, and Nebraska. Currently the Great Plains States account for about 48 percent of irrigated land in the United States. Over 80 percent of the water used for irrigation in this area comes from ground water, with the Ogallala the principal source.

The combination of a seemingly unlimited supply of excellent quality water, highly fertile soils, newly developed hybrid grain sorghum and other improved crops, a favorable climate, and readily available capital resulted in a tremendous expansion of agricultural production and associated agribusiness.

Feedlot development based on the abundant supply of feedgrains and the availability of feeder cattle followed, so that now more than 60 percent of all fed cattle produced in the United States are fed in the Great Plains.

Transformed by Ogallala

The Ogallala Aquifer thus transformed a region that had been used for dryland farming and ranching to a major irrigated area of profound importance to the region, the Nation, and the world.

It was in the 1960's, when the center pivot irrigation systems became quite popular, that significant well-drilling activity in Colorado and Nebraska was undertaken. The center pivot system provided a way of irrigating the undulating and sandy soil areas in the High Plains.

This system consists of a pipe supported about 10 feet above the ground on A-shaped towers with sprinklers mounted on the pipeline. The typical system is about a fourth of a mile long and irrigates about 130 acres. Supporting towers usually are spaced 100 to 180 feet apart and move in a circular pattern about a pivot point.

One can get an excellent view of this irrigation development while flying over the Great Plains. There are systems in use which irrigate a circle inscribed in one square mile. These systems are very adaptable to irrigating soils of low water-holding capacity, such as sandy soils. The light, frequent application of water possible with these systems can keep the water balance favorable, and very high yields are readily obtained.

Water Level Drops

As irrigation expanded, it became all too apparent that the aquifer's water level was dropping significantly and the once seemingly unlimited supply of ground water was rapidly being depleted.

The first adjustment by many farmers to maintain irrigated acreage was to add additional wells. While this was a suitable solution for the short term, it only accelerated decline of the ground-water level. These declines were most significant in the southern High Plains of Texas and Oklahoma and in southeastern Colorado.

Water stored in the Ogallala Aquifer is not uniformly distributed. Estimated water storage in 1977 was 3.04 billion acre-feet, underlying about 113 million acres. Nebraska has 36 percent of the land above the aquifer but more than 75 percent of the water in storage. Texas has 20 percent of the land area above the aquifer with only 9 percent of the water. Consequently the future of irrigation in the Great Plains States will vary greatly.

Even with more efficient irrigation systems, some irrigated land—particularly in the southern High Plains—will have to revert to dryland. The conversion of irrigated land to dryland will result from a declining supply of water and/or the inability to realize enough profit from irrigated farming to pay for energy costs associated with pumping from greater depths.

If water availability is a primary constraint, conversion of irrigated land to dryland will be gradual and will generally move from fully irrigated to limited irrigated dryland. Limited irrigation will involve only one or two irrigations during the crop growing season, or perhaps applying a preplant irrigation during winter.

Dryland Yields

These cropland areas can generally be returned to dryland farming without serious environmental impacts, and with modern technology will maintain a fair level of production. In fact, yields from dryland today will be higher generally than before irrigation, because improved farming systems better utilize rainfall.

Conservation tillage systems in the Great Plains can in many cases increase the soil water storage when crops are not grown. Conservation tillage also reduces wind and water erosion. These and other improved practices greatly minimize the likelihood of widespread duststorms as occurred during the "Dirty Thirties."

Continued use of some limited irrigation, however, will still contribute real benefits to agriculture in the Great Plains because of the stabilizing effect it has on crop production and the region's economy. The extreme variability in climatic conditions in the Great Plains would see yields under dryland farming range from fairly high in above average rainfall years, to very low—or even crop failure—in drought years.

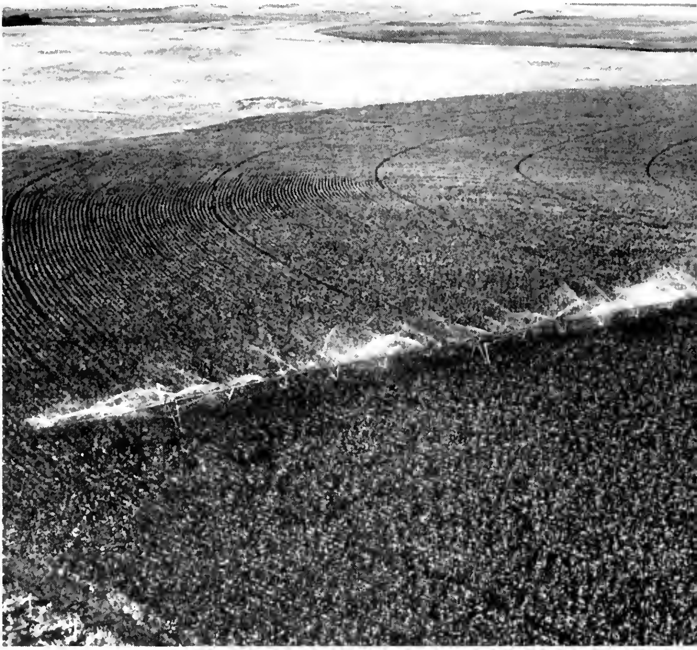
In contrast, the Northern Plains region, particularly in Nebraska, has significant new areas which will be brought under irrigation. Recent studies have projected that total irrigation in the Great Plains will increase during the next 50 years.

Pollution Threat

Much of the area to be developed is on very sandy soils which will see even larger use of center pivot sprinkler irrigation. The latest in technology must be used in managing these systems to maintain economical operations. If proper management is not used, environmental degradation of ground-water resources with nitrogen, insecticides, and herbicides as pollutants presents a real threat.

The latest deterrent at the present time to increased irrigation from the Ogallala Aquifer is the increasing cost of energy. In early years of development, irrigation wells were shallow, energy resources cheap, and total pumping costs often considered insignificant. These factors changed dramatically during the 1970's, and some farmers have ceased irrigation simply because of rising pumping costs, rather than lack of available water.

What is happening to the Ogallala is happening to many irrigated areas of the West, and for that matter to the rest of the country. Some States advocate letting economics and the free market determine how much farmers can draw down their ground-water levels before it becomes uneconomical to pump.



Even larger developments of center pivot sprinkler irrigation are expected in the years ahead on sandy soils in the Great Plains.

In other States, like New Mexico and Arizona, the solution is sought in increased State control over ground-water pumping.

The strictest ground-water law was adopted in Arizona in 1980. This law will set water duties to farmers using ground water for irrigation and will force increased water conservation and abandonment of irrigated land to reduce ground-water pumping to safe yield levels by the year 2025. Safe yield is the natural replenishment rate of the ground water. Pumping ground water at or below safe yield rates thus will not produce any decline in ground-water levels.

Land Subsides

Declining ground-water levels often cause subsidence of the overlying land. This is because material in the dewatered ground water zone has lost its buoyancy and thus exerts a greater pressure on the underlying formations which will then become more compressed. As the deeper layers compress, the entire overburden moves down.

For water table aquifers, the land surface typically goes down about 0.01 to 0.5 feet for every 10-foot drop in ground-water level, depending on the thickness and compressibility of the deeper materials. Many irrigated areas have subsided several feet to about 10 feet. The record subsidence is 30 feet and occurred in the San Joaquin Valley west of Fresno, Calif.

Land subsidence increases the flood danger of already low areas


Tim McCabe

(for example, Venice in Italy and the Houston-Baytown area in Texas), and has caused water wells to collapse. Subsidence is not uniform and varies from place to place in a given area. It has damaged roads, railroads, bridges, and buildings, and changed the gradients of irrigation channels and drainage and sewer lines.

Fissures Formed

Differential subsidence can also cause long cracks in the earth. Geologically, the irrigated valleys in the Basin and Range Province of the Southwest are particularly vulnerable to this kind of cracking. The cracks appear mostly along the periphery of the basins and valleys, parallel to the surrounding mountain ranges. Cracks also develop above underground bedrock ridges in alluvial fills.

Initially the cracks are only an inch or so wide, but since they tend to run parallel to mountain ranges, they intercept surface runoff and become eroded and enlarged. Mature fissures may be several yards wide and more than 10 yards deep, and may become several miles long. Fortunately, they have mostly developed in sparsely populated areas, but they could also form in cities like Phoenix where they can do considerable damage.

Land subsidence is essentially irreversible. It can be stopped by halting ground-water depletion, but the land surface will never revert to its original elevation—even when ground-water levels are restored to predepletion levels.

Artificial Recharge

In some areas, ground-water supplies are successfully augmented by artificial recharge. This calls for pumping water directly into aquifers through wells (like pumped wells in reverse), or by spreading water over the surface and letting it infiltrate into the soil and percolate down to the ground water. Both systems require a source of water (such as stored surface water, surface runoff, or treated wastewater). The spreading system also requires permeable surface soils and unrestricted flow of the water down to the ground water.

Artificial recharge is success-

Herman Bouwer

Subsidence due to lowered ground-water levels can cause deep cracks in the earth, and mature fissures may become several miles long. Land subsidence is essentially irreversible.

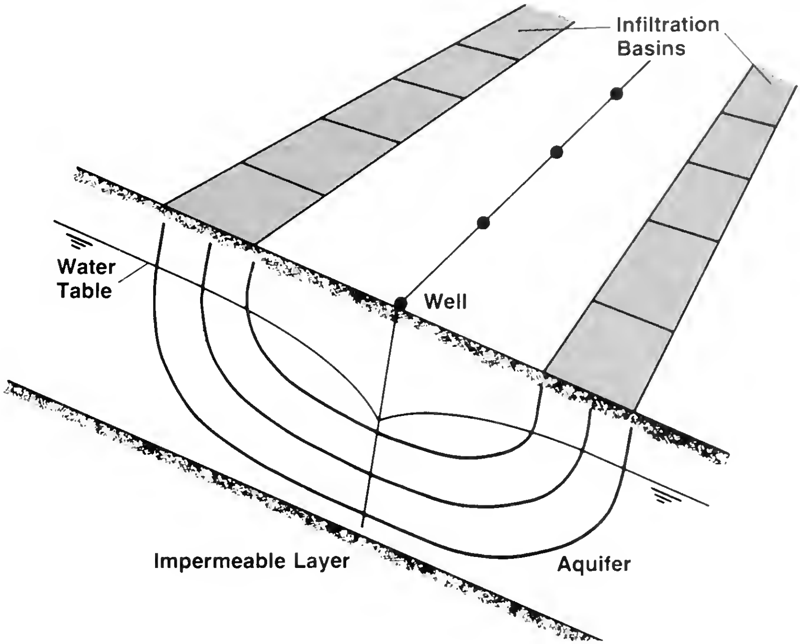
fully practiced in a number of places, particularly where there is an adequate supply of surface water during certain times of the year. Yet it cannot be considered a general solution to the problem of ground-water overdraft. Sound water conservation practices on the farm—and in water resource management generally—offer the best approach.

Filtering Wastes

Under the right soil and geological conditions, aquifers can be used as natural filter systems to treat sewage effluent or other wastewater so it can be used for unrestricted irrigation, recreational lakes, and other purposes. With such systems, partially treated effluent is infiltrated into the soil through basins arranged in two parallel strips.

After the sewage water has reached the ground water, it travels some distance through the aquifer before it is pumped as "renovated" water from wells located on a line midway be-

Infiltration Basins for Partially Treated Sewage Effluent, and Wells for Pumping Renovated Water After Soil-Aquifer Filtration.



tween the infiltration areas. The systems can be managed so no native ground water will move in from outside the system, and no sewage water will move into the aquifer outside the system.

Such systems generally give complete removal of suspended material, biodegradable organic matter, bacteria, and viruses from the wastewater. Phosphorus and heavy metals are greatly reduced. The systems can be operated to either leave the nitrogen in the renovated water where it has fertilizer value, or to remove about two-thirds of it by denitrification.

The renovated water thus is sufficiently pure for unrestricted irrigation and recreation, and with further treatment can even be recycled for drinking. This use of the aquifer could be valuable in municipal water reuse programs because "soil-aquifer treatment systems" are inexpensive to operate and provide a lot of purification for the money.

Ground-water resources are not infinite. When properly protected and managed, however, they can provide water "forever." This is the challenge of the future.

Ground-Water Conservation on the Texas High Plains

By A. Wayne Wyatt and Patricia Bruno

A. Wayne Wyatt is manager of the High Plains Underground Water Conservation District No. 1, Lubbock, Tex. Patricia Bruno is Information Director for the district.

Ground-water levels continue falling each year on the High Plains. While some wring their hands and hope for the salvation of imported water, one water district has earnestly set about learning—and teaching others—how to live well with less water. Their ideas are exportable throughout the arid West.

The High Plains Underground Water Conservation District No. 1, headquartered at Lubbock, Tex., is the oldest district in America. It is also one of the most progressive. Over 30 years ago, West Texas plainsmen voted to form a local governing body of directors and county committeemen to monitor and regulate their ground-water use. They even voted to tax themselves to support it.

Today the district serves all or part of 15 southern High Plains Texas counties sprawled over 8,000 square miles from the New Mexico line east to the edge of the Caprock, and from Amarillo south nearly to where the Ogallala Aquifer's ground water plays out.

Mother Nature gave this high, flat corner of the Great American Desert a variety of fertile soils from porous sands to tight clays, a moderate growing season, and 60 percent of her 18-inch annual rain between April and October. Agriculture is the prime consumer of her vast, nonrenewable ground-water reserves.

West Texas farmers gave the water district a tax base and a "show me" attitude toward trying new ideas. The district was charged with conserving, preserving, protecting, recharging and preventing waste of the ground water. Back when water and energy were cheap, the district's first challenge was to halt runaway irrigation tailwater waste and to stop salt pollution of the aquifer.

Ogallala Air Injection

Today the challenge is even tougher. The district is helping farmers stay in business. It is promoting profitable conservation techniques, research and technology transfer, and showing operators how to conserve rainfall, cut evaporation losses, apply less irrigation water more uniformly for the same or better yields, and increase efficiency of their pump plants.

The district also is pioneering investigations to coax even more ground water from the Ogallala by injecting air into the formation above the water table to release water still held by capillary attraction.

Its philosophy is broad-based and simple. It recognizes that you can't force anybody to conserve water, especially farmers. The district is dedicated to the principle that water conservation is best accomplished through public education.

To get broad participation, it taps the resources of other local service and research agencies, like the U.S. Soil Conservation Service, the Texas A&M Agricultural Extension Service, the Texas A&M Agricultural Experiment Station, the area U.S. Department of Agriculture (USDA) Research Centers, the Water Resources Center at Texas Tech University, and the Texas Department of Water Resources in Austin.

'Show Me' Approach

What makes the district's story a success is in part the variety of ways it tackles the job:

1) It invests manpower and equipment into a "show me" field approach to measuring and evaluating water management systems

2) It collects hard data to build a convincing information base and show farmers the costs and benefits of water conservation by putting that information into operators' hands in plain language

3) It continually monitors and maps ground-water changes to project a realistic picture of the area's current and future reserves

4) It invests operating funds in water conservation research and finds volunteer cooperators for field sampling of new crop varieties and chemicals to help cut the seven- to ten-year lag between research and commercial availability

5) It pioneers its own research, to prove (and sometimes disprove) its own theories out on the ground

6) It keeps a network of pacesetters in water management and conservation and the media informed about what's going on, and

7) It exchanges expertise with other agencies, cost shares on projects with mutual goals and benefits, and pursues grants to help finance field investigations.

The rest of the district's success lies in the results it gets. The staff has half a dozen projects going at one time. It doesn't see any one agricultural breakthrough bringing back the good old days of economic prosperity for farmers. It believes a whole lot of little improvements will be needed just to survive.

Mobile Water Wagon

The water district has teamed up with the Soil Conservation Service (SCS) to create a program to evaluate agricultural water management efficiencies on the Texas High Plains. The project called for a mobile water wagon.

A converted horse trailer was equipped as the first Field Water Conservation Laboratory. The lab was used for training and for demonstrating irrigation system evaluations on operators' farms.

SCS and district staff learned to check nozzles, flow rates, evaporation losses, and distribution patterns, and to measure runoff and detect water losses, in order to calculate efficiencies. The Texas Department of Water Resources (TDWR) offered financial support in exchange for evaluation data.

Demand for the evaluations spread. Eighteen minitrailers were designed, purchased, equipped, and pressed into service through SCS offices. Irrigators began seeing their poor efficiencies, often below 50 percent and well below the 75 percent that could be expected.

More than 600 irrigation systems have been evaluated in just over 4 years. As the teams identified common problems, irrigators improved their operations with resulting average efficiency gains near 15 percent.

Over 40 Minilabs

The North Plains (NPWD) and Panhandle (PWD) water districts, the electric co-ops and irrigation equipment suppliers got involved in the training and testing process. Sprinkler manufacturers began redesigning their equipment to further reduce evaporation losses and improve application and pattern efficiencies.

There are now over 40 minimobile labs on the High Plains, checking efficiencies. Through the work of TDWR, local soil and water conservation districts, NPWD, PWD, and SCS, the program is spreading beyond Texas to other States.

A leader in new technology for saving water, developed by experiment station engineers, is the Low Energy Precision Application (LEPA) irrigation system.

The LEPA system modifies a sprinkler to spoon-feed water to crops near the ground through drop-line hoses that drag or bubble water into shallow dikes banked every few feet across the furrow. These dikes are a key component of the LEPA design, which dramatically cuts evaporation losses.

Patricia Bruno

Droplines attached to a pivot irrigation system dramatically cut evaporation losses.

The system raises irrigation efficiencies to more than 85 percent.

District directors are both promoting the LEPA system and working with sprinkler manufacturers to install modified LEPA on their own pivots. The system raises irrigation efficiencies to greater than 85 percent. It reduces water losses by 30 percent and cuts energy needs in half. LEPA has been shown to produce higher yields with less energy, making more efficient use of irrigation water and rainfall.

Pumping Plant Payoffs

Inefficiencies at the irrigation pump plant became obvious as irrigation energy prices quadrupled in less than three years. The water district matched a grant from the Texas Energy and Natural Resources Advisory Council to test pump plant efficiencies and to demonstrate the potential energy and water savings to be gained by making repairs and improvements.

The district equipped a field van, trained staff to calculate the efficiency of electric and natural gas engines, and moved into high gear. More than 400 wells were tested in two irrigation seasons by SCS, the Extension Service, and the district working together.

After repairs, average overall pump efficiency rose by 25 percent on electric-powered units, and by nearly 30 percent on natural gas-powered engines, cutting costs per acre-inch of water pumped almost in half. The fuel savings realized usually paid repair costs within two years.

Patricia Bruno

Furrow diking is a new conservation tool that traps rain, stops runoff and reduces soil erosion. The photo shows how water was trapped after a brief rainstorm. In this field, every other row is furrow-irrigated.

Multiplied by the 70,000 pumps on the Texas High Plains, the potential of this program is tremendous.

Moisture Monitors

A full soil profile is a farmer's best crop insurance. To get the most out of water, an irrigator needs to know the amount of moisture stored in the root zone, particularly for preplant irrigation, and the amount the plant is using at each stage during the growing season. The district annually publishes a preplant soil moisture deficit map for all 15 counties it serves.

The staff installs access tubes and takes neutron moisture gage readings in a growing network of monitoring sites throughout the district. The data are used to contour maps that show a farmer the amount of water still needed in the soil to fill the root zone to field capacity. In conjunction with rainfall probability charts, the map is a guide for preplant irrigation.

The water district's staff also installs and demonstrates the use of gypsum moisture blocks as tools to measure growing season soil-water reserves. Over 600 gypsum blocks were buried and read with conductance meters for irrigators in one growing season. The blocks show the amounts of soil moisture taken by developing plant roots.

Most of the cooperators are now installing, reading and interpreting their own blocks to make irrigation decisions. The Texas Department of Water Resources financially supported both soil moisture monitoring projects.

Furrow Dikes

The district is promoting another water conservation tool to capture rainfall—furrow dikes. These are shallow dirt dams, mechanically scooped up every few feet across the furrow to trap rain, stop runoff, and reduce soil erosion.

Recognizing their potential with both dryland and irrigated crop watering, the water district is recommending furrow dikes in its monthly newsletter and out in the field. It publishes experiment station and USDA field research findings showing the profit potential. Diked USDA plots, for example, captured 3½ inches of potential runoff over 1 season which doubled dryland grain sorghum yields.

About two-thirds of Texas High Plains acres are still furrow-irrigated. For years the district searched for ways to cut water losses from flooded furrows, the oldest and most common form of irrigation in Texas.

Thirty years ago the district designed the first tailwater return systems now used throughout the irrigated West. These systems capture heavy irrigation runoff from the end of the furrow, channel it into a deep pit or modified field pond reducing surface evaporation, and make use of a centrifugal pump to recirculate the water back to the furrow.

Surge Irrigation

Now, a new row watering invention controlled by a microcircuit may help revolutionize furrow irrigation. This new technology is automating furrow irrigation with equipment that switches water flow back and forth between two sets at timed intervals. The new technique is being called surge irrigation.

The High Plains Water District has purchased 17 surge equipment systems to run test evaluations. Together with SCS and experiment station engineers it is checking efficiency rates, working out design bugs, and recording 30 to 40 percent water savings.

Moving into the 1980's the

water district has placed more and more emphasis on research. It is investing in equipment, manpower and outright grants to partially finance studies at several area research agencies.

These studies include work in plant-soil-water conservation, identifying stress-tolerant breeding lines, irrigation studies with anti-transpirants, growth regulators, surfactants, moisture barriers, water management systems and cropping patterns.

Beef and Potatoes

Researchers are developing new uses for beef fat with partial district funding. Experiment station scientists were the first to successfully suspend beef tallow, a cheap abundant High Plains resource, in a spray solution and apply it as an anti-transpirant to decrease plant evaporation. Test results on potatoes produced less plant stress, improved quality and increased yields.

Several years' studies treating cotton with PIX, a growth regulator, produced a shorter plant with less leaf surface. This cut evapotranspiration rates. In some cases, treated cotton had higher yields and better staple length and fiber. Vegetative growth was controlled in late summer and plant maturity enhanced.

Major equipment investments by the district, in soil core drilling rigs and neutron moisture gages, are extending capacity to measure soil moisture in agricultural research plots.

The district partially funded an urban lawn water conservation research project to evaluate water requirements of lawn grasses. Also evaluated were commercially available residential sprinklers.

The district's enthusiasm sometimes goes beyond accepted theories and practice into less charted frontiers. Directors took a calculated risk back in 1958 when they successfully sued the Internal Revenue Service for a cost-in-water depletion tax allowance for High Plains farmers using their ground water in the business of agriculture. That has saved area irrigators millions of dollars over 20 years and affirmed value of the water.

