# Evaluation of Bighorn Sheep and Mule Deer Habitat Enhancements along Koocanusa Reservoir

**Final Report**

**By**
**Bret Stansberry**



**June, 1996**

Montana Fish, Wildlife & Parks

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## Abstract:

Habitat enhancement projects were initiated along Koocanusa Reservoir in 1984 in an effort to increase bighorn sheep and mule deer populations. This report evaluates the efficacy of these efforts by measuring and analyzing the responses of vegetation and deer and sheep populations before and after habitat manipulations.

An evaluation of vegetation responses indicated that shrub frequency and volume measurements decreased in response to manipulation except for palatable species such as serviceberry and spiraea, which increased. Herbage production and understory cover composition both increased initially, but returned to pre-treatment levels within 2 years.

Bighorn sheep responded by increasing utilization of treatment units and adjacent habitat. A change in overall distribution of mule deer seemed to occur, but was less apparent than for sheep. Four deer changed from a migratory to a resident pattern, 3 shifted established winter home ranges, and the proportion of deer using spring and fall transitional ranges decreased from 69% pre-treatment to 0% post-treatment all suggesting a positive response by deer.

Home range sizes were variable over time for both species and revealed no clear relationship to habitat manipulation. Sheep and deer population estimates over the study period were variable, but did not support the hypothesis that populations should increase in response to habitat manipulations.

Bighorn natality and recruitment declined over the study period. Natality for mule deer also declined between the pre-treatment to post-treatment periods. There was no significant decline in survival for sheep during winter and spring between treatment periods. Survival rates for mule deer declined between periods, but not significantly. Age structures from mule deer harvest data indicated declining recruitment and a stable to declining population.

Bighorn sheep group composition suggested a decrease in recruitment and a declining population. Results of monitoring indicated that sheep and deer exhibited a positive behavioral response to habitat manipulation, but a long-term improvement in population dynamics was not evident from the data. Managers should reconsider their original mitigation goals of a 33% increase in mule deer and bighorn sheep populations.

# INTRODUCTION

Both bighorn sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*) occupy the Ural-Tweed winter range. The Ural-Tweed bighorn sheep population is the last native bighorn sheep population in northwestern Montana. This population has historically occupied slopes along the east side of the Kootenai River Valley from Cripple Horse Creek north to the Pinkham Divide (Brink 1941, Couey 1950, Brown 1979). Available information indicates steady population growth from the 1940's (Ensign 1937, Brink 1941) until the population stabilized in the mid 1960's. At that time, there were approximately 150-200 animals in the population (U.S. Dept. Inter. 1965). From 1965 to 1978, the population declined to an estimated 20-25 animals (Brown 1979). By the mid-1980's the population had started to recover from this low level (Yde and Olsen 1984). Population growth continued through the 1980's, with approximately 150 bighorn sheep in the population in 1990 (Yde and Coates 1990).

The Ural-Tweed range has been identified as an historical winter range for mule deer (Bergeson 1942 and 1943, Blair 1955, Brink 1941, Drumheller 1936, Zajanc 1948). In this area, mule deer typically winter along open slopes. Higher elevational ranges with areas of broken topography, such as the area between Tenmile Creek and Stone Hill, are preferred by mule deer (Zajanc 1948 and Blair 1955). These areas are above the usual winter range for white-tailed deer (*O. virginianus*) and overlap areas used by wintering elk (*Cervus elaphus*). Population estimates vary greatly because of the nature of the surveys upon which the estimates are based.

Ecological succession has limited the availability and quality of historic bighorn sheep and mule deer habitat. A series of aerial photographs (KNF files) show a habitat mosaic present throughout the range during the 1940's and 1950's. Additionally, there is an abundance of fire scarred trees in the project area. This is evidence that fire historically played a major role in determining habitats and habitat characteristics in the project area. Wildfire maintained a disclimax, open ponderosa pine (*Pinus ponderosa*) - bunchgrass community on the south and west facing slopes within the sheep range. Periodic burning also maintained forage availability and quality. With initiation of intensive fire suppression in the 1930's, the role of fire in maintaining the ecological disclimax community preferred by bighorn sheep and mule deer was circumvented. This resulted in establishment of more densely forested Douglas-fir (*Pseudotsuga menziessii*) communities. Stelfox (1976) noted similar fire suppression and resulting loss of bighorn sheep habitat due to advanced ecological succession in the Athabasca Valley, Alberta between 1921 and 1953. Other researchers have noted declines in suitable habitat for bighorn sheep due to conifer encroachment (Etchberger et al. 1989, Wakelyn 1987).