In the sixties, the district unsuccessfully experimented with filter systems, trying to eliminate silt clogging that severely hampered its aquifer recharge efforts.

Pollution Order Won

The first successful challenge to oil producers, who were contaminating the Ogallala Aquifer by disposing of briny water in shallow unlined pits, came from the district. Its fight before the Texas Railroad Commission won it the first "no pit" pollution order in Texas.

Today the district is pioneering an unprecedented investigation to quantify and then to identify a technically and economically feasible means to release capillary water from the formation. The objective is to free water held by capillary attraction in formational sands above the water table, by injecting compressed air to build and "push" a wetted front to raise the water table.

Two years of lab research and preliminary field tests have produced water table rises of up to 9 feet and a calculated net increase in storage of 876 acre-feet at a 140-acre site.

The cost is now estimated at $50 per acre-foot, making it already within reach for municipalities to use as a source of new water reserves. Future tests will concentrate on making recovery methods cheaper and adaptable for local farmers on a small scale.

Comic Book Issued

The water district's public education program doesn't stop at the turnrow. Besides publishing agricultural and technical reports—such as a cost analysis of irrigation ditch losses, and a summary of techniques and management practices for profitable water conservation—the district has published its own water conservation comic book and a textbook for Texas High Plains youngsters complete with teacher guides and workbooks.

The district's monthly newsletter has been read for 30 years in the classroom, office, corporate board room and out on the turnrow. *The Cross Section* capsules the district's history, its water resource, and the beliefs and accomplishments of its people.

Over the years the water district has contoured and published hundreds of maps. But the most detailed mapping investigation ever published for the Texas High Plains is a 1980 series of 15 county hydrologic atlases. Each atlas contains explanatory notes and maps contouring base of aquifer, land surface and water table elevations, and saturated thickness of the formation.

The district maintains a permit and driller's log file of 45,000 irrigation wells drilled in its service area since the district was established. District rules require that all water wells be permitted and spaced.

The district's regulating responsibilities do not end with permitting. Field staff still pursue tailwater wasters. They notify landowners to close hazardous abandoned water well holes, and monitor and test wells suspected of water quality deterioration.

The district helps local municipalities assess their current water supplies and the availability of future reserves to meet population demands; and provides water resource evaluations to document a community's economic prosperity for school bond ratings.

The payoff for all these programs and services has been the gradual slowing of the decline in the ground-water table. District records indicate an annual rate of decline of 2.5 feet during the 1960's, 1.4 feet during the 1970's and 1.0 foot of decline so far in the 1980's.

Ecological Managing of Crop Pests Pays Off

By Katherine Reichelderfer and Waldemar Klassen

A pest is simply any living organism whose presence conflicts with the interests of people. There are literally thousands of insect, weed, plant disease and other species that conflict with U.S. crop production activities. These species' pest status derives from the fact they cause crop losses by consuming, infecting, weakening, competing with or otherwise reducing the value of the crop being produced.

Pests may lower the quality of a commodity by causing a decrease in nutrient content, reducing the product's eye-appeal, or facilitating the production of toxic substances by the crop plant. Also of concern to farmers is the fact that attempting to control pests incurs high costs of agricultural production.

Undesirable as they may be, pest species are natural occurrences in the agricultural ecosystems created by man's food and fiber production activities.

It has proved to be virtually impossible to create a pest-free environment for crop production. In fact, modern monocultural production practices invite development of major pest problems by providing a simple and relatively unstable ecosystem in which abundant supplies of host material are made available for potential pests' exploitation.

Thus, pests are cohabitants of the ecosystem in which food or fiber is produced. We produce pests along with our crops.

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Interactions Network

Pest species take part in a network of biological and biophysical interactions in the farmland ecosystem. We are most aware of pests' detrimental interaction with the plant species being grown for farm profit and human consumption. But they also interact with other organisms in the crop field.

For instance, eggs of an insect pest that feeds on soybeans are, in turn, food for a different, nonpest insect. And a weed pest in that same field may provide shelter for the beneficial egg predator.

So when we attempt to eliminate or control a pest we are apt to affect, to some degree, a number of organisms other than the pest and crop species. Experience shows it is particularly important to preserve the natural enemies of insect pests.

The efficient agricultural producer wants to keep crop losses to pests as low as possible. There are a number of cultural, mechanical, physical, biological, chemical, genetic and regulatory means of doing this.

Field crops are largely protected from disease by means of varietal resistance. Chemical control, by using pesticides, is a predominant method for weed, insect and other pests' control in U.S. agriculture.

Pesticide Pros and Cons

Pesticide use is generally an economical way to control pests. When the appropriate compound for a particular pest's control is chosen and its application to the field is well timed to coincide with pest occurrence and crop vulnerability to the pest, benefits derived from pesticides can be many times greater than the cost of using them.

Many current pesticide materials are broad-spectrum biocides. They affect not only the target species they are used against, but also kill related species. Broad-spectrum insecticides kill most susceptible insects. Herbicides are available that can kill most broad-leafed plants; others kill most types of grasses.

While there are advantages to breadth of kill, these pesticides have the disadvantage of affecting the entire farmland ecosystem and of creating the potential for polluting noncrop sites.

They kill off predators, parasites or nonpestiferous competitors of pest species as well as the pests themselves. And in so doing they can further destabilize the ecosystem. Without effective enemies, the pest species can increase more rapidly and to higher than previous levels before the populations of parasites, predators or competitors can recover sufficiently to resume exercising some natural control.

Overuse Problems

Historically, many pesticide applications have been made according to fixed schedules—whether or not the pest problem exists.

This strategy is used when farmers believe or expect pests to be present at levels that cause crop damage. However, it can result in inefficiency. The pest may not be present or the population may be in a life-stage that is relatively invulnerable to the pesticide, resulting in unnecessary expenditures and environmental disruption.

Overuse of pesticides also accelerates the rate at which pest populations develop resistance to the pesticide. Presently, over 150 species of insects and mites and at least 5 major species of weeds in the United States have developed resistance to major pesticides, rendering them ineffective as chemical control agents. Resistance of plant disease organisms to antibiotics has become a serious problem in recent years.

Finally, the use of many pesticides can have detrimental impacts on environments outside the farm. Pesticides applied to crops can drift off-site, percolate through the soil, run off into water systems or persist on harvested crops, thus potentially affecting a range of nontarget species, including humans. In the United States, pesticide regulations administered by the Environmental Protection Agency are in effect to keep these off-site impacts as low as possible.

Ecological Methods

Recognizing that pests are active participants in the dynamic agricultural environment, and that poorly managed pesticide use disrupts both crop-producing and other environments, has led to the development and use of ecosystems-oriented methods of pest control. Among the environmentally sound pest control strategies currently receiving increased attention in United States agriculture are: Biological control, cultural control, and coordinated systems for joint pest and pesticide management.

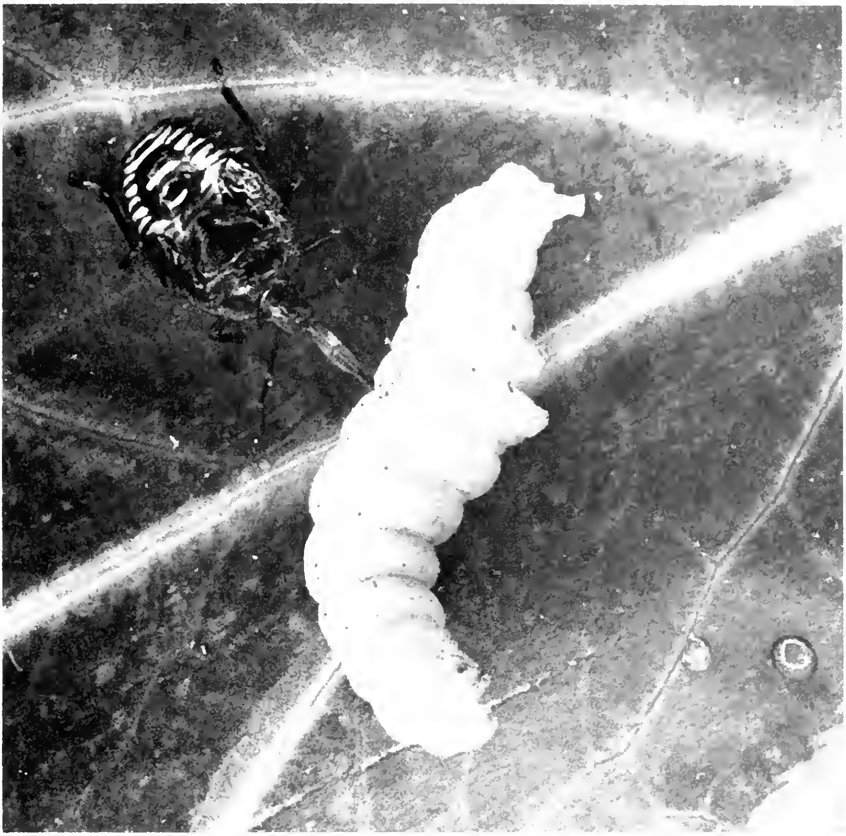
Biological control of pests involves conserving, augmenting or introducing beneficial organisms (natural enemies) to control pest species. Cultural controls are actions taken to modify the crop production environment so it is less conducive to pest problems. These actions include crop rotation, tillage and cultivation, destruction of pest-harboring crop residue, and manipulation of crop planting or harvesting dates.

Coordinated, ecologically based systems for pests' management rely first on biological and cultural control tactics, but follow up with well-managed pesticide applications whose type and timing are based on information from periodic monitoring of the crop-pest situation.

The basis for these systems, often referred to as integrated pest management (IPM), is sufficient knowledge and understanding of crop environmental relationships to allow us to better and more efficiently manage the pests that affect the crops.

Economic Threshold

Coordinated pest management


Joe Edens

Biological control is among the environmentally sound pest control strategies receiving increased attention in agriculture. Here, an immature predatory stinkbug feeds on a cabbage looper larva.

systems depend on the availability of information—collected through field scouting and other means—to determine when, if and how specific control actions should be taken. Decisions to treat or not to treat are based on economic threshold rules.

The economic threshold level of a pest's population is the pest density at which the cost of reducing the pest population equals the expected increase in crop value from that reduction.

At pest densities below the threshold, the cost of pest control is greater than the expected monetary benefit of control. Thus the economic threshold rule states control action should not be taken until information indicates pest populations meet or exceed that level.

The result of using this rule

basically is that we give up some of the crop to pests in lieu of spending money in an attempt to prevent pest-related losses from occurring.

Field scouts check insect population to determine what control action should be taken.

The "eco" in ecology and economics derives from the same Greek root "oikos," meaning house or habitat. Both disciplines involve study of the networks, cycles and other interrelationships that determine the function and stability of communities.

In agriculture, where biological processes are harnessed to produce marketable goods, ecology and economics are very closely related to one another. It is not surprising then that we find ecosystems-oriented methods of pest control are more economical.

Cultural Control

Cultural control is perhaps the oldest and most basic approach to preventing pest-related agricultural losses. The ancient Romans practiced crop rotation and intercropping to reduce pest problems. Soil tillage and cultivation, which disturb the habitat of soil-dwelling organisms, have long been principal tactics for weed and soil insect control in the United States.

As modern producers attempt to reduce costs of pest control and overcome the disadvantages of intensive pesticide use, interest has been renewed in cultural pest control techniques. A recent change in Texas cotton production systems provides one example.

Cotton producers in the Lower Rio Grande Valley and Coastal Bend regions of Texas traditionally planted long-season cotton varieties. Intensive insecticide application has been required in attempts to control mid- and late-season insect pests.

The late-season insect problems are especially severe when natural enemies are destroyed by early-season treatment for boll weevils. Cotton yields in these regions were declining as pest problems and pest control costs were increasing.

The solution to this deteriorating situation has been adoption by farmers of a short-season production system. An early planted, quick growing cotton variety is now used throughout the Coastal Bend and in much of the Lower Rio Grande Valley. The short-season cotton matures earlier and thus avoids late-season pest problems.

Profits Rise

For additional protection against early-season development of pests, portions of the cotton plant remaining in the field after harvest are destroyed. This kills eggs or overwintering forms of insects that otherwise would lurk in the field awaiting next year's cotton planting.

As a result of using the short-season planting strategy in conjunction with improved insect management, cotton production has become a more profitable venture. Adopters of the strategy have used 30 to 50 percent less insecticides and have enjoyed profits of $12 to $94 more per acre than can be realized using conventional, long-season production systems.

Many other environmental factors affect pest problems and can be altered through cultural control. For instance, when corn is planted year after year on the same soil, populations of corn rootworms build up to seriously damaging levels. But when corn follows a crop other than corn in a rotation sequence, corn rootworm is a minor problem.

One currently popular cultural practice for reducing soil loss frequently makes pest problems worse. Conservation tillage, where soil is disturbed as little as possible, is an excellent way to conserve soil. However, it may create a better environment for the development of weed pest problems. Many important insect pests spend one or more of their life stages in the soil. We are seeing a resurgence of some of these pests such as the common stalkborer.

Other pests, such as the Hessian fly, which overwinter in the stalk above the ground, have been reaching outbreak levels in recent years because the stubble is not being plowed under. Turning under plant disease inoculum can also be important. (Note, though, that pesticides are often used in conjunction with no-till farming.)

This illustrates the interdependence of various components of the farmland ecosystem, and suggests environmental and economic considerations are important in attempting to apply cultural control of pests.

Natural Enemies

Many native American insects and plants could be pests, but because their population levels are kept low by predators, parasites and diseases, they pose no pest problem. However, when insects and plants have been accidentally imported from other lands without natural enemies to keep them in control, they have become pests.

The first case of biological control engineered by humans in the United States occurred in California in 1888. The cottony-cushion scale was at that time a new pest on citrus. Its rapid spread and the ineffectiveness of conventional means to control it were threatening to destroy the Southern California citrus industry.

The U.S. Government sent an entomologist to Australia where the scale was common, and there he discovered the vedalia ladybird beetle feeding on the scale insect. Vedalia beetles were brought back to the United States and distributed in citrus groves. Within a year the dreaded scale was under natural control and the citrus industry was saved.

Since then, similar biological control programs have been implemented across the country. Just four years ago a different imported pest, the citrus blackfly, was threatening Florida's vast citrus industry. Producers wanted the insect eradicated, but an eradication program would have cost millions of dollars with no guarantee of success.

What did work was a biological control program through the rearing and wide distribution of natural enemies of the citrus blackfly in Florida's citrus-producing regions. The blackfly is still in Florida, but it occurs at such low levels that it no longer poses a serious pest problem.

Wasp Fights Beetle

Another current and somewhat unique example involves control of the Mexican bean beetle (MBB), the most destructive insect enemy of soybeans and other beans east of the Mississippi River.

A tiny wasp from India was found to be an effective parasite of the MBB. However, the wasp does not survive the winter weather and cannot, like many natural enemies, establish itself permanently. It has to be redistributed each year.

Experiments in Maryland showed that annual use of the wasp can result in the same or greater profits for soybean growers than does use of conventional pesticides for MBB control. Since 1979, the U.S. Department of Agriculture (USDA) and State governments and soybean growers in Maryland, Delaware, New Jersey and Virginia have cooperated to rear and distribute the wasp in a successful biological control program.

Weeds and plant diseases also

Without natural enemies to keep them in control, imported insects and plants have become pests. One potential control agent being evaluated is the female parasitic wasp, which lays eggs in the imported cabbageworm.

Joe Edens

can be controlled by natural enemies. The tansy ragwort weed on rangeland is in some areas controlled by insects that feed on it.

Two plant pathogens are registered for weed control in the United States. A program that uses "good" bacteria to outcompete a bacterium that causes a plant disease is now in experimental stages.

Won't Always Work

Biological control by itself doesn't work in all cases. It is most effective if all growers in a region use it. If only a few practice it, the natural enemies distribute themselves too thinly in relation to the area's pest population to be of much good.

Individual farmers can conserve the benefit of naturally occurring beneficial species by being careful their pest control actions have minimal effect on natural enemies. This requires good knowledge of the farm field environment and a desire to make decisions within an ecosystem framework.

Biological and cultural controls are best used in pest management systems where pest forecasting, crop scouting, and other information are employed to keep track of pest situations. This allows managers to coordinate cropping practices and determine the type and timing of pesticide inputs required for further crop protection.

Crop Scouting Pays

There are innumerable interrelationships among the growing crop, its various pests, beneficial species, the soil, and weather conditions. By gaining information on how these natural processes work, pests can be managed in ways that disrupt the system as little as possible. The collection of required information is done by farmers or by trained pest scouts and farm advisors.

Tree fruit producers in Wayne County, New York, have participated in a pest management program since 1973. Trained farm advisors monitor participants' orchards for insect, mite and disease problems on a weekly basis, and advise producers as to whether the scouting information collected indicates a need to use pesticides.

Producers pay from $6 per acre for peaches and cherries to $12 per acre for apples and pears to receive this service. In return they get healthier, more stable orchards; save money that otherwise would be wasted on unnecessary insecticide, miticide or fungicide applications; and realize higher profits from tree fruit production.

Producers employing the coordinated pest management strategy have pesticide costs that average $26 per acre less than their nonparticipating counterparts. Pest monitoring, information, and better orchard ecosystem management act as substitutes for pesticides. Also, as a byproduct of the ecosystem stability established through pest management program participation, the pest control expenditures made and fruit yield gained by participating producers have been more consistent from year to year than those observed for other tree fruit producers.

In short the tree fruit monitoring and advisement program has been successful in reducing pesticide use and pest control costs, while maintaining the quality and quantity and increasing the reliability of the fruit crop produced.

Almonds, Cotton, Grain

The Wayne County tree fruit pest management program is just one example of the many scouting and advisement programs that have been implemented on various cropping systems across the country.

Similar strategies are used in production units from California almond orchards, to Texas cotton fields, through Eastern Colorado's irrigated grain acreage and Midwestern corn and soybean regions, to North Carolina tobacco and peanuts and Georgia's multi-crop systems. In all these instances, producers employing the information-based, ecosystem-oriented pest management strategy enjoy greater profits as a direct result.

One benefit of coordinated, multipest management is it enables farmers to use pesticides more effectively and only when they are needed. This in turn becomes a public benefit by reducing adverse environmental impacts on water systems, wildlife, or human health.

Chemical pesticides once were seen as a miracle cure for agricultural pest problems. But now U.S. farmers realize they have to carefully manage the crop ecosystem as a valuable, dynamic and delicately balanced natural resource. Better management of crop pests is one way they are doing this.

Tech Use Grows

In 1982, two-thirds of farmers growing row crops had their fields periodically scouted for insect, weed, nematode and/or disease pests. While farmers performed their own scouting on much of the acreage, professional pest scouts were employed on over 10 percent of all U.S. row crop acreage.

Microprocessor and sensor technology increasingly are used to process information for pest control decisionmaking. Further, 12 percent of all farmers responding to a USDA survey indicated they could identify the natural enemies of pests affecting their crops. Many of those familiar with natural enemies reported they took action to preserve this presence in the fields.

This rising level of farmer awareness and support is a sign of the times. It demonstrates grassroots recognition that ecologically sound approaches to pest control are profitable ventures. There is every reason to anticipate that future crop pest management will become even more ecosystems oriented.

No Artichokes!!! Would Life Be Bearable Without Specialty Crops?

By Darwyn H. Briggs and Henry C. Wyman

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Henry C. Wyman is Public Affairs Specialist, SCS, at Davis.

Life without artichokes? What would happen if the remaining 10,000 acres of land growing artichokes in the Nation no longer were available to produce the popular crop because of urbanization, erosion, or air pollution? Of the Nation's 413 million acres of cropland, only these 10,000 acres enjoy the soil and cool, moist climate needed to grow artichokes.

Other crops such as prunes, navel oranges, and garlic have been driven from their historic centers of production because of urban development and air pollution. Despite that forced relocation, however, the crops still are grown because they adapt to a wider range of soil and climatic conditions than artichokes. In some instances, total acreages of these crops actually increased as a result of such moves.

But artichoke production would cease—the famed "choke" no longer would be grown commercially in the United States—if the small artichoke-growing area in the central coastal region of California was not available.

The world wouldn't come to an end with the loss of artichokes, of course. No one would suffer withdrawal symptoms as a result. And we all would survive if forced to do without other specialty crops such as asparagus, brussels sprouts, or broccoli. But these losses would affect the quality and diversity of our diets.

What's more, there is no real need to lose the remaining acres on which specialty crops are produced. In nearly every instance where urbanization threatens farmland, there are alternative locations for urban expansion. Where erosion is destroying cropland, conservation practices could save it. Where smog is killing crops, air quality improvements would permit a fresh start. Clear solutions exist to stem the continuing loss of specialty crops caused by saline ground water and other soil and water resource problems.

California Origins

The Franciscan Missions, established by the Spaniards during the mid-1700's, were the beginning of cultivated agriculture in California. A 1769 diary entry recorded establishment of the first "gardens" in California.

For the next 50 years, California was a necessary stop for ships of all nations sailing the Pacific Ocean. To prevent scurvy, the ships stocked fresh fruits and vegetables. Tree fruits, grapes, lettuce, melons, onions, potatoes, carrots, cucumbers, mustard, eggplant, and dozens of other vegetables were grown at the missions and traded to the Russian, Spanish, and English whalers and merchant vessels.

Large-scale commercial specialty crop production was begun in 1839 by John Sutter, the founder of what now is Sacramento. By 1849, Sutter was producing nearly 10,000 bushels of potatoes and countless other vegetables and fruits each year. By the end of the next decade, California was producing nearly two million bushels of potatoes annually. *The California Farmer* reported that a 30-pound beet, a 4-pound pear, and 25-foot corn stalks were exhibited at the 1858 state fair.

By the 1860's, vegetables and fruits were being planted widely on irrigated land in California. Dryland orchards and vineyards were planted both in the valleys and on hillsides. Railroad cars, refrigerated by ice, became common in the 1870's, and extended California's markets for perishable produce such as cabbage, lettuce, celery, and melons to eastern cities. During the influx of population in the 1880's and 1890's, demand increased for California's transportable produce crops—both at home and as far away as the east coast.

Production areas continually changed for each crop until a balance of the best soil, climate, markets, and rail service was found for the growers and shippers. Production generally began in the same coastal valleys where the first mission gardens were established, and expanded to areas with mild winters such as the Imperial Valley. As competition for land increased in the coastal valleys, the centers of production gravitated toward the interior.

Worth $6 Billion

By 1981, California's specialty crops represented about half of the Nation's total fruit, nut, and vegetable production. Grown on 2.6 million acres (about one-quarter of California's cropland), they accounted for almost $6 billion—more than 40 percent of the State's $14 billion agricultural industry.

Today, California leads the Nation in production of 48 agricultural commodities. Of these, 40 are specialty crops that include vegetables, fruits, nursery products, and nuts.

Much of the land historically devoted to specialty crops has been lost to urban development, air pollution, or water quality

Tim McCabe

A young vineyard just getting started in the Coachella Valley of California. Smog has greatly reduced grape production in many areas, forcing growers to move farther inland.

California's Specialty Crops Going. . . Going. . .
Since the mid-1700's, California has been a leader in specialty crop production. Sailing ships from all nations stocked up with fresh fruits and vegetables grown at the Franciscan Missions before beginning their long trek back across the Pacific Ocean. Today California produces about half the total U.S. fruit, nut, and vegetable crop. Nevertheless, this cropland—which accounts for 40 percent of the State's agricultural income—is threatened by urban development, air pollution, and water quality problems. Some crops, such as artichokes and dates, can be grown nowhere else in the Nation.

problems—primarily in southern California and in the coastal valleys. When the centers of some specialty crops were affected, the industries moved, in many cases 100 miles or more.

The prune industry, once centered in the Santa Clara Valley at the southern end of San Francisco Bay, was displaced by the rapid growth of the computer industry, which turned the area into "Silicon Valley," and the tremendous expansion of housing

USDA

The date palms of southern California—where almost 100 percent of the Nation's dates grow—are beginning to suffer from air pollution.

USDA

Artichokes require highly specialized soil and climate found only on California's central coast. Urbanization has taken all but 10,000 acres of this land.

which accompanied that growth from 1950 to 1970. The center of production and processing of prunes moved into the Sacramento Valley where land and water were available to improve economic return.

Mass exodus of the principal agricultural crop of the Santa Clara Valley resulted in dislocation of owners and operators and their families and of thousands of farm workers and their families, and the expenditure of millions of dollars to develop replacement orchards. It also resulted in the dislocation and re-establishment of processing and allied industries at a cost of many millions of dollars. And it caused dislocation of crops formerly grown where the new prune orchards were established.

A 1950 aerial photo shows Santa Clara County, Calif., still a major production area for citrus and prunes. But in just 28 years it became paved over and built upon, until solidly converted to suburban uses.

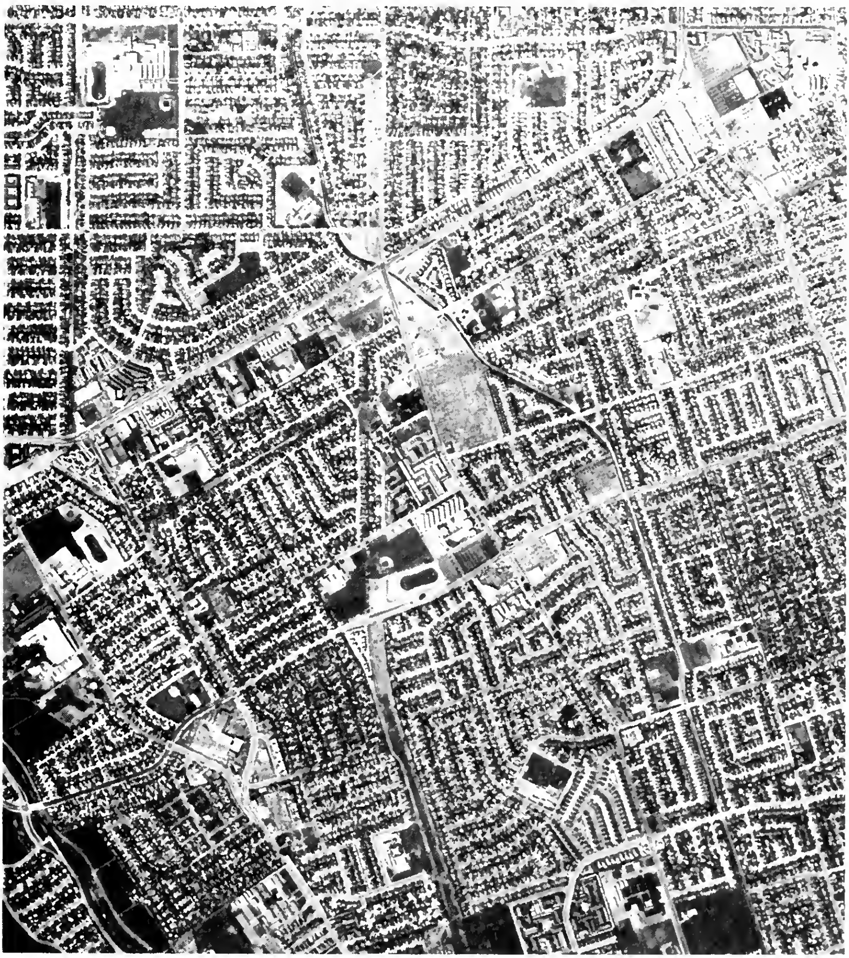
USDA

Urban Leapfrog

This chain of events began with a "leapfrogging pattern of urban development," according to Fred Angelino, president of the California Association of Resource Conservation Districts.

"Once developments began popping up in the midst of orchards, the adjacent farms were forced out because farming operations were incompatible with nearby residences," says Angelino, a lifelong Santa Clara Valley resident and a former prune producer. "Dust and sprays bothered residents, and soon farmers sold out to the next wave of developers and on and on.

"Those who were the first to sell to developers then re-established orchards in areas of the State with lower land and water costs and competed with their



old neighbors. Soon, the whole prune industry in the Santa Clara Valley collapsed, and along with it went other orchard crops grown in the region in smaller quantities—apricots, cherries, and walnuts. So, in the long run it really was economics that killed the Santa Clara prune industry, with urbanization lighting the fuse."

Even though the large production and processing centers had to relocate, California continues to produce all of the Nation's prunes. This was possible because prunes can grow in a fairly wide range of soils and climates in California. Producers of navel oranges and other crops also have been forced to move, their survival guaranteed only because the crops are adapted to a range of soils and climate.

Role of Smog

California's population growth centers are in the coastal and bay counties, where about 16.5 million people live. The many efforts to stem the amount, kind, rate, density, and direction of urban growth have met with limited success. Air pollution (smog) is continuing to increase in the coastal basins. It can kill crops, reduce their quality, and reduce yields.

Smog can reduce the yield for navel oranges by 50 percent. Coupled with the displacement of the groves by houses, businesses, and freeways, smog forced navel orange producers to move from the Los Angeles Basin to the southern San Joaquin Valley during the 1950's and 1960's.

The acreage of orange groves has varied from about 120,000 acres in 1925 to a high of about 230,000 acres in the mid-1940's. As a result of urban growth and air quality problems, the acreage was reduced to about 122,000 acres in 1965. Relocated groves were established, and the acreage increased to 195,000 acres in 1976. However, the acreage continues to decrease in southern California. According to the California Air Resources Board (CARB), San Joaquin Valley orchards are being affected by smog as well.

Air pollution also has had a dramatic impact on grape production in southern and central California. Smog reduced Zinfandel grape production by 60 percent in Riverside County and reduced Thompson Seedless grape production in the San Joaquin Valley by 25 percent, according to CARB reports.

One who has watched the effects of urban growth and its accompanying smog in Riverside and Orange counties is Gabriel Epstein, a current director of the Redlands Resource Conservation District and a retired U.S. Soil Conservation Service employee. "Agriculture was thriving when I arrived in 1943," he says. "When I retired in 1971, almost all the citrus and many other important crops were gone. Today, more is gone—many vineyards are just sitting, waiting for a developer. Smog has been a definite contributor in the overall process."

Epstein is concerned that the time is coming to an end when specialty crop farmers can "pack up and leave" to re-establish in an area untroubled by smog, water-quality problems, or urban development. "I deplore the situation, although our Central Valley will take up the slack for fringe agricultural areas for awhile. But these changes always end up costing the consumer more and adding to soil and water resource problems. We're headed for trouble, and it's just a matter of time."

Air Quality Worsens

Air quality is already so poor in some air basins in southern California that even if the spread of urbanization were halted, only a few low-value crops could survive the air pollution. According to the California Air Resources Board, the air quality in the San Joaquin Valley is getting worse. Annual conditions are closely tied to the summer temperature and wind patterns.

Less than 4,000 acres of dates growing in two southern California counties represent 99.9 percent of the Nation's total date production. No other area in the country has the right combination of intense desert heat and soil and water resources. Urban development is not yet putting pressure on farmers there, but air pollution from the coastal areas is beginning to spill over into that desert air basin.

Although some crops can tolerate relatively wide ranges of soil and climatic conditions, others are growing on the only areas available that can meet their needs.

The unique artichoke-producing lands are facing yet another problem. "We've got the special combination of soil, water, and climate," notes Sam Chinn, a third-generation farmer in the Salinas Valley and president of the Monterey Coast Resource Conservation District. "But we're starting to see a saltwater intrusion problem that's affecting artichoke production.

"Farmers are moving inland to the hillsides to get away from the saltwater that's getting into the ground-water supplies because of irrigation practices. People worry that the added costs of farming the slopes and the increased erosion problems someday may jeopardize the entire artichoke industry."

From 1973 to 1980, the artichoke acreage dropped nearly 15 percent. Today, fewer than 50 growers in four counties are carrying on commercial production in the specialized area.

Californians are becoming increasingly aware that special consideration must be given to efforts to preserve the State's croplands. California can continue to produce 50 percent of the Nation's fruits, nuts, and vegetables only if local governing bodies give high priority to maintaining the best agricultural land for growing specialty crops.

Urban Area Greenbelts and Parks

By Gary A. Moll

Urban sprawl! Who has not heard that term? What does that mean in the way of land area and usage in the United States?

Recent estimates put the amount of urban and suburban lands in the United States at over 94 million acres, or 4 times the land area covered by the State of Indiana.

Over 25 percent of this land is classified as open space and, consequently, contains a variety of natural resources that have a marked impact on the quality of life of the estimated 74 percent of the population who live in this urban/suburban land complex.

It is also estimated that two to three million acres of urban and suburban land are being added each year. This does not seem large until one visualizes three million acres as a two-mile wide corridor extending from New York City to Los Angeles.

The phenomenon of urbanization and suburbanization is not limited to our Nation's major cities. During the last decade there was a significant movement of people from urban centers to less urban and more sparsely populated areas.

Metropolitan areas—cities and their suburbs—grew by 9.5 percent, while the population of nonmetropolitan areas increased by 15 percent. As a result 91 additional communities were designated as new "urbanized" areas by the Census Bureau by the end of the 1970's. States with the highest rates of growth were all in the South and West.

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Turning to Open Space

As the sale of condominiums continues, as we purchase smaller homes and townhouses that require less energy, but also less land—or no land at all—for recreational purposes, we instinctively turn to the open space in our urban and suburban lands for our occasional respites, for the reflection and solace we sometimes desperately need in our often crowded and hectic lives.

These urban and suburban open lands—parks, greenbelts—offer opportunities for recreation away from the everyday traffic and rush hour madness of highly congested areas.

They offer city-raised children nature to delight over and touch, paths to follow, and glimpses of wildlife in their natural habitat. They provide educational opportunities for children and adults to learn about nature and the environment. They provide energy-saving opportunities and generate income through the sale of fallen trees or remnants of commercially harvested trees to the public for firewood. They shelter our homes from strong winds, cool them on blistering days, and increase the values of our homes.

These urban natural resources consciously or unconsciously touch the lives of every person who lives and works in this urban environment. Indeed, as the urban influence in our society grows, all resource management becomes urban in the sense that practices, whether in urban or nonurban areas, simply must be responsive to the values and needs of urban people.

Part of Ecosystem

Urban and suburban lands need to be managed as part of the environmental system, just like forest land, rangeland, wetland, and farmland. Why? To maintain watershed capabilities, to protect sufficient woodland and green space for recreational opportunities, for fish and wildlife habitat, to maintain our food and fiber productive land base, and for soil, water and estuary protection.

The science of natural resource management in populated areas is changing and maturing to meet these concerns. In recent years, professionals in management fields—such as forestry, wildlife and soil science—are beginning to apply their skills to urban areas.

Landscape architects and planners have long been instrumental in urban planning, design, and landscape work. Professionals like nurserymen, landscapers and arboriculturists have developed trades of significant size. Skills of these professionals are substantial and improve with each passing year. All are beginning to develop their ability to partner with other professionals working in urban and suburban areas.

Park management also has seen some major changes over the last few decades. In the past, management of the green elements of the physical park was secondary to the active recreational desires of park users. Active recreation includes baseball, basketball, or Frisbee tossing. To accommodate these user needs, most of our urban parks are flat grass, dirt, or blacktop playing fields. But this trend is changing. Today the passive recreational desires of park users such as hiking, bird-watching or nature study are being evaluated, and this is good news for the community ecosystem.

More Natural Areas

Natural areas within urban and community parks are becoming commonplace. Passive recreation and environmental education are becoming more and more popular. The study and management of nongame species of wildlife and urban wildlife management are growing sciences.

In the future our urban and suburban parks will be valued as much for their contributions to the green and growing ecosystem in and around a city as they are for their active recreational opportunities.

Comprehensive management programs for our Nation's urban natural resources are beginning to evolve. The history of most of our communities includes parks, green space, and street trees. Some of these green spaces and parks were incorporated into our population centers by far-sighted designers such as Frederick Olmsted. Perhaps his effort with Central Park in midtown New York is the most well known. Another example is Minneapolis, Minn., where a series of parks and waterways connect the green space to the city.

In contrast, some other areas have evolved thanks to zoning glitches or construction restrictions. In many cases these stumbling blocks for development were blessings in disguise.

Much of our urban green space is strained substantially by pressures of population and overuse. Not only do our urban natural resources have to survive the daily strain of the urban public, but these living spaces must also compete for space with roadways, utilities, housing, and industry. This competition takes place above and below ground.

Drastic Land Use

From an environmental quality standpoint, urban development is the most drastic land use the existing natural system has to deal with. From an aircraft, urban areas appear as islands in a sea of green vegetation. The water and air that cycle through this natural system pay a high price as they cross urban zones. More often than not, after passing through the city, water and air returns to the natural system cluttered with various pollutants.

Yet even the most ardent of the groups concerned with environmental issues would not propose to remove our towns and cities from the Earth. Because of this impact, therefore, we look to a future where leaders will give considerable thought to the extent, condition and function of the existing natural systems in and around our towns and cities.

A movement toward better management of urban vegetation is underway. Today, urban areas are anthills of activity involving green areas and open space. Grass roots organizations have sprung up everywhere—especially in downtown areas of the largest cities, such as New York, Philadelphia and Los Angeles. Many of these groups are literally creating lush parks on the rubble of demolished city buildings. With almost no resources except desire, willpower, a concern for urban trees, and people, they have done a fantastic job of involving the public.

In small towns, at the other end of the scale, people also are getting involved. They are forming tree boards and park commissions which start the management ball rolling early. Some of these volunteer groups have grown into substantial forces that must be reckoned with by elected officials in the community.

Much to Be Done

There is still a tremendous job to be done before we will be able to brag of our management programs on urban and suburban land. Management activities in these areas are still fragmented and far from utopian. The vision of the land around a city as a pulsing natural system does not lend itself to clean, methodic management.

This maze of natural plant communities involves parklands, public rights-of-way, streams or ditch-banks, private property and vacant lots. Since both the capabilities of the resource and the desires of the people are involved, urban and suburban land challenges the manager with a tremendous number of potential combinations. Decisions must be made on many issues confronting these land managers. And with each decision will come winners and losers.

People and natural resources will be winners when proponents can discuss special interests with an open mind and an understanding of the role and interactions of all the elements involved in this urban ecosystem.

Managing Soils for Your Garden and Homesite

By Duane A. Bosworth

There are thousands of different soils in the United States—but you need to know only the characteristics of the one or two soils on which your home, lawn, and garden are sitting.

How do you determine how suitable the soil is for a garden, for the lawn, or for ornamental plantings? Or what soil-related problems need to be corrected to make your lawn and garden as productive and attractive as possible? A good guide is a soil survey.

Modern soil surveys have been published for about 1,700 counties of the United States, and each year many more surveys are completed.

Copies of published soil surveys are available in most county libraries or at the closest U.S. Soil Conservation Service office or County Extension office.

Soil surveys include maps on which you can locate your property, and text that describes the soil characteristics for your land—as well as some interpretations of the soil for selected uses and some of the important management techniques for improving soil productivity.

Many soils in urban and suburban areas were disturbed to some degree when your home and those nearby were built. Topsoil has been removed in many areas. Cuts and fills are common. However, the soil survey can help because it also describes properties of the subsoil and parent material that may now be at the surface, where you intend to do your planting.

Duane A. Bosworth is Public Affairs Specialist, Soil Conservation Service.

Erwin W. Cole

Most soils are disturbed during home construction. In many cases the topsoil may be missing completely, leaving the subsoil which is inferior for growing grass, gardens, and ornamental plantings.

Subsoil Inferior

In most parts of the country, subsoil is much inferior to topsoil for gardens, orchards, and ornamental plantings. Generally, subsoil is more compact than topsoil, has very little organic matter, and does not contain needed nutrients.

If no soil survey is available, you could use a spade, soil auger, or posthole digger to examine the upper 2 or 3 feet of your soil. Dig down a few inches at a time, preferably when the soil is moist, so you can examine each layer for color, stones, and texture.

A dark brown or black soil contains a good amount of organic matter. Grey, bright yellow, or red soils are low in organic matter. Gray mottles mixed with yellow or red mottles often indicate that the water table is high at certain times of the year.

Determining texture is also important. Take a small amount of soil, moisten it, and rub it between your fingers and thumb. A gritty feel indicates your soil contains considerable sand (the largest soil particle). Clay particles feel very sticky when moistened and rubbed between your fingers.

A soil that contains too much clay (the smallest soil particle) is sticky when wet and hard when dry, and air and water move slowly into and through it. On the other hand, many sandy soils drain too rapidly and don't hold much water for plant use.

Silt (intermediate in size between sand and clay) has a "floury" feel. A good mixture of sand, silt, and clay gives the "loamy" texture ideal for gardens.

Topsoil Gone?

A common problem in many suburban areas is the absence of topsoil. Many land developers, before building, remove and sell the topsoil or mix it with the subsoil. The homeowner is left with a hard soil that contains little organic matter.

Sod placed on subsoil will survive and can even do well if adequately fertilized and watered. But trying to use subsoil for a garden or for foundation plants is almost hopeless in some soils.

Many gardeners plant a crop or two of green manure to turn into the soil. Grass roots loosen the soil, and incorporating the rest of the plant into the soil adds nutrients and more organic matter. A green manure crop planted in the fall and turned into the soil each spring also helps make subsoil act more like topsoil.

Another option is to buy enough topsoil to cover the ground with 4 to 6 inches of soil. But gardeners should examine the soil first to be certain it is good quality.

The role of organic matter in garden soil is so important to productivity that successful gardeners make sure the soil includes an adequate amount of organic matter before attempting to plant their first crop.

Soils with little organic matter are easily compacted, and seal over on the surface so that little rainfall enters the soil. Also, these soils may crust to the extent that a poor stand of plants results. Fortunately all of these problems can be alleviated by adding enough organic matter. Adequate organic matter makes plowing and cultivating easier and increases the nutrient reserve and water-holding capacity of sandy and clayey soils.

In many urban and suburban areas, however, finding organic matter is difficult. Many gardeners compost grass clippings, leaves, and other organic residues. But in arid areas where such materials are less abundant, this source is often not enough. In warm climates organic matter decays rapidly, often faster than it is being replaced.

In some areas, gardeners looking for organic matter can find suburban horse owners with excess manure and can offer to haul it away for use in the garden. Some cities accumulate leaves in large piles during fall collection periods. After several months of decay, the composted leaves are available free to local gardeners.

Mulching a Big Help

Mulching may be your most valuable garden practice. Mulching reduces erosion caused by runoff of rain or irrigation water, increases infiltration of water into the soil, and conserves water by reducing evaporation. Mulches also help to suppress weed growth, and keep the soil from getting hot under intense sunlight. Many plants, including those in vegetable and flower gardens, need a cool soil surface.

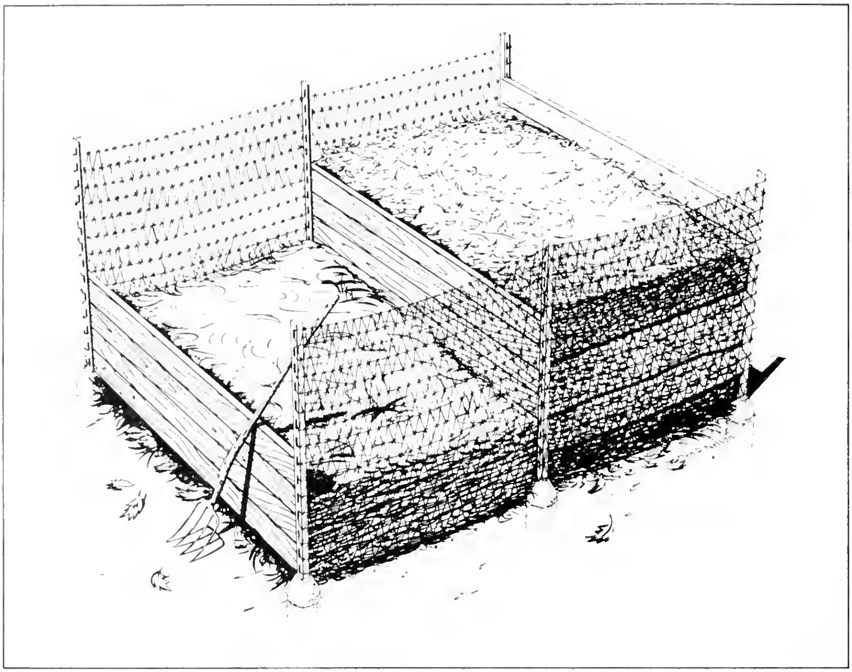
Many organic materials make good mulches. Organic materials used for mulch include leaves, lawn clippings, sawdust, straw, ground corncobs, peanut hulls, and organic refuse from food processing plants.

Some materials—such as straw, autumn leaves, bark, and sawdust—are rich in carbohydrates but very low in nitrogen. If large quantities of these are mixed into the soil without adding extra nitrogen, a temporary nitrogen deficiency can occur and your plants won't have the nice dark green color they should. To overcome this problem, mix one or two cups of fertilizer high in nitrogen (such as ammonium sulfate) into each bushel of these materials.