Construction of Libby Dam and impoundment of Lake Koocanusa resulted in the inundation of important winter and spring habitats for bighorn sheep and mule deer. This perturbation has further limited the ability of bighorn sheep and mule deer populations to adjust to habitat losses associated with successional changes. Approximately 1,761 ha of bighorn sheep and 6,950 ha of mule deer spring and winter habitats were inundated. These habitats provided essential winter and spring range components (Yde and Olsen

1984). Inundated habitats provided nutritious forage during periods of adverse winter weather and during the important spring "green-up." This has forced bighorn sheep and mule deer to use lower quality, dormant vegetation for a longer period. During development of the wildlife impact assessment for Libby Dam, an associated reduction in physical condition resulting in reduced reproductive success was predicted (Yde and Olsen 1984). The importance of "green-up" areas for female bighorn sheep during late stages of pregnancy and lactation has been documented (Stelfox 1976, Wishart 1978).

The Northwest Power Act of 1980 (P.L. 96-501) required, among other things, development of a program to protect, mitigate, and enhance fish and wildlife affected by hydropower facilities within the Columbia River system. In accordance with the Northwest Power Act, a joint project between the Kootenai National Forest (KNF) and Montana Fish, Wildlife & Parks (FWP), funded by Bonneville Power Administration (BPA), was initiated in September 1984. This project was designed to mitigate impacts of the Libby Dam hydroelectric facility and Highway 37 on the Ural-Tweed bighorn sheep population by improving sheep habitat on selected winter and spring ranges. By improving habitat, we assumed that carrying capacity would be increased on the remaining sheep range, partially mitigating for habitat losses from the reservoir and highway.

In September 1987 the mule deer portion of the project was added. As with the bighorn sheep, we began monitoring the characteristics and size of the mule deer population, it's seasonal and annual distribution, and it's response to the habitat enhancement efforts.

Specific objectives of the ungulate monitoring were:

1. Determine annual and seasonal distribution and analyze habitat use vs. availability for bighorn sheep and mule deer.
2. Determine changes in distribution of bighorn sheep and mule deer populations resulting from habitat treatments.
3. Determine size and age/sex composition of the bighorn sheep and mule deer populations.

Specific objectives of the vegetation monitoring were:

1. Determine initial changes in plant composition, herbaceous production, shrub frequency and volume, and overstory canopy resulting from habitat enhancements.
2. Determine long-term vegetative responses to habitat treatments, including duration of beneficial results and potential retreatment schedule.
3. Determine which habitat treatments produced the desired results. Compare results to determine which treatments should be maintained in the future.

In July 1991, monitoring was reduced to direct limited funds toward habitat enhancement work. Monitoring after this date focused only on estimating population size using wildlife staff and part-time technicians.

This report provides a summary and analysis of data evaluating effectiveness of habitat enhancement activities associated with the BPA mitigation program on bighorn sheep and mule deer populations on the Ural-Tweed winter range from 1984 through 1995.

# Description of the Project Area

The project area is located along the northwest flank of the Salish Mountains, approximately 48 km northeast of Libby, Montana (Fig. 1). Encompassing approximately 446 $km^2$, the area includes portions of the Rexford and Fisher River Ranger Districts, Kootenai National Forest. Boundaries are the Pinkham Creek Divide on the north and east, Fivemile Creek on the south and Lake Koocanusa on the west. Elevations range from 750 m at the full pool level for Lake Koocanusa to 2,142 m at the top of McGuire Mountain.