If high carbohydrate mulches are placed on the surface, they do not cause nitrogen deficiencies.

Mulching reduces soil erosion, conserves water, and suppresses weed growth. Many organic materials make good mulches.

Gene Alexander



The ideal way to make compost is to use two bins. This permits turning the compost by moving it from one bin to the other.

Some gardeners use sewage sludge for mulching. If you do this, ask your local sewage treatment plant operator if industrial sewage is treated in the plant and how much cadmium or lead is in the sludge. If the sludge contains heavy metals, it should not be used in vegetable gardens because cadmium and lead accumulate in plant tissues. When people eat the plants, the heavy metals are collected in the kidneys and may be harmful over a period of years.

Compost Bins

To provide a source for one of the best mulches, every gardener should have a compost bin for making compost from organic materials. You can make the bins yourself by attaching ordinary wire fence or boards to solid posts. Each bin should be 4 to 6 feet high, 3 to 5 feet wide, and any convenient length. One side should be removable for convenience in building up the compost material and taking it out.

Leaves, grass clippings, stems and stalks from harvested vegetables, corn husks, pea hulls, and fine twigs are good materials for composting. You should always compost leaves before using them as a mulch. Raw leaves are flat and may keep water from entering the soil. Avoid using any diseased plants.

The ideal way to make compost is to use two bins. Fill one with alternate layers of organic material 6 to 12 inches thick and garden soil 1 inch or more thick. Add fertilizer to each layer of organic material.

Be sure to moisten the organic material thoroughly. Repeat the layers until the bin is full or you run out of organic material. Pack the material tightly around the edges, but only lightly in the center so this area settles more than the edges and the water does not run off.

After 3 to 4 months of moderate to warm weather, commonly in June, begin turning the material by moving it from the first bin into the second. Before turning, it is a good idea to move the material from the edges, which dry out first, to the center.

In areas that have cool frosty winters, compost made from leaves in November and December can be turned the following May or June.

Erosion Control

Erosion in your garden can carry away the most productive part of the soil. Organic matter mixed in the soil reduces erosion because the soil does not seal over at the surface and more of the rain soaks in rather than running off. Some erosion control practices used by farmers—for example, contouring and no-till—may be useful in your garden.

Examples of Fertilizer to Add to Each Layer of Organic Material in a Compost Bin

Chemical	*Rate in Cups per Bushel of Organic Material*[1]	*Chemical*	*Rate in Cups per Bushel of Organic Material*[1]
	(Method 1)		(Method 2)
Ammonium sulfate	1	Mixed Fertilizer 5-10-5	3
or		Ground dolomitic limestone[2]	⅔
Ammonium nitrate	½		
Ground dolomitic limestone[2]	⅔		
or			
Wood ashes[2]	1½		
Superphosphate	½		
Magnesium sulfate (epsom salts)[3]	*⅙		

[1]Packed tightly with your hands
[2]For acid compost (for azaleas and rhododendrons), omit lime, limestone, and wood ashes
[3]Add epsom salts only if dolomitic limestone is unavailable and ordinary limestone is used (at same rate)
*Equivalent to 1 tablespoonful

Contouring. If your garden is on a slope, it should be planted on the contour. If water is channeled across the slope instead of down, the soil absorbs more rainwater, has less erosion, and is less affected by drought. This pays off in better yields and higher quality vegetables or flowers.

To contour your garden, first mark a contour line across the slope. It does not require special skill or equipment to find the contour line. A level can be improvised from materials on hand—an efficient device can be made from an ordinary carpenter's level mounted on a 2-by-4.

To determine a level line, begin about the center of the slope. Lay the 2-by-4 along the slope and move one end up or down until the bubble on the level is centered; mark the spot with a stake. Repeat this process across the slope to establish the contour guideline. Plant your rows of vegetables or flowers parallel to this line.

As you cultivate the garden, leave small furrows between the rows to collect and hold the moisture so it soaks into the soil.


USDA

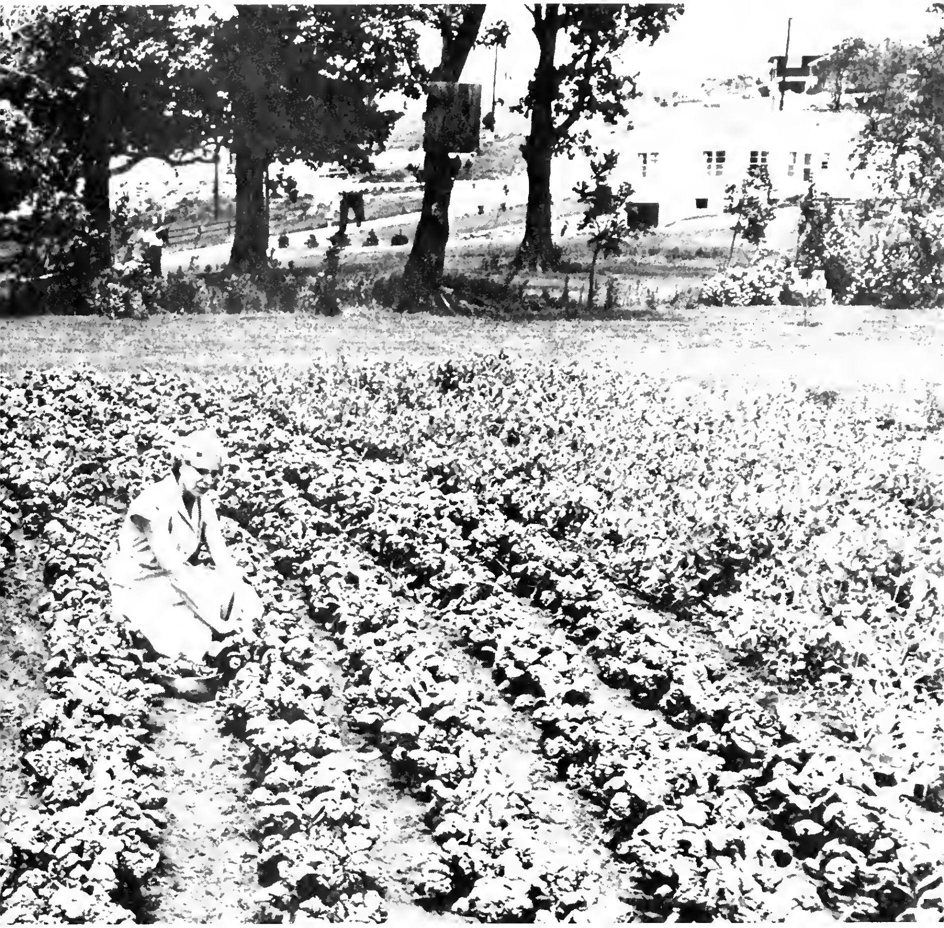
On sloping land, gardens should be planted on the contour to reduce soil erosion and make maximum use of rainwater.

Diverting Runoff

If water from your neighbor's property drains onto your garden, a diversion terrace can divert the flow of water effectively. When your garden is on the slope, terraces also can help to prevent erosion.

A terrace is simply a ridge of soil with a shallow channel on the upper side. You can build it with a hoe and spade. Or, if your garden is large enough, you may use a garden tractor or larger equipment.

Give the terrace a slight grade so water does not stand in the



channel but flows off gently. This water should flow onto a grassed area to prevent erosion.

No-Till. Many gardeners could adopt no-till, a conservation tillage practice now being used widely by farmers. Rather than plowing or spading, which leaves a clean surface susceptible to erosion, no-till allows you to prepare only a narrow strip of fresh soil in which to plant your seeds.

No-till usually requires use of a contact herbicide before planting, to kill those weeds that have started growing by planting time. But after everything starts to grow, you can mulch between the rows and only need to pull an occasional weed. No-till reduces erosion and keeps organic residues on the surface as a mulch.

HD Price

Large wet areas in a yard can usually be eliminated by installing subsurface drains, 2 to 5 feet deep.

Irrigation Tips

Rapidly growing garden crops such as sweet corn may require 2 to 3 inches of water per week from sprinklers or from natural rainfall during midsummer when the crop is approaching maturity.

Knowing your soil's water-holding capacity is important. Some soils hold only enough available water to last 3 days or less. Others may hold enough to last for 2 weeks.

Typically, sandy soils hold less water than do loamy or clayey soils. Soils with adequate organic matter tend to hold more water than soils low in organic matter.

If water is relatively expensive, you may want to consider using one of the new drip irrigation systems that put water only at the base of the growing plants, or a soaker hose that waters only the row where your plants are growing.

Drainage. If your garden is poorly drained, subsurface drain tile, 4 to 6 inches in diameter at a depth of 2 to 5 feet, may be the answer. Subsurface drains must be extended far enough to empty into an adequate outlet.

Some gardeners find that building raised, narrow beds 3 to 5 feet wide can overcome drainage problems. Such beds are separated by trenches 1 or 2 feet wide. Soil from the trenches is used to raise the growing beds. Raised beds are better drained and can be worked from the trenches rather than having to walk on and compact the soil in the growing area.

How to Avoid Ponding

Many urban and suburban lots have poor drainage and water tends to pond on them during certain times of the year. If water normally ponds next to your home, you should grade your yard so surface water drains away from the house. A minimum grade of 1 foot in 50 feet is usually adequate.

Ponding is generally caused by a dense clayey layer near the surface that prevents water from moving downward. Suitable downspouts connected to a subsurface drain or to an outlet leading away from the home will in most cases solve the problem. If the dense layer is near the surface, dig a small trench through the layer and fill it with sand or gravel or other coarse material to improve permeability.

For larger wet areas, 4- to 6-inch subsurface drains, 2 to 5 feet deep, may be needed. The drains should be covered with 6 to 12 inches of coarse sand or gravel or to within a foot of the surface. Topsoil can be used to fill the surface layer.

Your homesite may be downslope from a source of runoff water that adds to the drainage problem. In many cases this water can be diverted with a small earthen terrace that leads the water across the slope to a grassed outlet.

Urban Forests, Where Trees and People Go Together

By J.F. Dwyer,
F.J. Deneke,
G.W. Grey, and
G.H. Moeller

When we think of forests, we picture ponderosa pine in the Rocky Mountains, Douglas-fir in the Pacific Northwest, the hardwoods of rural New England, or vast tracts of pine woodlands in the South. However, there is a forest in virtually all our own backyards which we never see for the individual trees or the buildings. A forest we take for granted.

Yet it is this forest in which many of us spend most of our lives and it affects us in many ways. The forest we are talking about is one of the urban and community forests of our cities and towns. For many, these forests provide the only contact with a forested environment.

Trees have always been an important feature of our cities and communities. However, only now are we beginning to recognize and understand the many values of urban tree resources, and become more aware of the increasing need to manage urban trees and associated vegetation—the "urban forest"—as a system to produce desired benefits.

Where is this urban forest? It occurs everywhere in and near cities. It is owned by many different kinds of people and institutions—homeowners, government, and businesses. Like the rural forest, the urban forest is subject to many different pressures.

The urban forest occurs as an interconnected vegetative system throughout most cities. It occurs in lines along streets and sidewalks, powerlines, pipelines,

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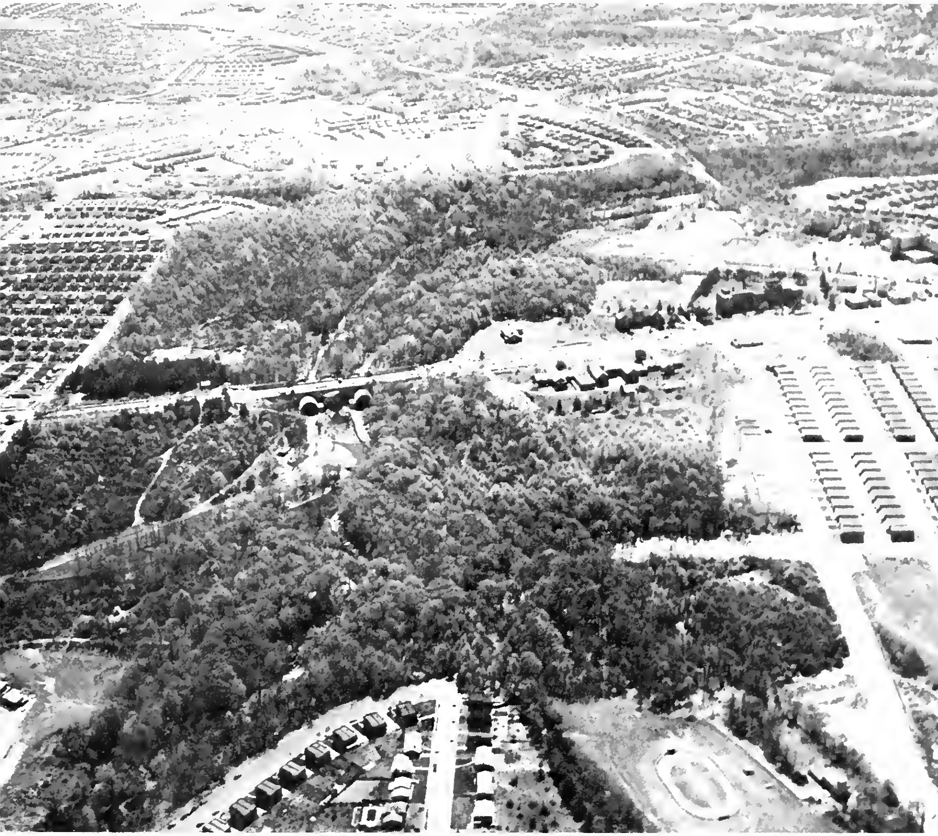

Gordon Smith

utility rights-of-way, transportation corridors, as trees in small groups occupying vacant lots, and in backyards.

It becomes an intricate network of corridors as these segments of the urban forest link with larger parcels of forest cover in parks, preserves, arboretums, municipal watersheds, cemeteries, and underdeveloped land. Each part of the forest system provides distinct benefits and complements other parts to provide a full range of contributions to society.

Estimates show 30 percent of the surface area of the average U.S. city is covered with trees.

Outdoes Countryside

How large is this resource? Fifty percent of the land area in the average American city is open—not covered by buildings, concrete, or asphalt—and is capable of supporting vegetation. How much actual forest cover is there?

About 30 percent of the surface area of an average U.S. city is covered with trees. This is a larger portion of forest cover than is found in the typical countryside! It is estimated that cities spend $300 million annually to maintain urban forest resources, valued at $25 billion.

Most of us have responded to high energy costs and inflation by spending more time closer to home. This has led to a resurgence of interest in enhancing the quality of life in our cities and communities, and to a rapid increase in use of urban and community forests. The results are increased demands on a limited resource, and expanded efforts on the part of municipal governments to provide high quality green space to meet these demands.

The urban forest is a highly diverse ecosystem characterized mainly by trees but including other plants, animals, climatic and soil conditions, and people and their works. It provides a broad spectrum of benefits and opportunities that range from the cool shade to hiking in the "wild" parts of forest preserves, to studying nature in arboretums, conservatories, or zoological gardens.

Tree-lined corridors linking larger tracts provide a forest setting for increasingly popular "linear activities" such as walking, jogging, bicycling, and hiking. These same corridors facilitate movement of wildlife throughout the system and aid seed dispersal from trees and related plants.

Niches for Enjoyment

The combination of open spaces and woody areas creates "niches" for our enjoyment—places for observing unique plants and wildlife, picnic sites with a mixture of sun and shade, and choice fishing spots along streambanks. The urban forest influences the neighborhood where leisure time is spent by adding to the character of the local landscape and microclimate; screening out unwanted sights, sounds, smells, and substances; moderating sun and wind; and enhancing wildlife.

Some cities in both the United States and Canada are developing their forests in new ways. Seattle has a park built over a freeway. Calgary, Alberta, recently completed a 2.6 acre park-under-glass that is linked to other small glass enclosed gardens and malls in the heart of downtown. Saskatoon, Saskatchewan, also has plans for glass-enclosed parks and walkways with a strong emphasis on cultural development.

The Chicago metropolitan area includes perhaps the most extensive urban forest under a single management agency—65,000 acres of forest that comprise the Forest Preserve District of Cook County, Illinois. Covering 10 percent of a county that has 5.5 million residents, the forest preserves are managed for resource preservation, environment education, and outdoor recreation.

They provide the setting for more than 31 million recreation visits a year.

Complex Task

Because the urban forest is so diverse, the job of management is very complex. Among the factors adding to this complexity are: The high value of urban vegetation and urban land, relative scarcity of forest and open space resource in relation to other urban demands, heavy use pressures, stress imposed by a people-dominated environment, unrelenting pressures for urbanization, high public visibility, and often diverging interests about appropriate land use.

Municipal forestry departments and private companies have been planting and caring for urban trees for many years. Utility companies, while providing needed utility services, attempt to manage urban vegetation to better the environment. Add large corporate landowners, managers of public forests and open space resources and, perhaps most important, individual property owners with their backyard "forests," and we begin to get an idea of the diverse groups that influence the urban forests.

Many different kinds of professionals, trained in the tools of their profession, contribute to planning and managing the urban forest resource. The landscape architect seeks to enhance natural beauty. The regional or urban planner integrates planning for urban forest values with comprehensive urban development. The horticulturist is concerned with the physiological processes that occur between a plant and its environment.

The arborist, wildlife manager, forester, recreationist, and many other professionally trained people manipulate those components of the urban forest that produce benefits associated with their professions.

The urban forest, then, is the part of the urban-suburban area made up of forest and associated vegetation, water, soil, wildlife, and related open space resources.

Pluses and Minuses

People share many benefits from properly managed urban forests. There also are some negative effects such as clogged sewers, broken sidewalks, vandalism, and destructive effects of wildlife. One goal of urban forest management is to maximize the positive benefits, while minimizing the negative.

Some benefits attributed to trees and forests in cities can be measured in dollars and cents. Trees provide economic benefits—they can increase housing values as much as 20 percent. When used as windbreaks and for shade around homes, trees can reduce fuel used for indoor space air conditioning by 10 to 20 percent.

Other benefits can be measured:

1) A 20-foot wide band of trees can reduce noise by 25 to 50 percent,

2) urban forests can improve air quality by intercepting 27 to 38 percent of particulate material and removing 9 to 13 percent of gas-like suspended particles from the air, and

3) a typical 40-acre city park can provide over a million visitor hours of recreation per year—more recreation use than provided by the average rural forest recreation area many times larger.

Some real benefits cannot be measured easily. For example, what is the value of a pleasant urban landscape that is enhanced by the presence of ornamental trees? What about the value of moderated climate—cool shade and reduced wind—due to the presence of trees? How about a quieter, more tranquil environment?

What is the worth of a diverse population of songbirds and other wild creatures that grace the urban landscape? And, what is it worth to an entire community to have a higher quality environment, a place where people can experience and benefit from nature first hand, while never leaving the urban setting? What are these things likely to be worth if energy becomes more costly and more scarce?

How to Go About It

Resource managers produce benefits by manipulating biological and physical components of the urban forest. Once we understand how these components interrelate to produce a particular effect, such as noise reduction,

the urban forest can be planned and managed to produce the desired result.

Urban forest managers always have known that urban trees enhance urban environments, but only recently have we begun to develop methods to increase the quantity and range of benefits through improved management practices.

Tree planting will continue as an important management activity because of the strong need

A 20-foot wide band of trees and shrubs in residential areas can reduce noise by 25 to 50 percent depending upon special selection and at the same time intercept and remove unwanted particles from the air.

for establishing or restoring urban forest environments, particularly among transportation routes, around dwellings, in urban development projects, and in parks and other open spaces.

These efforts will place strong demands on nurseries to introduce new and genetically improved species well adapted to the urban environment. Use of such plant materials will lower replacement costs and maintenance outlays.

Tree care should be complete. It should involve trimming, watering, and fertilizing, as well as protection from insects, disease, pollution, mechanical damage, and vandalism. The "plant it and forget it" approach to urban trees is too expensive for most managers.

Siting and Spacing

Planning the context in which trees are planted requires increasingly critical attention.

Tree planting will continue to be an important management activity because of the strong need for establishing urban forest environments in urban development projects.

Managers should strongly resist attempts to cover all urban green space with tree canopy. In many places people do not want an unbroken tree canopy; they prefer clusters or corridors of trees intermingled with grass and other ground cover, roads and parking lots, buildings, recreation facilities, and other developments.

Heavy demands for athletic fields, urban gardens, prairies and other treeless green space should be considered in urban tree planting. Improperly positioned trees may disrupt these important uses.

Proximity of trees to other resources is a key determinant of subsequent tree loss and damage, as well as of maintenance costs. In many cases, managers can save money with no loss of benefits by maintaining appropriate spacings between trees and facilities.

The Forest Preserve District of Cook County concentrates picnic facilities in relatively open grassy areas with scattered trees rather than in densely forested areas. The result is less tree damage and a better place for picnicking and many other uses.

Damage to trees and related resources is also reduced by placement of roads and parking lots and creation of traffic barriers.

Tree Planting

Tree planting has important implications for other components of the urban forest and the associated benefits to city people. Managers are beginning to look at the forest not as a collection of trees but as an ecosystem characterized by trees and including plants, animals, climate and soil, and people.

To do otherwise is to risk creation of such undesirable conditions as damage to nearby homes and gardens from wildlife brought by an extensive tree planting effort, or loss of understory vegetation when many trees are planted close together in a particular area.

Urban forest management is getting more attention for many reasons besides the rapid increases in recreation use. Diseases have killed many urban trees, requiring massive tree removal and planting programs and new pest management strategies.

Large-scale suburbanization has extended residential developments into farmland and other open space areas that have been cleared of forest, thus creating the need for establishing and managing the urban forest in new neighborhoods. Urban redevelopment has created similar needs in the inner city. The 1970's environmental movement focused more attention than ever before on improving the quality of urban life.

High Stresses

Managing urban forests is complicated by high stresses imposed on vegetation by

1) The character of the urban environment, and

2) high levels of use.

Urban soils often have been disturbed, compacted, or filled, hindering root development. Root problems are particularly critical for the urban forest located in flood plains and subject to periodic flooding and drought.

Salt spray, toxic runoff from streets, air pollution, and mechanical damage often pose problems for urban forests. Heavy use by city people has compacted soil; damaged trees, other plants, and facilities; and disrupted wildlife populations.

Because urban trees and associated plants under stress are highly susceptible to insects and diseases, pest management probably will grow more important and complex.

Close public scrutiny of urban vegetation usually leads to early detection of pest damage. City dwellers generally have a low tolerance for such damage and often engage in or call for highly intensive pest management and heavy use of pesticides. The impact of pesticides on urbanites and their environment is leading to some significant rethinking of urban pest management strategies.

Wildlife Problems

The squirrels, deer, birds, and other wildlife of the urban forest add to the recreation experience, but they also may become troublesome pests by damaging gardens, homes, and recreation facilities.

Control of animal damage often is complicated by strong public sentiment against actions that may harm animals. Development of management strategies that maximize the benefits of wildlife but minimize the damage is a major challenge.

Creating urban forest environments through tree planting and subsequent care is one aspect of management; other efforts involve changing the existing urban forest to accommodate new uses. Prominent changes include the development of homes, transportation routes, and recreation facilities.

Urban forests are highly prized sites for homes because much recreation takes place near the home. Managers face a major challenge in maintaining a pleasing forest environment while providing for construction of homes and associated utility and transportation developments.

In most instances, managers try to minimize damage to tree roots and stems during construction and subsequent maintenance, and protect against soil compaction and disturbance, disruption of soil drainage patterns, and exposure of the remaining trees and related vegetation to sunscald and wind damage.

Restrictions, Options

Urban forest resources are managed by many public and private organizations with various purposes, interests, and levels of expertise. Individuals responsible for these resources may have experience in diverse fields including forestry, arboriculture, landscape architecture, urban planning, parks and recreation, wildlife management, engineering, and environmental education. The diversity of objectives and managerial backgrounds complicates urban forest resource management.

Urban forest managers often have fewer and somewhat different management options than their rural counterparts. Limiting use through permits, blocked roads, or other direct restrictions on access usually does not work with large concentrations of city people nearby. Less direct controls such as facility design, placement of vegetation and barriers for channeling traffic, design of roads and parking facilities, rules and regulations, and use of patrol personnel tend to be more effective.

Objections of urbanites often make the use of fire and the cutting of live trees unacceptable as management techniques. Harvesting dead trees for firewood is limited by concern about the spread of insects and disease and the city residents' overwhelming demand for "do-it-yourself" firewood. Most urban forest management programs lack the manpower to supervise firewood cutting.

Public Involvement

The usually high level of public interest and involvement in urban forest resource management is increasing. Neighborhood associations and conservation groups are playing a more important role in urban tree planting and care, as well as in control of vandalism and other undesirable behavior.

Examples include the Greening of Boston, the California Conservation Project (The Tree People), the Magnolia Shade Tree Commission of New Jersey, Philadelphia Green, the Magnolia Tree Earth Center in Oakland, the Street Tree Consortium in New York, the Adopt-A-Block Program in Oakland, the Adopt-A-Park Program in Detroit, the Green Guerrillas, and the Oakland Tree Task Force.

In many urban areas, homeowners are being given greater responsibility for selecting, planting and watering "street" trees in front of their homes as well as for sharing in the cost of the trees. Expanding citizen involvement may result in substantial cost savings.

Substantial cost savings can be achieved by applying modern management techniques to the urban forest. One change may involve combining urban forestry efforts fragmented under street tree, park, public housing, utility, transportation, water resource, and other programs. Such an effort would facilitate coordination among urban forestry programs, improve their effectiveness, and save money.

Integrated Planning

At the same time, urban forestry should be more closely integrated into city and regional planning for housing, utilities, recreation, land use, water resources, and transportation. Without such integration, urban developments may continue to eat away at urban resources, reducing user benefits and requiring large expenditures for restoration.

Effectiveness of integrated planning will depend, in part, on the ability of urban forest managers to anticipate changes in the system—especially in transportation, housing, and utilities—and to develop innovative ways of responding.

The urban forest probably will continue to change with urban development in the years ahead. Growing concern about effects of noise and congestion on urbanites is likely to draw attention to the forest's role in moderating noise and in screening particular areas, including portions of recreation sites. The character of residential and "street" trees and related open spaces is likely to change as multifamily housing and new developments in mass transit become more popular.

LESA Shows Which Lands Should Stay in Farms

By Lloyd E. Wright

Making land use decisions is a difficult process. How do we choose the use that will best meet the community's overall needs and objectives? How can we preserve and strengthen agriculture and at the same time promote needed development?

One of the first steps is to thoroughly evaluate the land. We need to know which land is best suited to farming and which can be converted to other uses with little harm to our agricultural resources. In response to this need, the Soil Conservation Service (SCS) over the past two years has developed and tested the agricultural Land Evaluation and Site Assessment (LESA) system.

More comprehensive than previous methods of classifying land, LESA takes into account location and social, economic, and governmental factors as well as soil quality. It can be applied consistently, and yet allows for flexibility. Local planners work out details of the system and thus can adapt it to local circumstances.

LESA makes full use of available information, including soil surveys, land use plans and policies, and natural resource inventories. It combines existing systems for determining soil quality, minimizing the limitations of each.

The LESA system is part of the U.S. Department of Agriculture's farmland protection program. It is included in the 1983 proposed rule as the basis of the criteria for implementing the 1981 Na-

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C.H Harper

tional Farmland Protection Policy Act (FPPA).

Purpose of FPPA is to minimize the extent to which Federal programs contribute to unnecessary conversion of farmland to nonagricultural uses. The act instructs USDA, in cooperation with other Federal agencies, to develop criteria to identify adverse effects of Federal programs on farmland preservation. A Federal agency involved in a proposed conversion must consider alternatives that would lessen these adverse effects.

Local planners work out details of the Land Evaluation and Site Assessment system, adapting it to local circumstances.

Point System

LESA consists of two parts—land evaluation and site assessment. In each part, relative values are assigned to a site. The maximum number of points assigned to any site is 300. The land evaluation part has a maximum of 100 points and the site assessment part a maximum of 200 points.

In the *land evaluation* part, soils in a given area are rated and placed into groups according to their suitability for a stated agricultural use. A relative value is determined for each group. The best soils are assigned a value of 100 and the others are given lower values. Ratings are based on data from the National Cooperative Soil Survey.

The *site assessment* part identifies factors other than soil quality that contribute to suitability of a site for agricultural use. These factors are selected at the local level. Each factor is assigned a range of values according to local needs and objectives.

In 1981, LESA was field tested in 12 pilot counties in 6 States. Local governments all over the country are now developing their own versions of the LESA system. Following is a closer look at the system in three of the pilot counties: McHenry County, Illinois; Whitman County, Washington; and Clarke County, Virginia.

City Comes to Country

In McHenry County, Illinois, the farm economy struggles to keep a place in the sun. Just 50 miles to the southeast looms Chicago, the farm market become megalopolis, the center of world trade and industry whose vast suburban mantle has transformed the surrounding area.

Numbers tell a story in McHenry County: The city has come to the country. About 150,000 people now live within the county's 611 square miles. Population jumped by a third from 1970 to 1980. In those 10 years, while the county's rural population was increasing by 13 percent, urban population rose 50 percent. Four out of five new county residents since 1970 live in urbanized areas.

Yet the county has retained its rural identity, and farming still contributes to the local economy. About three-fourths of the county remains in agricultural land uses. It has 239,000 acres of cropland, 28,000 acres of pastureland, and 16,000 acres of forest land. The value of crops and livestock in 1982 was $111 million. Statewide, the county ranks seventh in hay production and fourth in dairy production.

In October 1979, the McHenry County Board adopted a Year 2000 Comprehensive Land Use Plan that provided a framework for guiding growth in the county. The board also enacted a zoning ordinance to implement the plan. The ordinance established an agricultural zoning district designed to protect farming and restrict other uses. Single-family residential use in the agricultural district would require a minimum lot size of 160 acres.

Lawsuits Filed

Putting the land use plan and zoning ordinance into effect resulted in four lawsuits. In one lawsuit that was brought to the appellate courts, a landowner contended the only profitable use of his farm was conversion to nonagricultural uses, but

Gene Alexander

In rating soil productivity, the McHenry County planners used field corn as the indicator crop.

county officials, with the assistance of the local SCS office, produced evidence that the land could be farmed productively. The courts upheld the county zoning ordinance.

McHenry County was interested in LESA as a possible means of supporting its planning and zoning efforts. Edward Weilbacher, SCS District Conservationist, provided overall leadership for developing the land evaluation part of LESA. A work group composed of SCS staff, assisted by local officials, evaluated each soil in the county. The group used three systems commonly employed in USDA for rating agricultural land:

Land Capability. Soils are grouped into eight classes according to their limitations for field crops.

Important Farmland. Soils are evaluated for their suitability for producing food, feed, forage, fiber, and oilseed crops. Important farmland includes prime and unique farmland and land designated important at the State or local level.

Soil Productivity. Productivity is based on expected yield of a given crop under a high level of management. McHenry County used field corn as the indicator crop and developed a productivity index employing State yield data.

10 Soil Groups

With the resulting information, the work group arranged soils in the county into 10 groups and indicated the percentage of land area in each group. Soils with similar productivity, important farmland status, and soil limitations were placed in the same group.

Next, the work group assigned relative values to each soil group. They adjusted the productivity index for all soils except those in land capability class I. These adjustments took into account the cost of applying conservation practices needed to overcome soil limitations such as wetness or erodibility. The county was now ready to formulate a land evaluation rating for any of its farms.

Steve Aradas, McHenry County Director of Planning, and his staff led development of the site assessment part of LESA. They worked with the county planning commission and other interested officials.

First, Aradas and his staff reviewed the county comprehensive plan, the zoning ordinance, and the State farmland protection policy. They also collected information on the county's land use trends, number of vacant lots, and existing and planned sewage, water, and transportation facilities. They reviewed the case files of pending lawsuits concerning the zoning ordinance. They drafted, reviewed, and revised a list of site assessment factors that they considered locally important in determining which farmland to protect.

The staff next outlined a point system for rating each factor. A maximum of 10 points was assigned to conditions that best supported agriculture and 0 points to conditions that did not support agriculture.

Each site assessment factor was weighted to indicate its relative importance in the county. The highest weight (10 points) was assigned to the factors "percent of area in agriculture" and "compatibility with comprehensive plan." The lowest weight was assigned to "impact on historic/cultural features." Weights were adjusted based on field testing, so that site assessment points would not exceed two-thirds of the total LESA points allowed.

Calculating for 2 Sites

Here is how this site assessment rating was calculated for two sample sites. Site A is located 10 miles from an urban center, in a predominantly agricultural area that does not provide urban support services. Site B is adjacent to an urban center, and most of the needed services are already available.

Soils on both sites are well suited to agricultural use, having a land evaluation rating of 88 out of a possible 100. However, the site assessment ratings differ significantly.

Site A has an adjusted rating of 182 points out of a maximum of 200. Converting this site would probably adversely affect other farms in the area. Site B, on the other hand, was assigned only 39 points out of 200. Converting Site B would thus be preferable to converting Site A. Site A should remain in agricultural use.

The McHenry County Planning and Zoning Committee approved LESA as part of its integrated farmland protection program.

The system is being used to evaluate land conversion proposals and develop recommendations presented to the McHenry County Zoning Board of Appeals and the County Board.

The County Soil and Water Conservation District also adopted LESA. The district uses LESA ratings in the natural resource inventory report, which it is required to make by State law. These reports, which are distributed to local governments, include an assessment of agricultural land conversion.

Palouse Wheatland

Fifteen hundred miles west of McHenry County is the vast Palouse wheat country, more than 1 million acres of some of the most productive soils in the Nation. In eastern Washington, heart of the Palouse, spreads Whitman County, its 2,200 square miles containing some of the most fertile—and erodible—Palouse soils. The county's 1,700 farms have an average size of about 800 acres.

Whitman County is consistently one of the Nation's top producers of winter wheat. With about a fourth as many people as McHenry County and nearly four times the land area, Whitman County is in no immediate danger of being paved over. From 1970 to 1980, its population grew slightly less than 6 percent, to about 40,000.

Still, many county residents have long been concerned about farmland protection. While most conflicts over land use have involved water-related developments such as dams and reservoirs, the fertile yet erodible soils must be protected so that farming can continue to flourish in the 21st century. Soil conservation, therefore, is a priority. So is the need to keep the best soils in agriculture.

Residents also are concerned about leapfrog development of housing and industry in farm areas, rather than having development in existing urban centers where it would not disrupt the farm economy.

Tim McCabe

Whitman County, Washington, is one of the Nation's top producers of winter wheat. It also has some of the region's most erodible soil.

In 1978, the county adopted a comprehensive plan that strongly supported farmland protection. A task force organized to implement the plan was not satisfied with any of the existing systems for evaluating agricultural land.

Soil Suitability Rating

Leadership in developing the land evaluation part of LESA was provided by Dennis Roe, SCS District Conservationist. Roe and his staff decided to use the soil potential index (SPI) for wheat as the major criterion since wheat is the predominant crop.

The SPI is a numerical rating of the soil's relative suitability for production of a selected commodity. It is expressed by the equation:

$$SPI = P - (CM + CL)$$

P is an index of yield in relation to a local standard. CM is an index of costs of corrective measures, such as grassed waterways or terracing, to overcome or minimize soil limitations. CL is an index of costs resulting from continuing limitations.

Because the county has no land in capability class I, little in class II, and only 3.6 percent prime farmland, the soils were not divided into groups. The relative values were calculated directly from the soil potential indexes.

Assessment Units

William Wagner, the former county planner, assisted by members of the local planning commission and Frederick Steiner, a professor at Washington State University, developed the site assessment part of LESA for Whitman County. Wagner's group selected the following site assessment factors:

Percentage of area within one mile that is in agricultural uses. Land use adjacent to the site. Wasting of agricultural land by cutting off access. Availability of nonagricultural land for urban or other development. Compatibility of proposed use with comprehensive plan and zoning laws.

Also, availability of public services. Compatibility of proposed use with uses on adjacent lands. Environmental factors. Open space taxation (Washington has a preferential taxation system for agricultural, forest, and open space land). Other factors unique to the site.

A score of 1 to 10 was assigned to each factor, resulting in a maximum of 100 for a site best suited to agriculture. Unlike McHenry County, Whitman County did not weight the factors. Each factor is equally important.

Over the past year, LESA has been used in Whitman County to evaluate proposed sites for substations of the Washington Water Power Company. The system helped identify sites that were least valuable as farmland and could be converted with minimal negative effect on the area's agriculture.

Small is Beautiful

Clarke County, Virginia, is a rural heartland only about an hour's drive west of the Nation's Capital. The county is home for some 10,000 people, and 70 percent of its 174-square-mile area is farmland. The farms, about 250 of them, average 303 acres—small by Whitman County standards, perhaps, but they form the economic base of Clarke County.

Despite the county's size, it is rich in soil and water resources and recreation opportunities. Nourished by fertile limestone soil, the main farm enterprises are orchards and pork, beef, and dairy production. Statewide, the county ranks second in commercial apple production.

The Shenandoah River makes several wide, leisurely turns on its course through the county. Along the county's eastern boundary—the crest of the Blue Ridge Mountains—winds the Appalachian Trail, arguably the most famous hiking trail in the world.

One might say that Clarke County is small but not forgotten, least of all by the people who live there. Farming is the economic base, but many residents are concerned about its future. Urban development has occurred rapidly in adjacent counties and, they believe, is headed their way. But they want urban growth in Clarke County to be properly planned so its agricultural base will be protected.

A few years ago, the county became involved in a conflict with a neighboring county over location of a proposed regional sewer project. In April 1981, Clarke County initiated and obtained revisions in State legislation that established a policy to preserve important farmland.

Clarke County conducted the land evaluation part of LESA much like McHenry County, assigning ratings for land capability, important farmland status, and soil productivity, and arranging the soils into groups. Leadership was provided by Mark Davis, SCS District Conservationist.

The site assessment part of LESA was developed by a committee chaired by G. Robert Lee, county administrator and planner. Lee was assisted by Margaret Maizel, Chairman of the Clarke County Agricultural Advisory Committee and member of the county planning commission.

Factors Selected

The committee selected the following site assessment factors: Size of farm. Compatibility of proposed use with the comprehensive plan. Adjacent agricultural use. Public investment already made for urban development (sewage service, transportation, water utility). Private investment for urban development.

Also, land use regulations. Presence of a current conservation plan. Percentage of area within a 1-mile radius where agriculture is predominant. Distance to town. Water resources. And family farm value.

Weights were assigned to each factor according to local conditions and objectives. The maximum number of points in the system is 100. A maximum of 33 points is assigned in the land evaluation part and a maximum of 67 points in the site assessment part.

The LESA system was endorsed by the Clarke County Agricultural Advisory Committee, Planning Commission, and Board of Supervisors.

In the past year, county officials have used LESA to evaluate 256 parcels, totaling 22,310 acres, for inclusion in agricultural districts. The LESA criteria were written into an ordinance that established the districts. It allows land use changes in an area adjacent to an agricultural district only if the effect on the LESA ratings of tracts inside the district will be minimal.

LESA is also being used to modify the county's comprehensive plan. Compatibility with the plan is now the second most important factor in the site assessment part of the LESA system. The county planning commission is using LESA to assess rezoning applications in agriculturally zoned areas and intends to write the system into the comprehensive plan at the next revision.

Besides the agricultural LESA, Clarke County has decided to develop a LESA system to use in forested areas on the slopes of the Blue Ridge Mountains.

IV. Human Dimensions in Resource Management

How People Interact With Resources

By Marion Clawson and Emery N. Castle

Natural resources affect people and people affect natural resources. Many problems and opportunities arise from this mutual relationship.

Many qualities or attributes of nature are customarily described as "natural resources"—soils, climate, plants, minerals, and others. But these are not really resources for human welfare until appropriate amounts of human energy, resourcefulness, capital, and managerial capacity have been applied to these qualities of nature, to transform them into materials or services usable by people.

Oil existed in the ground for many centuries. But until it could be brought to the surface, it could not be transformed into products usable by people. Fish in the sea or in the river are a potential resource but not an actual one unless some means exist for catching them. The finest soils likewise are a potential resource but not an actual one until some means for tillage and some crops adapted to the climate and the soils exist, so that food and fiber can be grown for human use. One could multiply examples many times over.

Application of human energy, resourcefulness, capital, and managerial capacity must be efficient, in terms of the value of the output compared with the value of the inputs, if the resource transformation process is to continue and be viable. By dint of extraordinary inputs, one might grow bananas on a cold mountaintop, for instance, yet

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the results would be so inefficient as to make the whole enterprise absurd.

And the process of natural resource transformation must produce something which people, or at least some people, want: Food, shelter, beauty, recreation, and other goods and services. We could probably grow ragweed in many of our better agricultural areas, yet few if any people would really want more ragweed than grows by itself, or indeed often grows despite our efforts to eradicate it. Sometimes the output is desired by some people and rejected by many others—marijuana, for instance.

Always Scarce

Natural resources, defined broadly as suggested here, are always scarce in relation to human wants or demands. Not only the attributes of Nature are limited—the acreage of the most productive soils, for instance; human efforts also are limited. It is precisely because natural resources are scarce in relation to demand that they are valued.

Various writers have dreamed of a place where everything anyone could possibly want was readily available, just for the taking, with no real effort required. It is greatly to be doubted that any such place ever existed.

Perhaps a very few people could find enough food in some setting, with a minimum of real effort to garner it. But to achieve a level of living above bare existence, any considerable number of people would find it necessary to invest effort and thought into providing resources for their use. When resources are scarce, they are valued, and the process of valuation and its consequences concern us here.

Many natural resources and their products are traded in markets. The basic concept is that of the willing seller negotiating with the willing buyer, until they have agreed upon the terms of trade.

In primitive economies, there may actually be a trade or barter, of one kind of goods for another. But nearly all the world has abandoned this kind of trade for one in which goods are sold or bought for money, for some commonly accepted medium of exchange.

If both seller and buyer are reasonably well informed about the commodity or the service and about alternative uses or alternative supplies, and if there is no interference by monopoly or government, then the price agreed upon between seller and buyer is an important resolution of the scarcity of supply and of the intensity of demand. Through bargaining, they arrive at a price which more nearly satisfies the demands and wants of each than can any other price.

Besides the relative freedom of the market, this process is much dependent upon the relative wealth position of each party. The rich buyer may be able to drive a sharp bargain with a poor seller, or it may be the seller who is rich and the buyer poor.

Price as a Guide

When a price has been arrived at in a market, and this price is generally known, it is an important piece of information which can guide both producers and consumers. Producers can make their production decisions in light of the price; actually, they should use the price they expect when their product is ready for market. Consumers can use the price as a guide for purchases and consumption decisions.

Although reported prices may seem like cold statistics, behind them always lie multitudes of very human decisions—the consumer agonizing over use of limited funds, to satisfy the most pressing desires of the family, and the producer wondering how best to use limited capital, energy, and managerial talent. In many cases, time is needed to make the decisions effective, especially on the supply side.

Prices so arrived at are valuable guides to both producers and consumers, for substituting one good or service for another. The family buying food is guided in considerable degree by the relative prices of different foods available in the market. Likewise, the producer is influenced by the relative costs of different inputs: Skilled labor versus machines, or one kind of machine versus another, or prices of one potential crop versus prices of another, and so on.

The market for many kinds of natural resources and their outputs conforms, in a general way, to this model. Cropland and pastureland are sold in more or less formalized markets; so is forested land, and even land for outdoor recreation. Mineral lands are sold or leased.

The various agricultural commodities, many forest products, and most minerals (including oil and gas and other energy minerals) are sold in markets. Some markets have imperfections of one kind or another, as compared with the idealized market of the economists. But money prices do exist and transactions involving money do take place.

The private market which mobilizes the convictions and actions of millions of consumers and producers is a wonderfully productive economic machine.

What's Not Traded

Some natural resources and their services are not customarily traded for money in markets. Many environmental and amenity values do not customarily have a money price nor can they readily be traded in any kind of a market. For one reason, often it is not possible to exclude the nonpayer and often it is not possible to capture the values involved.

If a family wants to obtain food from a grocery store, it must pay for it; if farmers want to obtain the use of land to grow crops, they must pay for it in some way. But the person who enjoys the beauty of a mountain scene rarely can be required to pay for that enjoyment. On the other hand, this same person may experience a loss in environmental quality because of the action of someone else, without being in a position to pay for a better environment. These are the externalities, positive and negative, about which we hear a good deal and which pervade much of our society.

Though these natural resources and services are not customarily traded in markets and typically do not have money prices attached to them, it is a serious mistake to assume they have no value. There is a value, often one highly regarded by many people—but not an easily measured price in money terms. Lacking such markets and prices, those persons who wish to see such values preserved or increased have often sought to have governments supply the resources or services directly. Or they seek to have government regulate the use of privately owned property to provide at least a minimum level of such resources.