Topographic features of the study area can be separated into two components. From the lake level to approximately 1,525 m, the area is characterized by very steep, broken terrain, including steep cliff faces and talus slopes. The diversity of terrain is conducive to mesic microsites, where green vegetation persists throughout the summer and often into the fall. On Stone Hill, this steep, broken pattern holds, but the area is terraced. Several of the terraces are mesic and sustain lush vegetation longer than the adjacent area. Above 1,524 m, the terrain becomes less rugged with more gentle slopes extending to the ridgetops. These gentle slopes lack the topographic variation of the lower slopes. This results in fewer mesic sites within this zone.

A variety of timbered habitats cover the majority of the project area. The primary commercial use of the area is timber production. Limited livestock grazing occurs on portions of the project area.

Using strata maps (U.S. Forest Service files), which show the existing vegetative conditions, we categorized the area into four major coniferous cover types. These cover types are:

1. Ponderosa pine / Douglas-fir type. This type occurs along the lake shore upwards to an elevation of about 1,035 m. Ponderosa pine is the major overstory species with Douglas-fir usually found throughout. Common shrubs include common snowberry (*Symphoricarpos albus*), Saskatoon serviceberry (*Amelanchier alnifolia*), rose (*Rosa spp.*), and bearberry (*Arctostaphylos uva-ursi*). Bluebunch wheatgrass (*Agropyron spicatum*), rough fescue (*Festuca scabrella*), and pine grass (*Calamagrostis rubescens*) are important grasses. Western yarrow (*Achillea millefolium*), silky lupine (*Lupinus sericeus*) and various asters (*Aster spp.*) are the most common forbs.
2. Douglas-fir type. This type occurs to an upper elevation of about 1,585 m throughout much of the project area. Douglas-fir is the major overstory species with some mixing of ponderosa pine and western larch (*Larix occidentalis*). Common snowberry and bearberry are the dominant shrubs. Pinegrass is the most predominant grass, with rough fescue also present. Western yarrow, heartleaf arnica (*Arnica cordifolia*) and woodrush pussytoes (*Antennaria luzuloides*) are common forbs throughout the area, while silky lupine occurs in areas with more open canopies.