Thus we have laws, regulations, and subsidies on such matters as soil erosion, air and water pollution, building limitations (zoning), and others. Government to a degree substitutes for a private market.

Recreation Facilities

One of the economically larger instances where natural resources and services are not fully priced in an organized market is the provision of facilities for outdoor recreation.

Outdoor recreation is engaged in by a substantial proportion of the total population but not by everyone. Millions of people enjoy camping, for instance, while others could not be dragged into a camping trip.

Many billions of dollars are spent annually in the United States to buy recreation equipment, to travel to recreation areas, and for specific recreation activities. Outdoor recreation is big business, in the modern American sense of the term.

There is some private supply of recreation opportunities at a price, but the vast majority of outdoor recreation areas are publicly owned and provided, either free or at prices which do not pretend to measure the total values.

The recreation area may be free or available for use for a modest fee; this does not mean that its use is free to the urban or suburban dweller who has to travel to reach the area. Most of the private expenditure is to take advantage of the free or low charge public recreation area.

Fairness Questioned

In these days of tight budgets at all levels of government, questions are increasingly being raised about the equity and fairness of providing public recreation areas and facilities to some people and not to others—to those who can both afford the travel and want the experience, but not to those who cannot afford it or do not want it. Moreover, the question is increasingly being raised about the effect on private suppliers and would-be suppliers of outdoor recreation, when the public areas are available at such minimum charges.

Perceptions of natural resources may be as important as the reality of them. Indeed, what is "reality," if it is not perception? Different persons, viewing the same scene, may perceive it differently.

Perception always involves personal or subjective values of the observer, as well as any qualities of the scene that can be objectively measured—and agreed to by most if not all observers. Not merely is beauty in the eye of the beholder, but so are all other characteristics of the scene.

Some people will see beauty, others opportunities for pleasure, others opportunities for personal gain, and still others may fear what they see, all looking at the same scene.

Majesty or Menace?

For instance, how does one regard a majestic mountain? As beauty or as a potential volcano, destructive to all who live near it? Does one see the hills as beautiful or as the place where an earthquake is likely to occur? Is the river beautiful and scenic or the source of a destructive flood?

Even if everyone will agree that the river may flood some day, or the mountains may tremble in an earthquake some day, or that the volcano may erupt some day, there may still be the widest divergence of estimates of the probability of such events and of the damage that may be caused.

How do people adjust to their perceptions of the natural environment? Do they decide to use the flood plain and to flee when a flood is imminent, or to use drought-prone areas and suffer losses when the droughts actually occur? How far do they try to protect themselves against an almost certain ultimate threat—by building a levee along the river, or by building monetary reserves to tide over the drought, or by other action against other perceived threats?

How far do they try to modify the environment to meet their desires—to change the composition of the forest or indeed to remove the forest altogether? How far do they seek to modify the actions of others—by enacting zoning restrictions on occupancy of the flood plain or by passing laws and adopting regulations restricting pollution of the air or water?

In every case of individual or group action, it is perception of the resource situation which governs the actions. The perception by one person or group may not correspond with the reality as measured by someone else.

For instance, surveys have repeatedly shown that occupants of flood hazard areas underestimate flood risk, as measured by hydrologists and land-use specialists, in all years except those immediately following a severe flood. The specialist sees one hazard, the average citizen perceives something quite different. Or many citizens perceive beauty in a mature forest which many foresters do not. My perception may not coincide with yours, and my reaction is likely to be that I see reality while you dwell in fantasy.

Looking to Future

Perception and reality perhaps contrast more strongly when one considers resource provision for tomorrow, than they do in any other aspect of ordinary life.

Do we think the price system will provide resources adequately for future generations, because the owner or user of the resources will be guided by relative prices in determining whether to use up or to save resources? Or do we think that government must intervene, in order to guarantee adequate natural resources for our children and grandchildren? This general issue arises for soil erosion and soil conservation.

No one challenges the idea that much soil erosion exists today, although opinions differ as to how much and how serious it is. And no one challenges the idea that productive soils will be needed in the future, although there may be much difference of opinion as to the risk that soils may be too seriously destroyed to provide for future food and fiber needs. We all see the soil erosion and we all grant the need for conservation, but we differ greatly in our perception of the problem and in our prescription for its resolution.

Experts Differ Too

Experts, no less than the general public, differ in their perceptions of the natural resource situation—as to the present situation and more particularly as to the outlook for the future. Some may use different data or facts than do their contemporaries, or they may argue about the meaning of the same or closely similar facts.

Merely because experts have a level of learning above that of the ordinary citizen and a professional lot of experience does not make them less the servants of preconceptions, even intuitions. The expert is likely to cloak perception of a situation more in quantitative or empirical terms, and less in qualitative or subjective terms than is the ordinary citizen, but the personal element is never wholly suppressed. What is a "fact" and what are the true relationships among facts?

In the past many experts from many fields emphasized scarcity of natural resources now and particularly for the future. In the 19th century it was Malthus, whose views have so colored thinking ever since.

In the past couple of decades the Club of Rome sponsored the book, *Limits to Growth*, which took a most gloomy view of the future. In particular, that book forecast a sudden catastrophe some day, with little or no advance warning—the world would simply and sharply fall off the edge. Those extreme views provoked a lot of criticism and the Club of Rome essentially repudiated the study it had commissioned.

In recent years the *Global 2000* report emphasized what would happen if the trends its authors thought they perceived continued unchanged until the year 2000. While not quite as doomsday as the *Limits to Growth*, the *Global 2000* report did emphasize problems and difficulties ahead, and called upon the world to mend its ways before it was too late.

Discounting Foreseen?

These doomsayers or pessimists start with certain obvious facts: World (or country) population is increasing; land area is fixed; therefore, land area per person is shrinking. And from this they project shortages of food, water, wood, minerals, energy, and other natural resource materials and services. They also point to rising pollution and increasing concentrations of wastes of all kinds.

In the more extreme forms, these projections present a very gloomy future indeed. Some persons not sharing their views will credit these pessimists with complete sincerity while others will conclude that extreme pessimism is expressed in the expectation that it will be discounted by the public to about the appropriate level of concern.

In contrast to these gloomier prophets are those experts who stress human adaptability to cope with adversity and human ingenuity to develop new and better ways of using natural resources of all kinds.

Erich Zimmermann, as early as 1933, stressed the major role that human inputs played in developing effective natural resources from otherwise useless rocks, soils, and trees. Julian Simon in 1982 argued that people are the ultimate resource, who can greatly extend the productivity of every natural resource.

These analysts, and others with generally similar views, point out that man as a species has survived for millennia, enormously increased the numbers of persons, and become dominant among living things in the struggle for survival. They stress that humans achieved biological success and dominance because of their great ability to adapt to different and changing conditions—more so than almost any other species.

Life Span Cited

The analysts go further, pointing out that people today live at a much higher level of well-being than did their ancestors of a few generations back, including as a basic biological measure a greatly increased life expectancy. Even *Global 2000*, while bemoaning the loss of well-being it thought inevitable, projected that life expectancy at birth would rise substantially by the year 2000, and more so in the lower than in the higher income countries.

Those who stress human adaptability believe it will continue in the future, enabling people to meet their future problems as well as they have met their past ones. If those taking a rather rosy view of the future think the pessimists are doomsayers, the latter retort that the optimists are Pollyannas, heedless of the gathering gloom.

Everyone familiar with American agriculture knows about the enormous advances in agricultural productivity in the past generation or so. From the same or slightly smaller crop area, with a third the labor input, and with no more capital (though in different form), farmers today produce more than double the total output their forefathers did 30 to 50 years ago.

There has never been a peacetime year in these decades when there was a shortage of food and fiber in the United States. On the contrary, in most years there have been surpluses which could not be sold at prices remunerative to all the productive inputs.

Agricultural science, technology, and managerial skills have well served the American consumer; the farmer has not always fared as well. On the record, American agriculture conforms more to the optimistic than to the pessimistic view of future resource availability.

Impact of People

Ready availability and moderate cost of natural resources affect the welfare of people but people in turn affect the basic resources, often severely so. Mankind around the world has increased its numbers about sixfold in ten generations. No species can do that without severe impact upon itself and upon its environment, and humans are no exception.

We have cleared forests to provide cropland, we have mined energy and other minerals to supply our factories and homes, we have dumped all manner of wastes into the air and water and on the land. Through plant selection and animal breeding we have enormously changed the natural strains from which the present domesticated species and varieties have been developed.

Wheat, corn, cotton, and other crops we grow are greatly different than the primitive strains from which they originated. So are the cattle, horses, sheep, pigs, and other animals greatly different than the species and strains from which they originated. Man has changed these species into forms more useful for him; and in the process often has so changed the original species and varieties that the modern ones could no longer survive without human care.

Few persons would doubt that some actions by people have been harmful to the environment. We have accelerated natural erosion, sometimes to the level where continued existence of a productive soil is threatened. We have altered watersheds so that streams and

Bob Elbert

Today American farmers produce twice as much as their forefathers did 30 to 50 years ago on the same or slightly smaller acreage and with a third less labor.

lakes have become greatly changed, and for the worse from our point of view.

We have eliminated some species of wildlife and greatly changed the habitat and hence the number of other species. And in other ways we have injured the natural environment—as a home for us, to say nothing of our effects on it as a home for many kinds of wildlife.

All of this is true enough, though there is considerable difference of opinion as to how extensive and how serious these changes have been.

Resources Improved

It is less generally recognized that many changes from the original or primitive condition have improved natural resources, at least as measured by their ability to support the human race. The wild wheat and

other cereals could be gathered by primitive peoples, to satisfy their hunger, but the yield per acre and per hour of labor was very low. The modern wheat field produces enormously more food for people, from the same area of land and from the same input of labor.

Ancient man could hunt wild cattle to provide a little meat (and probably pretty stringy stuff!) to nourish his family. But the meat output per unit of land area and per unit of labor was only a small fraction of that produced by modern cattle raising. The primeval forest yielded a little wood annually but nothing like that produced by a modern well-managed forest.

One could go on with many other examples of greater output and more useful output from the same basic environment and from the same quantities of human effort.

Man as a species has largely transformed the world, whether one thinks this is for better or for worse. The world is increasingly what we have made of it. There had to be trade-offs—copper, iron, or coal at the expense of unspoiled natural scenery, and thousands of others.

Perhaps no one would argue that all the past trade-offs have been optimum or wise. Some mistakes were made, some actions did not turn out as expected, sometimes future costs were ignored. Moreover, only the most extreme optimist would argue that all future trade-offs will be wise or optimum. But the vastly increased numbers of people, living on the average several times as long as did their ancient ancestors, is evidence in the purely biological dimension that people's use of natural resources has been to their interest, at least up to now.

The pessimist will say: Just you wait, your profligacy will do you in, in time. The optimist will say: We have dealt with problems in the past, we can do so in the future.

Ventriloquist, Many Others Do Volunteer Forest Work

By Jean P. Ground

Bill Westfall is a retired ventriloquist. A year ago he walked into headquarters of the Modoc National Forest in Alturas, Calif., and announced: "I love the National Forests, and I'd like to do anything I can to help you out."

The forest staff asked him to help teach schoolchildren about fire prevention. Now Bill's "conversations" with Smokey Bear and Woodsy Owl puppets about how to prevent fires at home and in the woods are a big hit in schoolrooms throughout Modoc County. Bill recently added a new character to his show: "Stinky the Skunk," who threatens to move into your home if a forest fire burns him out of his.

Bill's contribution is even more remarkable than you might think—he's been blind since 1965.

Tom Dibblee, a retired geologist, became a Forest Service volunteer in 1979. Since then he has mapped the geology of the 900,000-acre Los Padres National Forest, which occupies the rugged central coast range between Santa Barbara and Big Sur.

His mapping has been invaluable in the preparation of environmental assessments, in locating sites for bridges and water wells, in landslide control, dam safety and drainage studies, and in many other resource activities.

President Reagan personally presented Tom with the 1983 Presidential Volunteer Action Award last April.

Debbie Irvin, 19, is a computer science student at Lassen Col-

Jean P. Ground is Regional Volunteer Coordinator, U.S. Forest Service, San Francisco, Calif.

Nancy Gardner

Ventriloquist Bill Westfall helps Smokey bring the fire prevention message to schoolchildren in Modoc County, California. Bill, who volunteers for the Modoc National Forest, is one of more than 11,000 who contributed their skills to the National Forests in California in 1983.

lege in Susanville. As a volunteer on the Lassen National Forest 80 miles north of Lake Tahoe, she enters resource data into computers, which now are an essential tool in managing National Forests. This work allows her to use advanced computers and gain experience toward her chosen career.

Volunteers Double

Bill, Tom, and Debbie are three of the more than 11,000 volunteers who contributed their skills to the National Forests in California last year. These volunteers contributed 477,000 hours of work valued at more than $3.1 million.

The Volunteer Act of 1972 opened the door of the National Forests to public service, and the line out front has been getting longer ever since.

In 1981 there were 5,000 volunteers on National Forests in California. That jumped to 11,000 in 1983, or about two volunteers for every permanent employee. The number of volunteers is expected to triple to nearly 33,000 by 1985. Obviously there is a special relationship between the National Forests and the folks who want to help manage them.

The Forest Service manages nearly 193 million acres of National Forests and National Grasslands across the country. For administrative purposes, the Forest Service is divided into 9 Regions. Region 5 consists of 18 National Forests in California which contain about 20 million

Dan Roach

At the Chico Tree Improvement Center, Volunteer Betty Rutlidge marks genetically superior seedlings. The center is on the Mendocino National Forest in California.

acres or a fifth of the land in the State. They are natural attractions for volunteers.

The forests include the Big Sur coast, the Sierra Nevadas, Mt. Shasta, Mt. Lassen, and Mt. Whitney, the dense Douglas-fir forests of the north coast range, the mixed timber and grasslands of the Cascade Mountains to the north, and the rolling chaparral brushland and oak and pine woodlands in the high country surrounding Los Angeles and San Diego.

Many Opportunities

The National Forests in Region 5 contain 23 wilderness areas, 31 ski resorts, and 946 campgrounds. They are habitat for bald eagles, spotted owls, wolverine, deer, bear and other critters, and have some of the finest salmon, trout, and bass fishing streams, rivers, and lakes in the State.

At the business end of the spectrum, the National Forests supply half the timber cut in California and about half the water supply used in crop irrigation, homes, and industry. Grazing of cattle and sheep—and the mining of uranium, tungsten, oil and gas, and countless other minerals—are common on many forests.

This is part of "multiple use management" of forest resources. It also explains why there are so many different jobs to do.

National Forest managers spend winter months planning timber sales, campground openings, watershed surveys, road building and repair, wildlife habitat and archeological site surveys, and on and on.

Come spring, the snow melts, the roads dry out, and Forest Service people head for the woods to get the jobs done. More and more volunteers are going with them.

Retirees, professionals, tradespeople, homemakers, students, teenagers, youngsters, even international visitors are volunteers in California. They participate in almost every aspect of Forest Service management. Volunteers mark timber for harvest, plant seedlings in harvested areas, help build roads, repair buildings, and survey wildlife populations and nesting sites.

Even Count Fish

They help Forest Service hydrologists survey snowpacks, repair streambanks eroded by spring runoff, and conduct soil surveys. They help wildlife biologists survey spotted owl habitats, estimate deer populations, and count fish in streams.

Working closely with permanent professional staff provides close supervision, lots of responsibility, and a chance to discover firsthand the wildland resources.

Volunteers also get job experience that may help them toward full-time employment. For example, Peggy Markham, a journalism major at California State University at Chico, worked in the information office of the Mendocino National Forest. This experience helped her with her current job as a newspaper reporter.

Fire Prevention

Wildfire burns about 99,000 acres of National Forest land each year. As the State's population increases, more communities are forming in areas of high fire danger and the number of wildfires caused by people is on the rise.

It is Forest Service policy in California not to use volunteers to fight fires. But through the Volunteers-in-Prevention program, individuals, organizations, and public service groups are assisting in a variety of prevention activities.

On the Sierra National Forest, located in the foothills of the Sierra Nevada Mountains in central California, volunteers patrol hazardous areas in marked vehicles during holidays, weekends, and times of extreme fire danger. The patrols are highly visible and discourage arson, a major cause of forest fires in California.

Many forest fires are accidental and can be prevented by educating those who live, work, or play in the wildlands to act in a fire-safe manner. Volunteers work at fire information centers and distribute fire prevention information and materials to local groups.

Volunteers perform rural home fire prevention inspections and explain to homeowners how to make homes fire-safe. Volunteers also inspect equipment such as chainsaws and lawnmowers, to see that they have legally required spark arresters and are in fire-safe condition. Most homeowners are happy to get these free inspections since the house they save may be their own.

Recreation Activities

The great migration to the woods comes when spring fever strikes millions of folks throughout the State and everywhere else for that matter. About 20 million people visit the National Forests in California each year to swim, fish, hike, camp, backpack, pan for gold, ride horses, motorbike along trails, forget their boss, or just loaf.

Recreation use is seasonal, and hiring year-round people for part-time work too expensive. Volunteers help get jobs done and save taxpayers money.

In California nearly 60 percent of all Forest Service volunteers choose to work in recreation. They help in campgrounds, at visitor centers, and even at archeological sites. In fact, a volunteer crew of graduate anthropology students discovered the highest known prehistoric Indian village site in North America in the White Mountains on the Inyo National Forest.

The Campground Host program is one of the most successful volunteer programs in Region 5. National Forests in California receive about one-fourth of the total nationwide recreation use in the National Forests. Accommodating millions of visitors and keeping the personal touch is a job made for volunteers.

For example, Carl and Irene Lemmons are Campground Hosts on the Plaskett Meadows Campground of the Mendocino National Forest about 80 miles north of San Francisco. They live in the campground, greet visitors, and answer questions about services and things to see and do.

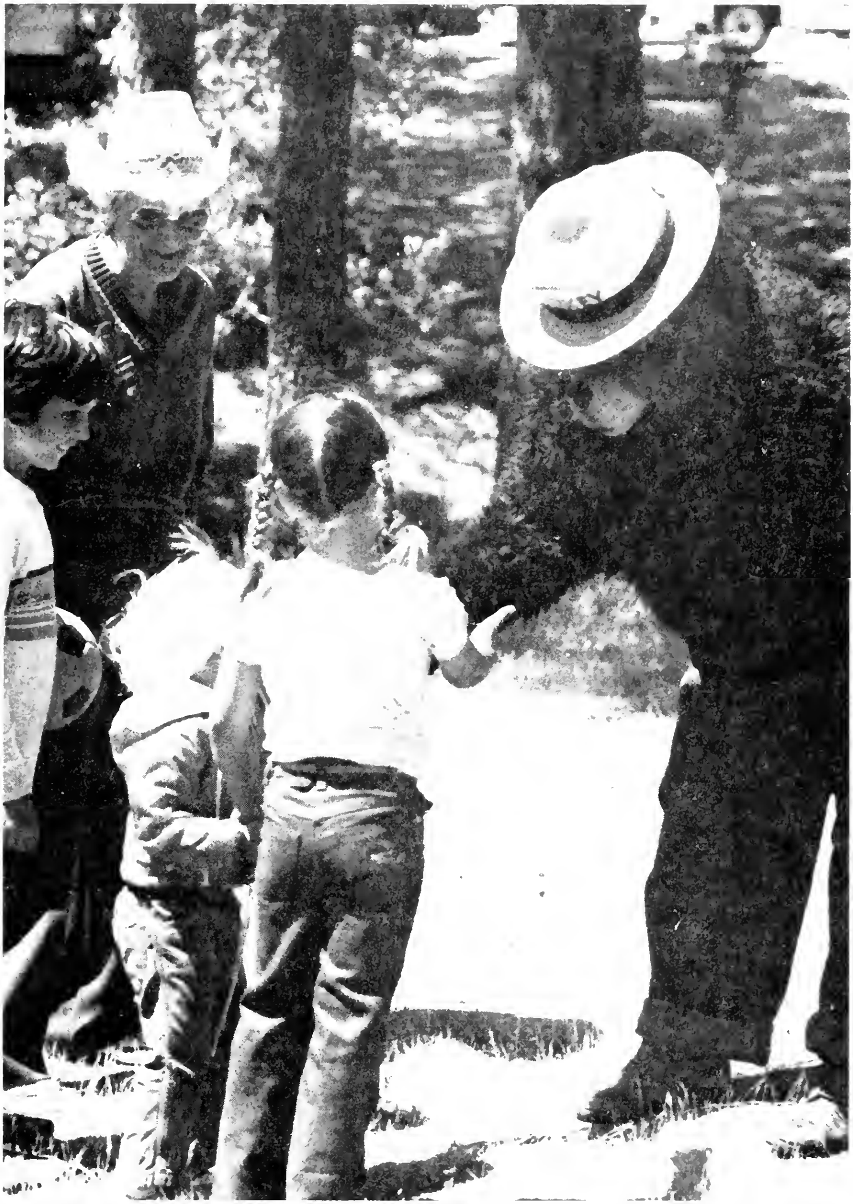
Besides acting as Forest Service representatives, Carl and Irene help maintain the area. As Irene said, "I know how much I appreciate a clean campsite, and so I work hard to keep all 32 campsites clean and orderly."

The nice thing about having Carl and Irene and the hundreds of other Campground Hosts is that they make the National Forest campground a "home" for visitors.

Adopt-a-Trail

Many jobs are nice to do, important to do, but don't get full-time funding or people to do them. Building and maintaining trails is an example.

The National Forests in California have about 13,000 miles of trails for horseback riding, hiking, trailbiking, and general recreation use, as well as hundreds of miles of primitive roads (often called trails) for 4-wheel drive vehicles. These trails and primitive roads are not considered part of the National Forest road system, so money to build or repair them often is scarce.



USDA

Campground Host Ruby Dunne introduces Smokey Bear to young campers on the Cleveland National Forest in southern California. She and the many other Campground Hosts make National Forest campgrounds "home" to millions of visitors.

The volunteer Adopt-a-Trail program came to the rescue. Trail maintenance is hard work, but a number of groups actually compete for the privilege of keeping "their" trail passable.

For example, the 4-wheel drive trail from Dark Lake to Barrett Lake on the Eldorado National Forest just west of Lake Tahoe has been adopted and maintained for several years by 4-wheel drive clubs in the area. Volunteer work on this trail is so popular that each club is allowed to work on it only every few years.

Members of a 4-wheel drive club fortify a streambank at the Lion's Campground in Los Padres National Forest in California.

Trail maintenance usually means a weekend spent restoring the trail bed, removing rock and debris, repairing or constructing drainage culverts, repairing gullies, rerouting washed-out sections, cleaning up campsites along the trail, and putting up signs. In some cases groups volunteer to reroute or improve a trail and construct new facilities.

So far, 19 4-wheel drive clubs in California have adopted trails

on the National Forests. Other groups, such as horseback riding clubs, snowmobile clubs, and hiking clubs also have adopted trails.

The forest staffs arrange for volunteer work with groups through Sponsored Group Volunteer Agreements. In these agreements the forest specifies certain maintenance standards to be met. When possible, the forest provides materials and trail signs that credit the club for maintenance done on its "adopted" trail.

Horse Camp Fixed Up

Horse people are just as dedicated as 4-wheel drivers. On the San Gorgonio District of the San Bernardino National Forest 80 miles east of Los Angeles, the Southern California Horse Camp Improvement Association tackled rehabilitation of the Heart Bar Equestrian Group Camp. They constructed 46 steel horse corrals, installed several picnic tables, a community fire circle, manure dumping stations, and a fenced enclosure. All this work was completed at virtually no cost to the taxpayer.

A particularly ambitious trail project in California is one selected by the Appalachian Mountain Club as a demonstration area under their National Volunteer project. The club is assisting a core volunteer group in developing the technical and organizational skills to construct and then maintain the Tahoe Rim Trail, a 150-mile hiking trail circling Lake Tahoe, which will pass through six counties, three National Forests, and two States.

Wilderness Rangers

The National Forests have about 2.6 million acres of wilderness in California that attract about a million visitors each year. Volunteer Wilderness Rangers are helping to make back-country travel safer for both dudes and experts.

Since no motor vehicles are allowed in wilderness areas, volunteers travel on foot or on horseback. Their tasks include picking up trash and litter, sign maintenance, minor trail repairs, and providing a presence to assure visitor safety and compliance with rules. They also report accidents and get help for backpackers in trouble.

Keys to Success

There is more to running a successful volunteer program than simply putting out a "Help Wanted" sign. Region 5 believes its success is due to three factors: Agency commitment, keeping the program simple, and matching volunteer interests to forest needs.

The Forest Service in Region 5 is committed to the Volunteer Program, not just as a temporary panacea but as a permanent complement to the regular work force. It has been incorporated into the Region's program planning and budgeting process and is supported at all levels of management. There are Volunteer Coordinators on all Forests and Ranger Districts, and in each Staff Group in the Regional Headquarters in San Francisco.

Region 5 keeps implementation of the program as flexible and unencumbered as possible. Enrollment is easily achieved by completing a short standard volunteer agreement form.

Recordkeeping is kept to a minimum. Placement is facilitated through a regional computerized volunteer data (VOLDAT) referral system. VOLDAT makes it quick and easy to match volunteer offers with National Forest needs throughout California.

Matching the right person to the right job is really the trick. Region 5 responds not just to offers, but to the volunteers' interests and goals.

Motivation Varies

Reasons for volunteering vary enormously. Hiking clubs adopt a trail to make sure "their" trail is safe and passable. Fire prevention volunteers help to protect their own homes and communities. Others volunteer to use their skills or learn new ones.

Students often volunteer to earn college credit. Some people volunteer for a challenge, to keep busy, or even for a new locale. Whatever the motivation, Region 5 tries to provide volunteers with work that matches their expectations to the needs and mission of the Forest Service.

Most of all, volunteering is as American as barn raising and apple pie. Since Ben Franklin organized the first volunteer fire department in the 1700's, Americans have been giving time and money and heart to a lot of good causes. Working with the great natural resources of our National Forests happens to be one of them.

The reason the volunteer program in California is such a huge success is that basic American values haven't changed. People still make the difference.

Dan Roach

Tree planting is one of the many tasks volunteers undertake in National Forests. Here, two forestry graduates from Holland broaden their experience as part of a student intern program for master's degrees in forestry. They'll return to Holland to complete the program and practice forestry.

Population Gains Put Pressure on Natural Resources

By Anne H. Ehrlich

The past half century has seen unprecedented growth in the human population. Since the early 1940's the world's population doubled—from less than 2.3 billion to over 4.6 billion in 1983. The annual rate of growth ranged between 1.5 and 2 percent during most of that time, and now is about 1.7 percent.

The most rapid expansions of population have been in the low-income developing countries, which more than doubled their populations since 1943. Kenya and a few other countries achieved annual rates of natural increase as high as 4 percent, a rate that would double the population in only 17 years.

Such extraordinarily rapid growth puts enormous strains upon these societies in attempting to meet the most basic needs of their people for food, water, shelter, health care, and education—let alone to improve the lot of the average person. The economic strains of the effort are more than matched in many countries by stress upon their natural resources. The more slowly growing populations of the developed countries also have put increasing pressure on Earth's natural resource bases, largely because of rapidly rising levels of consumption per person.

Earth contains a finite amount of land that is suitable for growing crops or supporting livestock or forests. Most of it already is in use today. Expansion of cropland, for example, now is achieved mainly at the expense

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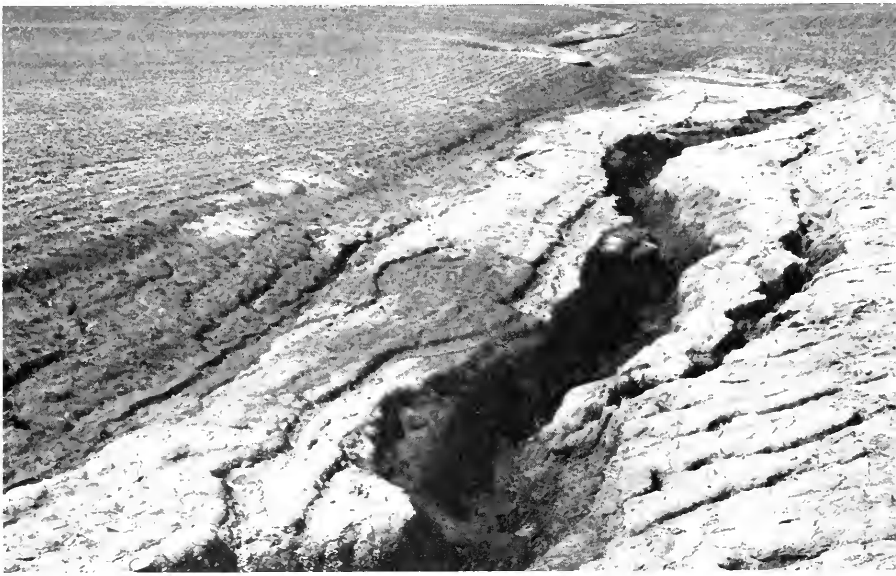


Gene Alexander

Soil erosion threatens long-term agricultural productivity the world around. In the United States, heavy spring rains have eroded tons of soil from this Nebraska wheat field.

of grazing land or a reduction of forest land.

Agricultural soils, freshwater resources, fishery stocks, forests, and pasture grasses, however, are all "renewable" resources. If properly managed, they continue to supply food, water, and other goods to society indefinitely. Indeed, intensive management (as in modern high-yield agriculture or forestry or well-designed irrigation systems) can greatly enhance their productivity. But when abused or mismanaged these resources become, in effect, nonrenewable.

Soil Problems

Soils can be eroded by wind and water, depleted of nutrients, or subject to buildups of salts or waterlogging from poorly designed irrigation. All these problems plague croplands the world around, including the United States, threatening long-term agricultural productivity.

On top of these obvious threats to soil fertility are subtler problems stemming from air pollution and acid precipitation. They may have adverse effects on critical soil micro-organisms as well as on the crops themselves.

Surface water systems in many parts of the world are under increasing pressure for competing uses. This is a growing problem throughout the Western United States.

Moreover, many underground water sources are being tapped at rates far above natural recharge rates, thus treating a renewable resource as a nonrenewable one. This is occurring in the San Joaquin and Imperial Valleys of California and the Ogallala Aquifer of the Great Plains, among other places.

At the same time, natural recharge of aquifers is being reduced in some areas by urban development (Long Island), and probably elsewhere by deforestation or as a result of the changes brought by desertification.

Exploited Fisheries

Fisheries are susceptible to overexploitation to the point that the populations of organisms being harvested have been pushed to extinction or at least so depressed that the ecological relationships within their ecosystems have changed, preventing their recovery. A well-known example is the California anchovy, but numerous fish stocks have been driven to economic extinction, especially in the North Atlantic and adjacent seas.

Marine fisheries yields, reflecting this depletion and an approach to maximum sustainable yields in many other stocks, have risen only slightly in the last decade—producing a decline in the global catch per person.

Deterioration of rangelands, usually from desertification, is a serious problem for human populations dependent on them. Desertification is caused most commonly by overgrazing or overcultivation of fragile lands. The tragic results of this process for the Sahel region of Africa have received a great deal of public attention. But symptoms of desertification can be found in most arid and semiarid regions, including extensive areas of western North America.

Worldwide, an estimated 14 million acres per year are desertified, an area roughly equal to the State of Maine. Like erosion and salinization of soils, drainage of aquifers, and depletion of fisheries, desertification is preventable, but for practical purposes irreversible once the process passes a critical point.

More Than Wood

Forests are natural resources that can be exploited in renewable or nonrenewable ways. Total removal with no attempt to replant is the most extreme example of the latter.

Unfortunately, forests too often are perceived only as sources of wood, without even differentiating between types of wood. Hence replacing a natural forest with a tree monoculture may be viewed as no loss, or even as an improvement, since more board-feet may be produced in 20 years' time.

A diversified natural forest, however, can supply many other benefits besides wood to society. These are lost with conversion to a monoculture.

Perhaps even more important (and still less valued by most of society) are the free services provided by natural ecosystems.

Ecosystem services include: Maintenance of atmospheric quality; moderation of climate; regulation of the hydrological cycle (including flood control and recharge of aquifers); regeneration of soils; disposal of wastes and cycling of nutrients; control of pests and diseases; pollination; and maintenance of a vast "genetic library" from which society has already drawn the very basis of civilization and may yet discover a host of new foods, medicines, chemicals, and other useful materials.

Forests are major providers of ecosystem services, which are performed relatively poorly by tree farms and other agro-ecosystems.

After deforestation, regeneration may be extremely difficult or impossible, depending on the extent of damage to the soil and its fragility.

Tropical Forests

Moist tropical forests are by far the most valuable forests biologically and ecologically. Yet they are the most threatened, and among those least capable of regeneration—mainly because of their characteristically thin, fragile soils. These forests may in effect be nonrenewable resources, as are the multitudes of plant and animal species they harbor. The extinction of these species through deforestation is an irreversible loss of incalculable magnitude.

All the above symptoms of stress on natural resources are worldwide problems. All are to be found to a greater or lesser degree in the United States. The increase in their frequency and severity are indications of rising pressure on the carrying capacity of Earth for human life with its present means of resource utilization. This is quite apart from any consideration of the future implications of consumption and dispersion of nonrenewable resources such as metals and fossil fuels.

Existence of these symptoms in the United States suggests that, although this Nation might in some respects be considered underpopulated, on the whole it is not.

A more important consideration is that the symptoms themselves result from processes that, if continued, will severely reduce the carrying capacities of the areas affected, and at a time when the population to be supported is expanding rapidly.

Better management undeniably can halt, and even sometimes reverse, the processes of deterioration. It also can resolve problems of competitive uses by choosing the best use of a given resource and by minimizing waste. But there clearly are limits to what even the best possible management of resources can accomplish.

Population Growth

The human population today is far larger and growing more rapidly than ever in history. The rapid growth of the recent past, moreover, holds the seeds for future growth.

High birth rates during the past few generations have produced populations with a preponderance of young people, the parents of the next generation. Thus even if reproductive rates fell overnight to "replacement level" (where each parent generation exactly replaces itself—an average of about two children per family), the population would continue growing until the first "self-replaced" generation reached old age.

Because of this built-in momentum to growth, populations in developing countries (where average family sizes currently range from three to eight children) are committed to many decades of further growth. This holds true even though family planning programs have been established in most nations, and reductions in birth rates—in some cases, large reductions—achieved.

Most industrialized countries have had relatively low birth rates for decades, and now have below-replacement-level reproduction. Yet sufficient momentum remains to prevent the prompt end of population growth. Only a few European nations have stopped growing and begun a very slow population decline.

6 Billion by 2000

Recent projections indicate the global population will increase from 4.65 billion in 1983 to slightly over 6 billion by 2000.

In 1981, the United Nations projected an ultimate world population size of about 10.4 billion, reached around 2110. This was its "medium" projection. The "low" variant was 8 billion in 2070, the "high" was 14.2 billion in 2130.

Ninety percent of this growth is slated to be in developing countries; but large differences exist among them in growth potential. The population of East Asia, for instance, including China (which has dramatically reduced its fertility) and Japan (a developed country), is projected to expand by only about 40 percent. Populations in Africa, Latin America, and South Asia will roughly triple.

By contrast, populations of the industrialized nations are projected to increase by less than 25 percent on average. This varies from under 2 percent in Europe to 23 percent in North America and 40 percent in the USSR.

Population projections, of course, are subject to considerable inaccuracy, especially as they extend further into the future. Both fertility and mortality rates can change rapidly in unanticipated ways. So can migration rates, which can have significant effects on growth rates in both sending and receiving countries.

That the global population will be near 6 billion in the year 2000 can be stated with considerable assurance, though, unless death rates are greatly increased by some enormous catastrophe.

J. Breitenbach

Stress on natural resources is increasing as world population continues to grow rapidly. Recent projections indicate that the global population will rise to more than 6 billion by the year 2000.

How soon and at what level the world population will ultimately reach its peak is open to considerable doubt and unquestionably could be changed by different policies. For instance, much stronger efforts to reduce birth rates clearly could accelerate the present downward trend, resulting in a peak population of 8 billion or less, followed by a slow decline.

U.S. and Immigration

The United States is one of the developed countries with considerable momentum built into the population age structure, thanks to the "baby boom" of 1946-1964. Although fertility has been slightly below replacement level since the early 1970's, natural increase is still about .7 percent per year. Surveys by the U.S. Census Bureau of fertility expectations of young women indicate no great change in reproductive behavior in the near future.

The situation in the United States is complicated by a relatively high rate of immigration, however. In the early 1980's, net immigration (immigrants minus emigrants) has been roughly 750,000 to 1 million per year. Uncertainty is due in the main to the unknown net number of illegal immigrants entering the country each year, estimated as 350,000 to 500,000. Including both natural increase and net immigration, the United States annual population growth rate is about 1.1 percent.

Whether future rates of immigration rise, fall, or remain constant will make an enormous difference in both size and growth of the U.S. population.

If the *total fertility rate* (TFR: the average number of children each woman would bear in her lifetime at given age-specific fertility rates) remained constant at 2.0 (it now is 1.9), and net immigration were reduced to zero, the U.S. population (235 million in 1983) would be only about 250 million in 2000. It would reach a peak of 268 million around 2030, and decline slowly thereafter. But if net immigration continued at 1 million per year, the population would soar to 274 million by 2000, pass 400 million by 2080, and keep growing indefinitely.

Census Figures

The Census Bureau's most recent projections, which focus on changes in fertility rather than in immigration, fall within the same range. The medium projection assumed a continuation of current fertility (TFR = 1.9) and an annual net immigration of 450,000. This would produce a peak population size of 309 million in 2050, then a slow decline.

Small changes in both fertility and immigration can make dramatic changes. As early as 2000, the range of variation between high and low projections by the Population Reference Bureau is nearly 50 million.

Such uncertainty in the population size of the United States even in the near future underlines the need for a national population policy that includes reasonable control over immigration.

The substantial growth that could result from continued high rates of immigration and/or from a small increase in fertility carries serious implications for the Nation's natural resource base. Accommodating 100 million additional people in the next 40 years, for instance, would greatly intensify the already visible stresses on natural resources, cause a disproportionate amount of environmental damage, and almost certainly produce a decline in living standards.

Population Distribution

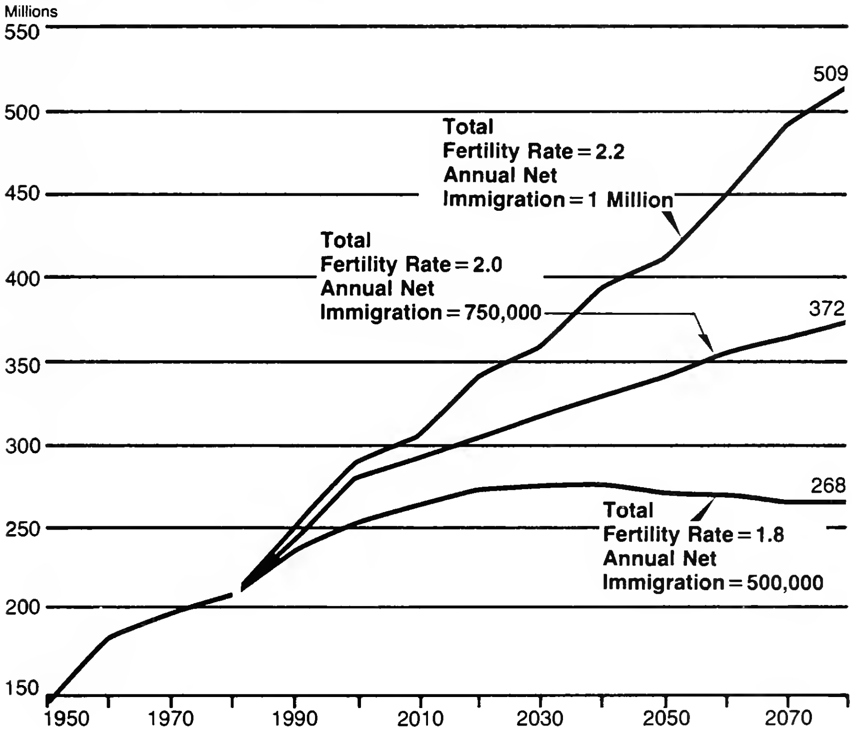
While population growth poses the most direct threat to natural resources, changes in population distribution can complicate problems of resource management. Large population increases in the arid Southwest and in Florida, for example, have caused serious problems for management of local freshwater resources. In the Southwest, rising urban demand for limited supplies of water has forced abandonment of agriculture in some areas.

The trend begun in the 1970's of population movement from urban to rural areas may well change land-use patterns, particularly for agriculture. The economic structure of prices for land, water, and other resources tends to undervalue agricultural uses and overvalue urban and industrial uses. Over time, this disparity may lead to losses in agricultural productivity, unless other measures are taken to protect agricultural land and water rights.

A substantial increase in the population of the United States also holds profound implications for world trade and the resources of the rest of the world.

The U.S. must now import growing amounts of materials (petroleum and an expanding list of important metals) to support its large, affluent population. Simultaneously the United States is by far the world's largest exporter of grains, the staple foods

United States Population Growth



United States population size, 1950-1980, and three scenarios for 1983-2080, based on different assumptions for fertility and immigration.

Tim McCabe

The United States is by far the world's largest exporter of grains, the staple foods on which most of the human population depends.

on which most of the human population directly or indirectly depends. Over 100 nations are net importers of grains, and growing dependency is a global trend, especially among developing countries.

Half Billion Ill Fed

In the last decade, many developing countries have fallen behind in efforts to keep their food production ahead of their rapidly expanding populations.

Food production per person in Africa has declined by more than 10 percent since 1970, and it was seriously inadequate then. In some other regions, per capita production has risen only slightly, permitting little improvement in diets of the poor.

Worldwide, international agencies estimate that about a half billion people, mostly in poor countries, are significantly undernourished.

In poor countries, mismanagement of agricultural resources clearly arises from direct pressures to produce immediately needed food for local, rapidly growing populations. Conservation measures are extremely difficult to establish in such circumstances; deterioration of land and soil and depletion of water resources are among the consequences.

Population pressures thus engender and perpetuate poverty, and the poverty in turn hinders efforts to curb population growth and develop more sustainable, productive agricultural systems.

Pressures in U.S.

In the United States, the pressures are less direct, but no less real and no less tied to overpopulation.

American farmers since the mid-1970's have been under intense economic pressure to produce more food, largely for export. The exported grain earns foreign exchange to help pay for importing needed resources, especially petroleum. Obviously, if the United States population becomes substantially larger, its needs both for imported resources and for food will increase accordingly—unless there is a dramatic change in consumption patterns.

Although the United States raised its agricultural production during the 1970's and early 1980's enough not only to feed its own population abundantly but to triple its grain exports, this country is unlikely to be able to repeat that performance. Expansion of cropland and increased yields, due in part to expansion of irrigation, especially in the Great Plains, were major factors in the increased grain production.

Both of these were examples of overexploiting renewable resources: The irrigation was achieved by tapping the Ogallala Aquifer; much of the cropland was marginal, erosion-prone land. A continuation of policies that encourage such poor long-term management of resources can seriously jeopardize our Nation's future food-producing capabilities—just when the world's growing population will need it most.

Further Reading

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Accountability Revamps Plans for Managing Our Resources

By Lawrence W. Libby

There can be no question about the need for managing natural resources for future enjoyment by people. The overriding theme of this book is that resources and human life are inseparable, if not synonymous—all parts of the same natural ecosystem. There is no reason to assume that the relationship will be any less important in the future. But people have unique capacity to affect the character of the entire ecosystem through deliberate or inadvertent manipulation of its parts. Planning implies thoughtful manipulation sensitive to human needs as well as to natural limits.

Significant natural resource planning activities are underway in the 1980's. They are expressions of a collective commitment to acknowledge future claims on resources. All resource-using actions taken today will affect the opportunities available to future users. Planning and management programs are simply designed to guide those actions in ways that are sensitive to the future.

Resource and commodity markets can do much of the management job. That is, buyers and sellers are people with their own perceptions of future needs and present values.

There is no particular reason to assume that governments are more perceptive than people (if such a distinction can be drawn). The role of government is to help people enjoy resource services that simply cannot be bought and sold, and to be more

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cautious with our resource endowment than individuals might be. Government can help us avoid the unfortunate consequences of protecting fewer resource options for the future than we need for survival.

Resource management programs discussed here focus on soil and water resources of the Nation, and the forests. Both sets of resources have highly developed markets for the commodities they produce. Government programs are directed at side effects of private use (erosion, water pollution), and provision of certain resource services (such as wilderness) that aren't provided otherwise.

These public programs are comprehensive management systems, geared to the mix of resource services involved and a broad range of judgments as to how the resources should be used. They are designed to influence private use of resources in ways sensitive to future needs.