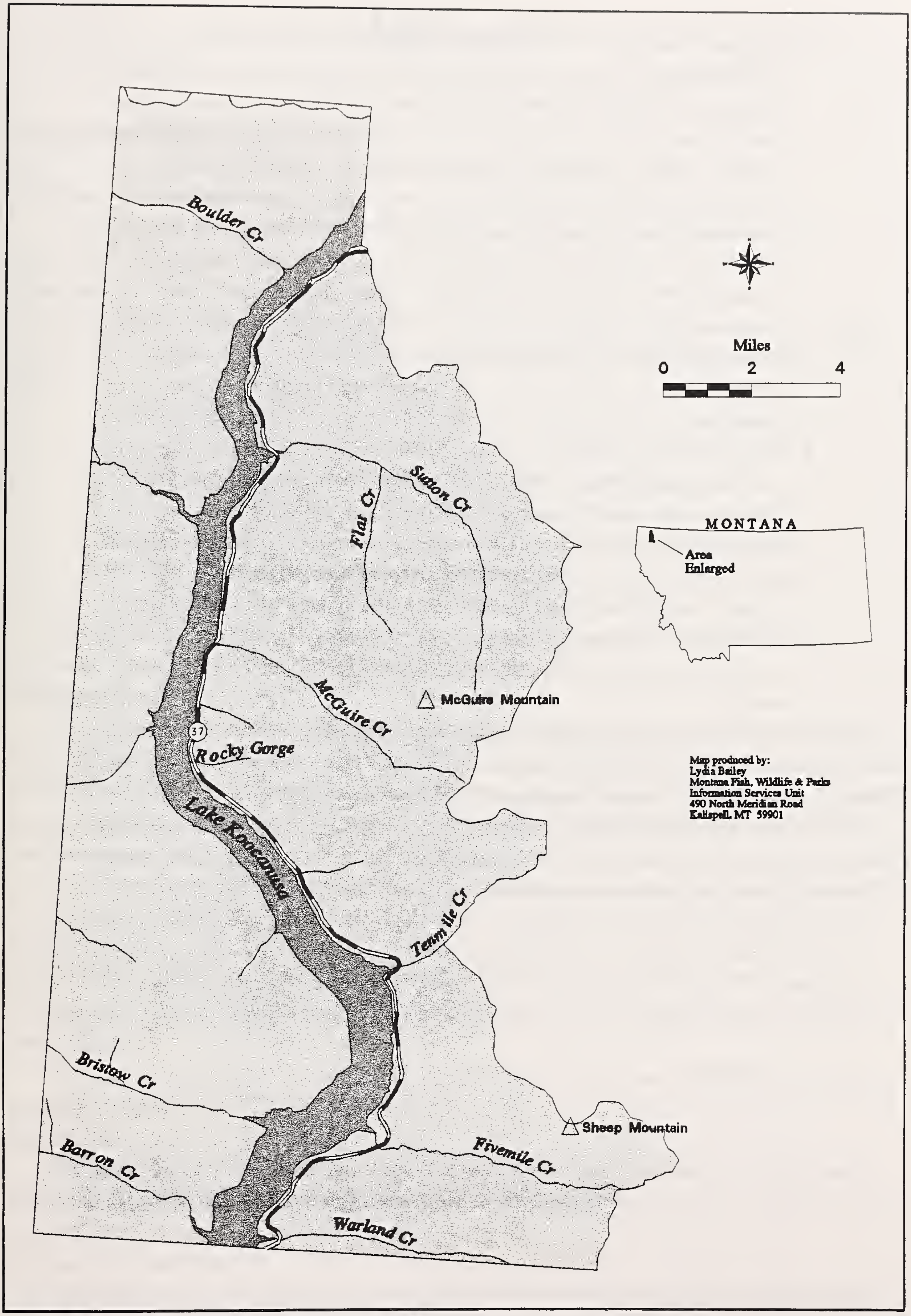


Figure 1. The Libby Dam study area.

3. Lodgepole pine type. This type had a lower elevational limit of approximately 1,585 m, and extended to the highest point on McGuire Mountain. Lodgepole pine (*Pinus contorta*) probably is a seral species with it's establishment influenced by large fires that occurred between 1910 and 1920. Lodgepole pine is the dominant overstory species, with sub-alpine fir (*Abies lasiocarpa*) occurring in understory of several stands. The most common shrubs were grouse whortleberry (*Vaccinium scoparium*), sitka alder (*Alnus sinuata*) and bearberry. Pinegrass was the most common grass, although elk sedge (*Carex geyeri*) is locally common. Common forbs are heartleaf arnica, mountain arnica (*Arnica latifolia*) and glacier lily (*Erythronium grandiflorium*). Silky lupine is also common in areas with open canopies.
4. Sub-alpine fir/Englemann spruce type. This type has a lower limit of 1,675 m on south-facing slopes and 1,340 m on north-facing slopes. Sub-alpine fir usually occurs with Englemann spruce (*Picea engelmannii*), but is sometimes found in pure stands. Common shrubs are menziesia (*Menziesia ferruginea*), sitka alder and grouse whortleberry. Beargrass (*Xerophyllum tenax*), both species of arnica, twinflower (*Linnaea borealis*) and queencup bead-lily (*Clintonia unifloria*) are common forbs. Common grasses are pinegrass and elk sedge.

In addition to the major types, small, isolated patches of western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) occur throughout the project area. Further description of the project area can be found in Brown (1979).

In July 1991, monitoring efforts were refocused on a smaller portion of the winter range extending from Tenmile Creek to Rocky Gorge. This area was identified as a core winter range area from previous observations of radio-collared deer and sheep.

# Methods

## Vegetation treatments

**Treatment techniques**

Slashing, prescribed fire, and fertilization were used singly or in combination to accomplish vegetation treatment.

<u>Slashing</u>

Trees less than a pre-determined diameter-at-breast-height (dbh) were cut reducing the overstory canopy and increasing the amount of fuel. Three slashing techniques were used.

1. Broadcast. Conifers up to a specific d.b.h. were slashed over the entire treatment area.
2. Strip slashing. Alternating strips 50-80 feet wide were slashed to create sufficient fuel to carry a fire into the unslashed strips.
3. Hand piling. Similar to broadcast slashing except that slashed conifers were piled away from fire-sensitive black cottonwood trees to prevent them from being injured or killed by prescribed burning.

Slash was allowed to dry for at least one summer and normally one year before burning.

<u>Prescribed fire.</u>

Fire was used to remove trees and decadent portions of shrubs and open the understory. Prescribed fire was used alone or in conjunction with slash treatments. Specific burn prescriptions were written using the BEHAVE program (Andrews 1986) after treatment objectives were defined. This program defined a range of climatic conditions and fuel moistures needed to achieve specific objectives.

Desired intensity of burn, fuel loads, and topography were utilized in selecting the burning season. Spring and late fall burns were planned for areas containing fire sensitive bitterbrush and areas with heavy fuel where a low mortality (<10%) of live trees was desired. Late spring and early fall burns were planned in areas where 15-75% mortality of live trees was desired. Late August burns were planned in areas where fuels were light and discontinuous.

Drip torches were used for hand ignition of treatment areas and a PREMO MARK III ignition device was used for aerial ignition.

<u>Fertilization.</u>

Nitrogen fertilizer (21-0-0) was aerially applied at a rate of 223 kg/ha to a trial plot on Stonehill. This plot was a flat, rocky bench with discontinuous fuels that did not lend itself to slashing or burning.

**Treatment descriptions**

Treatment areas were located on deteriorated winter/spring range with demonstrated use by bighorn sheep. These areas were identified using data gathered during the current project combined with Brown (1979). Cooperators in the project felt that well designed habitat manipulations would provide favorable vegetative responses - an increase in production of understory vegetation - which would in turn benefit the bighorn sheep and mule deer populations.

Habitat treatment areas were previously described by Young and Yde (1990) and are repeated here in condensed form. Eleven BPA projects were completed on the project area between 1984 and 1988. In addition, seven Whirlybird helicopter logging units were completed between 1985 and 1989 (Figure 2, Table 1).

Vegetative change on treatment areas was evaluated by comparing years before the treatment was completed (pre-treatment) to years after the treatment was completed (post-treatment) for each treatment. Therefore, pre- and post-treatment periods were different for each treatment area.

Evaluation of deer and sheep response was done by comparing years before all treatments were completed (pre-treatment) to years after all treatments were completed (post-treatment). In this case, pre-treatment covered 1985 to 1989 and post-treatment covered 1990 to 1995.

Tenmile

This was a 100 acre area at the mouth of Tenmile Creek between Highway 37 and Lake Koocanusa. The area contained a multi-story conifer canopy. Past logging activity removed mature conifers.

Treatment planned for this unit was a broadcast slashing of all conifers <10 inches dbh followed by a prescribed fire. The objective of the fire was to significantly reduce the small conifers but leave the mature ponderosa pine, Douglas fir and larch. The riparian habitat along Tenmile Creek and another small drainage were to be protected.

Conifers <10 inches dbh were slashed in 1985 and the unit was burned using drip torches in mid-April 1988. The fire was low-intensity to minimize mortality of large, overstory trees so consumption of slash was not as complete as was hoped.

Sheep Creek East/West

This area, located below Highway 37, consisted of approximately 120 acres of south to southwest-facing slopes. The area was at one time a more open ponderosa pine/bunchgrass community; however, conifer encroachment, including ponderosa pine and Douglas fir, reduced the forage production potential of the site.

Treatment prescribed for the unit was broadcast slashing followed by a high intensity prescribed fire with the objective of reducing overstory canopy coverage. It was decided to slash all conifers <10 inches dbh to reduce canopy coverage and increase the fuel load for later prescribed burning.

The majority of conifers <10 inches dbh were slashed during October and November 1984 and left to dry. The unit was burned in May 1987. The original prescription was for a fall burn, but warm, dry conditions in the spring created an ideal situation for high mortality of overstory trees. Subsequently, merchantable trees killed by the fire were harvested by the helicopter logging company working on the adjacent Whirlybird timber sale.