Accountability Era

National programs for conserving soil and water resources of the United States have existed for over 50 years. They began after the Dust Bowl days when the need for action was most apparent. The productivity of American agriculture was dramatically redistributed, blowing in great clouds from the heartland to the steps of the Capitol in Washington.

Response to this clear emergency produced a national soil conservation program that has matured into a formidable political and social movement. Soil conservation is a *cause* as well as a program. The diffuse system for delivering technical and financial assistance from the Federal Government to farmers has produced a political network that helps sustain conservation programs in the 1980's.

But the late 1970's and 1980's are an era of accountability in government. Soil conservation, the retention of soil productivity longer than might occur in the absence of public action, has to be weighed against other social "goods," like improved highways and rebuilding cities. This has always been the case, of course, but soil protection, public forest management and several other natural resource programs where the commodities are not easily measured had escaped detailed scrutiny in the past.

In 1976 the General Accounting Office (GAO) in Washington questioned the payoff from more than $20 billion spent on soil conservation programs. GAO was particularly skeptical that the "cafeteria approach" of offering assistance to all who requested it was the most effective way to reduce erosion.

An oversight letter from the Senate Committee on Agriculture, Nutrition and Forestry directed the Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service (ASCS) to present data on the physical and economic performance of programs and techniques for reducing erosion.

SCS and ASCS responded, but discovered that their data system for answering these accountability questions was hopelessly inadequate.

The RCA Program

The soil conservation political "power cluster" in Washington responded to this general pressure for a more efficient soil conservation effort by drafting the Soil and Water Resources Conservation Act (RCA). It became law in 1977.

Scope of RCA is enormous—calling for an appraisal of all the non-Federal land and water resources of the Nation, analysis of existing programs for getting conservation practices on the land, and making periodic recommendations to Congress and the President as to how the job might be done better.

As of mid-1983 the RCA system has gone through the first cycle. Several volumes have been published describing soil and water resources of the Nation (including historical trends), identifying major uses, and projecting resource needs in the context of world food demands. Existing Federal, State and local laws directed at soil and water conservation were identified, and in September 1982 proposals for improving the delivery system for conservation techniques were presented to Congress and the President.

The RCA *can* produce a truly dramatic change in the process by which soil and water decisions are made throughout the

country. But the potential of this resource planning and management system has to confront the cold reality of U.S. policymaking. Since any change implies realignment of rights, opportunities and obligations of relevant actors, major policy changes inevitably come in small steps. That is the inherent strength and perhaps the greatest source of frustration in our pluralistic form of government.


USDA

Fifty years ago, the Nation saw its topsoil blow from the heartland to the steps of the Capitol in Washington. The days of the Dust Bowl brought the beginning of national programs for conserving soil and water resources in the United States.

RCA has its critics, to be sure. Some feel it is doing too much, others too little, and others question how the process functions. But planning systems that must cope with a broad range of political definitions of good and bad are seldom very precise. Even when the planning unit can act on perceived preferences, as with public land management (discussed below), progress is intermittent.

2-Part Appraisal

A balanced appraisal of RCA as an emerging system for guiding public investment in the soil conservation actions by farmers must consider both the *process* and *product* results of that system. Both will affect policy performance over time. First, the process aspects of RCA:

One of the first steps undertaken to implement RCA within the U.S. Department of Agriculture (USDA) was creation of a system of structured interaction among the eight agencies with direct responsibility for implementing any of the 34 resource conservation programs. For the first time, literally, agencies of USDA focused on the "so what" of a myriad of special purpose programs in a reasonably coordinated and systematic way. The U.S. Office of Management and Budget and USDA program, budget and evaluation staff were involved as well.

With RCA as the stimulus, a small group of analysts and policy specialists roughed out an analytical scheme to appraise the performance of existing conservation programs in terms of projected crop production needs and, more importantly, to compare alternative institutional approaches to achieve conservation goals at lower cost.

The process was not neat and tidy, despite all the flow charts and diagrams that evolved. The potential stakes for each agency and subagency were substantial. Bargaining became more intense as boundaries of the political "turf" became clarified.

With the benefit of hindsight, many have criticized the early days of RCA. To say the final product of that interaction was something less than a textbook quality analytical system for soil and water conservation policy is an understatement. It is also largely beside the point.

Reoriented to Results

RCA literally forced the agencies to reorganize their thinking toward results rather than activity, outputs rather than inputs. It created a mechanism for communication, even bargaining, on the substance of conservation policy. It created new demands for analytical talent within the agencies—people who could organize information and data in ways that highlight choices. RCA changed the way we think about future soil and water actions.

If RCA is taken as seriously in the future as it was in the beginning, soil and water management for future needs will continue to improve. Continued coordination among those Federal agencies whose actions directly influence use of soil and water is essential. We must not let the agencies slip back into the more comfortable posture of counting paper clips and guarding "turf."

There were other process changes as well. RCA has broadened the agenda for soil conservation programs. More policy options are discussed now than ever before. Emphasis is on encouraging farmer actions that are sensitive to the broader social stake in future soil quality.

The agenda has been stretched in three directions. *First*, purposes other than protecting on-farm soil productivity have been added to the discussion. Erosion causes water pollution, affects wildlife habitat, influences water supply available for various uses. Soil conservation efforts provide a full list of services beyond keeping productive soil in place for the farmer. Acknowledging this list can produce a different conservation program.

Secondly, RCA has broadened the political base for soil and water conservation. More people and interest groups are aware of soil conservation as a national objective than ever before. Groups like the National Audubon Society, Natural Resources Defense Council, and Sierra Club have taken active positions on soil conservation issues.

Broadening the political constituency is a deliberate part of RCA. The law says that resource issues will be reviewed with "conservation districts, state soil and water agencies, and other appropriate citizens groups. . .to assure public participation."

Consensus Problem

Any time the diversity of those seeking response from a particular political process is increased, the problem of reaching consensus is increased as well. The soil conservation constituency is less definable or predictable than was the case pre-RCA. Partly it is a response to the broader agenda—more groups see they have a stake. Some are more concerned about the wildlife habitat implications of conservation; others stand to gain from construction of traditional conservation structures. This broader constituency means a more volatile political environment for the future.

A further aspect of this broader constituency has been greater attention by professions and academic disciplines other than soil science and agricultural engineering. Academics know a good bet when they see it, too.

Sessions on soil conservation have been held at annual meetings for sociologists, political scientists, biologists, systems scientists, ecologists, even economists. There have been more papers written, studies undertaken, seminars held. A real intellectual investment has been made in the substance and implications of managing soil and water resources for future needs. This is important.

The *third* dimension of the widening conservation agenda concerns growing awareness of impacts of other agricultural programs on soil-conserving behavior by farmers. We know that farmers respond to the realistic choices they face in remaining economically viable while protecting land quality. Some of those choices for farmers are influenced by agricultural programs. Some have observed an

Tim McCabe

Erosion not only decreases soil productivity, it is a major cause of water pollution.

unintended, yet real, incentive to abuse the land built into various commodity and tax programs for farmers.

RCA has had a profound and lasting effect on conservation policy, beyond any tangible products of that policy. It has irretrievably altered the political setting and hopefully the agency process for considering a policy agenda.

Evidence of Impact

The products of RCA have already been mentioned. Their importance should not be misunderstood. They provide a valuable and definitive reference on soil and water resources of the Nation, including physical dimensions of the erosion problem. Subsequent versions may focus more specifically on high erosion areas.

Information needs to support policy recommendations help the agencies organize data and identify data gaps. The Soil Conservation Service has outlined its major resource needs as a result of the RCA process.

Identification of the broad policy options—including special tax incentives, limited regulation, mandatory or bonus cross compliance between conservation and commodity programs, variable cost-sharing—has led to pilot testing of these options throughout the country. Performance-oriented data systems have replaced the simple tabulation of miles of diversion ditch, numbers of cooperators or acres planned that had existed pre-RCA. We have the prospect of future soil conservation programs based on defensible evidence of impact.

Iowa State Base

The rough scheme for organizing RCA in the early days of implementation has led to a rigorous and sophisticated analytical framework to support policy development. The system, based at the Center for Agricultural and Rural Development at Iowa State University, involves the linking of a multiregion linear programming model with models of the impacts of erosion on plant growth and productivity.

The L-P model is not unique to RCA; earlier versions were used for the National Water Assessment. But the early RCA brainstorming on what would be needed for a truly comprehensive performance-oriented soil conservation program provides the needed intellectual underpinning for the formal models.

Utility of the models is still being examined. They must be useful, understandable and adaptable. Each iteration of the RCA process will produce an improved analytical system.

These are some of the products of RCA. They represent greater capacity to understand the implications of policy choices for soil and water management. The capacity for enlightened choice is apparent. The *will* requires constant attention.

Forests, Range

Another example of a planning and management system for future resource needs involves the federally owned forests and rangeland of the Nation.

A resource planning and management system similar to that being established under RCA is in place and functioning under the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA). It preceded and in fact was the model for RCA.

It calls for an "analysis of existing and anticipated uses, demand for and supply of renewable resources. . .supply, demand and price trends, an inventory of present and potential forest resources and an evaluation of opportunities for improving their yield of tangible and intangible goods and services." This part applies to all 1.7 billion acres of forest and rangeland, both public and private.

Promising forest investment opportunities are to be identified. Output targets for each forest commodity or service are assigned to the producing regions, as appropriate.

The law also requires preparation of a suggested program for the President on the protection, management and development of the National Forest System. Everything the Forest Service does is supposed to relate directly to this long-range plan. All personnel actions are tied in. Both the assessment and program are to be updated periodically.

As with RCA, the RPA system is intended to inject thoughtful and coherent planning and management into the policy process affecting the use of all forests and rangeland. Emphasis is on national forests, where government, primarily the U.S. Forest Service, has sufficient leverage to actually implement appropriate management schemes.

Priorities Established

The RPA process helps Congress and the agencies establish priorities for budgeting. It improves the chances that management actions will be taken with some knowledge of their consequences. Investments in each of several forest resource systems (such as timber, recreation, fish and wildlife habitat) are analyzed for their qualitative and quantitative impacts on the other systems.

The uninitiated outside observer might assume that such a basis for choice had always existed in Washington. Otherwise, how would we know what we (the taxpayers) are buying for money spent on the national forests? Good question. The previous system had relied primarily on the judgment of professionals in each national forest with some guidance from regional and national administrators.

Since the broad range of services available from national forests were well known by highly trained forest supervisors, the inevitable tendency was to get a little bit of every service in every forest. The internal reward system of the Forest Service placed particular emphasis on timber production, the "guts" of forestry. Thus every forest supervisor wanted a strong timber management program.

Legislative guidance for the mix of outputs was incomplete—the 1897 Organic Act refers to harvesting only "dead or diseased trees." Even the Multiple Use-Sustained Yield Act dealt with physical production potential rather than economic criteria. Thus the RPA came along as part of the growing demand for accountability in resource policy to meet future needs.

Harvest Criterion

Another national law added specificity to the economic part of forest management. The National Forest Management Act of 1976—an amendment to RPA—establishes the basic rule (among others) that timber should return in revenue at least what it costs to prepare it for sale. That criterion leaves many acres, even whole forests, out of the timber business.

There is just no logic in harvesting trees for sale in areas that are generally inaccessible or unproductive. All of the cable and helicopter harvesting techniques make exciting training films, but seldom make economic sense.

RPA/NFMA are geared toward comparative advantage forestry. Some areas clearly offer wilderness experience at lowest possible cost, while other national forests are good for timber production. Targeting management funds where they will have the best payoff improves efficiency of the whole system.

Interestingly, both wilderness groups and timber groups applaud this emphasis on comparative advantage forestry. Both see their present and future interests best served by a management system that acknowledges comparative advantage.

RPA Limitations

The RPA System has significant potential. But there are limitations as well. Many of these are relevant for any such effort to systematically plan for current and future use of a natural resource. As noted, our political system is seldom as precise as the resource planners might like.

First the limitations: The RPA program is really a budget document. It builds the case to meet certain resource needs identified in the assessment. Yet any budget document, even one built on all that analysis, is just the beginning point for negotiation. It is a political document, representing the biases and judgments of the current administration. No matter how sophisticated, the document will not replace politics. The RCA program is less a budget than is the RPA—just by the nature of the management decisions to be influenced.

The RPA process may impose some internal stress on the Forest Service, as well. It challenges the existing distribution of power that has evolved over the years. RPA has enormous needs for analytical skills. It creates a new elite, with more emphasis on formal training than years of experience. These stresses and strains will of course be worked out over time.

RPA implies substitution of rules for judgment. The Forest Service has had an enviable record for sensitive professional management "on the ground," where the resources and people are. Shifting the emphasis to computers and procedures instead of human judgment is unfortunate, according to some observers. Decisions appear to be mechanistic rather than thoughtful. Linear programming may obscure rather than elucidate.

Still, attributing so drastic an impact to RPA overstates the real strength of new procedures. People will still be involved, though the system will be more centralized. Any system to reallocate resources based on regional or forest comparative advantage is bound to draw more discretion and power back to the source of the analysis—in this case, Washington, D.C.

Data Problem

Another perceived limitation of RPA is the data problem. Some forest outputs are more easily measured than others. Clearly, the market for forest commodities and services of the National Forest System cannot do the whole job. In fact, the reason for public forests is that some forest services cannot be marketed, yet are desired by a major sector of the population.

Crossover impacts—effect of timber harvest on elk or deer habitat, or effect of oil extraction on quality of the wilderness experience—will be particularly hard to measure. Some forest policy specialists feel that the attempt to force quantification on the more ephemeral qualities of the forest environment may actually give these fuzzier services an advantage in comparison with marketed services. They may become numerical constraints on timber outputs, for example.

Any analytical system is only as good as the people who run it and the institutions within which they must operate.

Strengths of RPA

There are significant strengths to RPA, however, and I believe the balance is positive. It represents a deliberate effort to organize information for choice in a way that the consequences of those actions can be apparent.

RPA can sharpen the terms of debate, so those arguing for more wilderness or more timber can have some idea of the impact involved. It is the best hope for considering future forest needs without the sloppiness of program-by-program bickering. RPA also has the potential for relating national forests to state, local and private forests. At least the information system is established.

Conclusions. RPA and RCA are the two most prominent examples of comprehensive resource planning. Several states have followed RPA with forest management systems of their own.

The accountability theme in resource policy simply will not go away. The "missionary" aspect of protecting soil and forests is important, but when it costs public money the taxpayers want to feel they are getting the most good for their dollars.

Both RCA and RPA have opened the political process for these resources. Soil conservation used to be a well-defined compact set of political groups. Greater visibility can mean greater support. It can also mean higher expectations from the resources involved.

There is likely to be a trend in policy toward shifting greater social responsibility onto the resource owner. Part of the greater political awareness is the expectation that private owners or users will take the needs of others into account.

There may be pressure for more mandatory controls on erosion, forest harvest, or land conversion from agriculture to other uses. Yet mandatory measures are not always the most effective. These institutional options must be analyzed.

Computers are very much a part of these and future resource management systems. They facilitate rapid manipulation and storage of huge quantities of data. No amount of hand-wringing about replacing people with computers will alter that fact.

The systems will become more elaborate. But as the first round of RCA demonstrated, sometimes our technology outruns wisdom. That process generated far more printouts than anyone could read. Judgment still has a role.

Further Reading

Batie, Sandra S. *Soil Erosion: Crisis In America's Croplands?* The Conservation Foundation, 1717 Massachusetts Avenue N.W., Suite 30. Washington, D.C. 20036. $8.50.

Halcrow, Harold G., Heady, E.O., and Cotner, M., eds. *Soil Conservation Policies, Institutions and Incentives*. Soil Conservation Society of America, 7515 Northeast Ankeny Road, Ankeny, Iowa 50201. $6.

Robinson, Glen. O. *The Forest Service: A Study in Public Land Management*. Johns Hopkins University Press, Charles and 34th Streets, Baltimore, Md. 21218. $26.50.

Sampson, R. Neil. *Farmland or Wasteland: A Time to Choose.* Rodale Press, 33 East Minor Street, Emmaus, Penna. 18049. $16.95.

Stairs, Gerald R., and Hamilton, T.E. *The RCA Process: Moving Along the Learning Curve.* Duke University, Mayna Dragdn, Rm 214, Bio. Sci., Durham, N.C. 27706. $6.

Acid Rain—rain that has an acidity greater than the postulated "natural" pH of about 5.6. It is formed when sulfur dioxides and nitrogen oxides as gases or fine particles in the atmosphere combine with water vapor, and precipitates as sulfuric acid or nitric acid in rain or snow, or as dry particulates.

Alluvial Plain—the plain created by accumulation of soil and other materials where a river issues from a steep course upon flatland.

Anadromous—fish that go from the sea up rivers to spawn.

Aquifer—water-bearing formation, especially one that supplies ground water, wells or springs.

Arid—parched with heat; dry, arid, barren.

Biological Control—control of pests using natural means.

Biomass—the total quantity of living organisms of one or more species per unit of space.

Biota—combined fauna and flora of any geographical area or geological period.

Biotic Pyramid—communities of living organisms with size groups on the vertical coordinate and numbers of organisms on the horizontal coordinate which describes a pyramid when plotted. Large numbers of living organisms of small size with a somewhat progressively decreasing number of large organisms balancing out the ecology of the community.

Bottom Lands—lands, usually flood plains, adjacent to a river or watercourse.

Canopy—more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.

Carnivores—flesh-eating animals.

Carrying Capacity—maximum population of a species possible without damaging the vegetation or related resources. It may vary from year to year because of fluctuation in forage production.

Clear-cut—an area from which all trees have been removed by cutting.

Climax—final stage in plant succession for a given site where the vegetation has reached a highly stable condition and continues to reproduce itself.

Commensalism—associated or living with another animal in a nonparasitic relationship.

Competition—contention of two or more for the same object, food, or superiority.

Coniferous—cone-bearing trees, mostly evergreens that have needle-shaped or scale-like leaves.

Conservation—using in a wise or economical sense; usually associated with natural resources.

Deciduous—perennial plants that are leafless for some time during the year.

Deferment Management—method associated with grazing of rangelands where only parts of an area are used at any one time.

Desertification—creating desert-like conditions by unwise use or overexploitation.

Diversity—relative degree of abundance of wildlife species, plant species, communities, habitats, or habitat features per unit of area.

Dominant—plant species or groups of species which, by means of their numbers, coverage, or size, influence or control the existence of associated species.

Ecofallow—cultivated land left idle during the growing season.

Ecological Niche—the role a particular organism plays in an environment.

Ecology—study of the interrelationship of organisms with one another and their environment.

Ecosystem—an interacting natural system including all the component organisms together with the biotic environment.

Effluent—sewage after purification treatment.

Environmental Impact—changes in the environment, positive or negative, created or caused by some form of management.

Erosion—the wearing, washing, or carrying away of materials by wind and water.

Estuary—wide mouth of a river where it is met and invaded by the sea, especially in a depression of the coast.

Even-aged—where all the plants in a community are about the same age.

Evapotranspiration—loss of moisture from a plant by evaporation plus the life processes.

Fauna—animal population of a particular area.

Flora—plant population of a particular area.

Food Chain—representative links in a chain where interdependence of animals on plants and on each other for food determines the balance of the ecological community. A single strand of a food web.

Food Web—the total complex pattern of feeding relations of an independent, self-maintaining major community. Food an animal eats as normal behavior in its ecological community, based on availability of all the food chains in the community.

Forbs—fleshy-leafed plants.

Fossil Fuel—energy derived from plants and animals of a prehistoric era.

Genetic—those characteristics of an organism due to inheritance or the action of genes.

Ground Water—all water in and saturating the soil.

Habitat—arrangement of food, cover, and water required to meet the biological needs of an animal.

Herbicide—a chemical weed killer.

Herbivores—animals that feed mainly on plants.

Highgrading—logging situation where only the best or choice trees are taken. Usually considered to be irresponsible.

Hydroelectric—creating energy by using water flow.

Indigenous—native to a particular area or region.

Insecticide—a chemical killer of insect pests.

Irrigation—artificial watering of land to stimulate plant production.

Management—skillful use of means to accomplish a purpose.

Marine—pertaining to the sea or oceans.

Mast—fruit of trees suitable as food for livestock and wildlife.

Metabolism—expenditure of energy to maintain life.

Microclimate—climatic conditions within a well-defined small or local habitat.

Microcosm—a small community of plants and animals.

Minimum Till—energy-saving and erosion-control method involving less cultivation in the growing of crops.

Non-point—usually associated with pollution that comes from a large area with no single, well-defined source.

No-till—growing crops with little or no land preparation or cultivation.

Parasitism—an animal or a plant that lives on or in another organism at whose expense it obtains nourishment or shelter.

Pesticide—a chemical killer of avian or mammalian pests.
pH—degree of acidity of water or soil.
Photosynthesis—process by which plants form carbohydrates from carbon dioxide and water through sunlight acting upon chlorophyll.
Pollution—substance which makes another substance unclean, dirty, or impure.
Predation—act of living by preying upon others.
Prescribed Burning—controlled use of fire for management purposes.
Preservation—protect from destruction or exploitation.
Productivity—increase in quality, quantity, or value.
Public Involvement—having people interested and participating in a decisionmaking process.
Pyroclastic Flows—lava flows following a volcanic eruption.
Raptor—bird of prey.
Respiration—process by which a plant or an animal takes in oxygen from the air and gives off carbon dioxide and other products of oxidation.
Rotation—order of sequence of succession of a plant community, usually associated with farming.
Rural—country rather than city, usually associated with agriculture.
Savanna—tract of level land covered with low vegetation; a treeless plain.
Selection—method of forestry where only trees of a certain age or species are harvested.
Snag—standing dead tree from which leaves and most of the limbs have fallen.
Soil—earth material so modified by physical, chemical and biological agents that it will support rooted plants.
Species—a unit of classification of plants or animals consisting of the largest and most inclusive array of sexually reproducing and cross-fertilizing individuals which share a common gene pool.
Spoil—material removed by digging or excavating.
Sprinkle Irrigation—artificial watering of land by sprinkling.
Subclimax—a stage in succession before the final, recurring stage or climax.
Succession—orderly stages in the progression of a plant community.
Territoriality—characteristic of an animal species that inhabits and will defend a specific area.
Tilth—physical condition of the soil in its relation to plant growth.
Topography—physical features of an area or region.
Transpiration—loss of moisture and other gases from tissues of a plant.
Tundra—a rolling, treeless, often marshy plain of arctic regions.
Understory—trees growing under the canopy formed by taller trees.
Urban—having characteristics of a city.
Wilderness—lands intentionally managed, or left alone, to maintain their primitive character.

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