Table 1. Habitat treatments and sizes on the Libby Dam project area, 1984-89.

| Unit name | Treatment by year | Size (ha) |
|---|---|---|
| BPA contract | | |
| Tenmile | slash 85/burn spring 88 | 40 |
| Sheep Creek East/West | slash 84/burn spring 87 | 49 |
| Rocky Gorge | slash & handpile 85/ burn fall 85 | 12 |
| McGuire/Tweed[a] | slash 86/burn summer 87 | 178 |
| Lower Stonehill | burn spring 86 | 34 |
| North Stonehill | slash 85/burn summer 87 | 113 |
| South Stonehill | strip slash 85/burn summer 87 | 57 |
| Lower Sutton Face | burn spring 88 | 40 |
| Stonehill Fertilization | fertilize spring 86 | 10 |
| | | subtotal = 533 |
| USFS Whirlybird Timber Sale[b] | | |
| Peck Gulch | slash 88/burn fall 89 | 230 |
| McGuire Creek | slash 87/burn spring 88 | 237 |
| Rocky Gorge | slash 85/burn spring 87 | 317 |
| Allen Gulch/Sheep Creek | slash 87-88/burn fall 89 | 155 |
| Tenmile | slash 85/burn spring 87 | 180 |
| Packrat | slash 87/burn summer 87 | 141 |
| | | subtotal = 1260 |
| | | total = 1793 |

[a] - Includes area of Tweed Creek Whirlybird timber sale unit.
[b] - All harvesting was completed between 1985-1987.

Rocky Gorge

Several small peninsulas along the east shore of Koocanusa Reservoir comprising about 30 acres receive extensive use by mule deer and limited use by bighorn sheep. A large mineral lick located within the area is utilized seasonally by both species. All the peninsulas were cleared during the initial phase of dam construction and revegetated into dense stands of lodgepole pine.

The original prescription was to use bulldozers to remove the conifers and prepare a seedbed for grasses and legumes followed by fertilization. Cultural resources on the area precluded use of bulldozers so the prescription was changed to slashing and burning.

This treatment complemented two existing treatment areas. In 1984 the USFS thinned

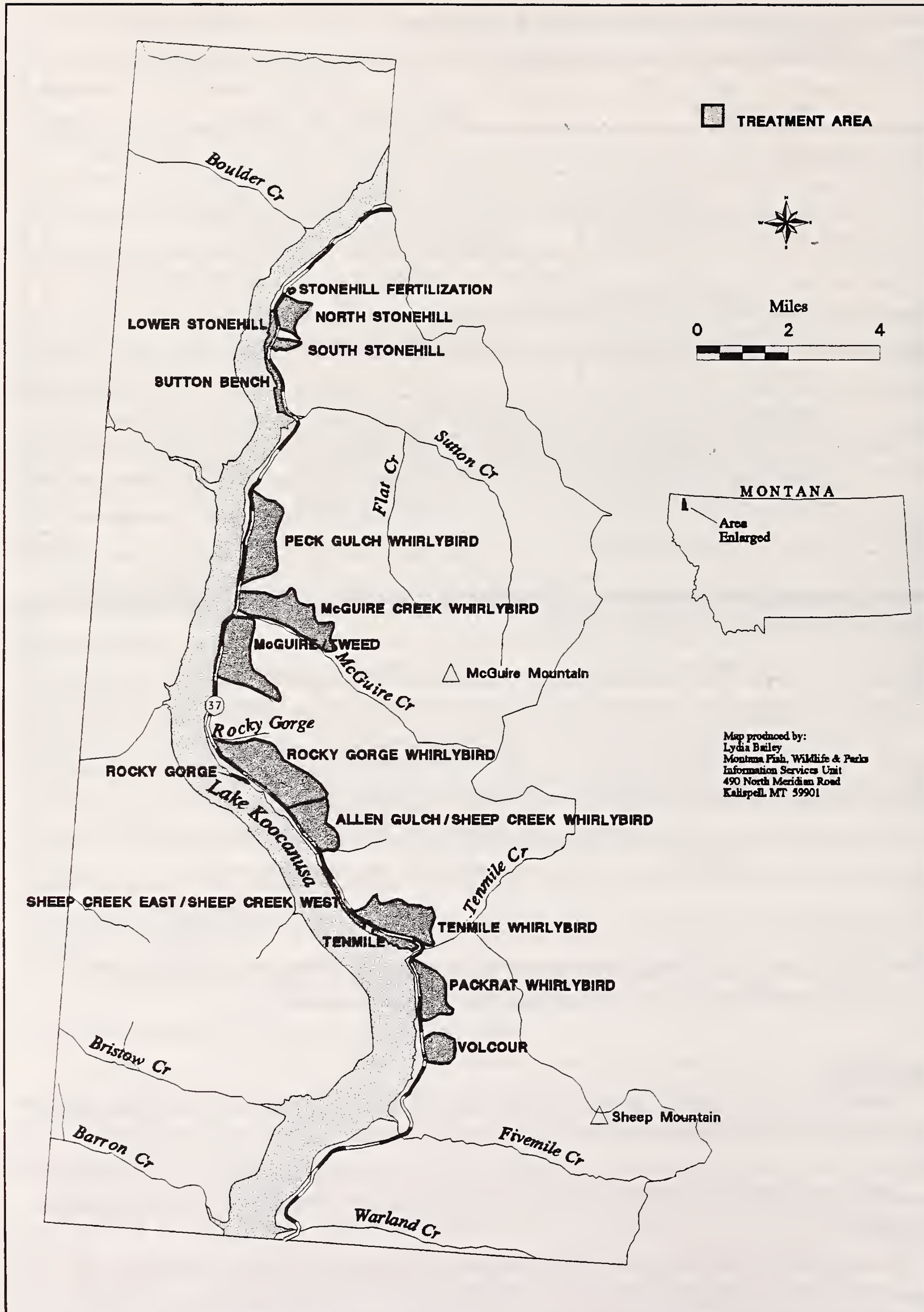


Figure 2. Winter/spring range treatment areas on the Libby Dam study area.

an adjacent stand of ponderosa pine to create a seed cone plantation. A large unit of the Whirlybird timber sale was also adjacent to the area.

Fifteen acres of young lodgepole pine were slashed and piled in July and August 1985. On one peninsula with numerous cottonwoods, slashed trees were piled away from the cottonwood stands to prevent damage to them during prescribed burning. The area was burned in October 1985. In 1986 the Forest Service conducted an underburn within the adjacent seed cone plantation. This fire burned into the eastern-most control unit of the treatment, but did not modify a very large percentage of it.

McGuire/Tweed

This area was characterized by a steep, west-facing slope bisected by a series of rocky benches. Treatment planned was a broadcast slash of conifers <8 inches dbh over the majority of the area, strip slashing in a small patch of lodgepole pine, and a prescribed fire.

Approximately 140 acres were slashed in October 1986. Aspen groves and conifer stands in draws were left unslashed to provide vegetative diversity and watershed protection. A few areas of very dense, small diameter trees were slashed with 100 foot cut strips alternating with 50 foot leave strips.

The unit was aerially ignited in late August 1987. The normal September rains failed to materialize so this unit continued to burn until mid-November. The fire burned well outside the planned unit, but stayed within wildlife winter range so no suppression action was taken except for a small area along McGuire Creek to keep it from spreading to the north. The fire reached a total size of about 800 acres.

This treatment unit did not have a paired control unit.

Lower Stonehill

This 85 acre area was located within the 1958 burn which scorched the west slope of Stonehill and was characterized by a flat bench with a steep west-facing slope.

The planned prescription for this area was a spring prescribed burn. Selected areas of deciduous shrubs were targeted for protection from the burn to preserve habitat diversity and benefit avian species.

Approximately 55 acres were burned in 2 stages during 1986. In late March a strip along the upper side adjoining Highway 37 was burned to create a blackline on the uphill side. The remainder of the treatment was burned in early April. Conifer mortality was <46% across the majority of the area. Consequently, the area was slashed in the fall to further reduce the conifer overstory.

North Stonehill

This was a 280 acre area within the 1958 Stonehill burn. The area contains a series of south- to west-facing benches largely covered with dense conifer regeneration. The area also contains fairly abundant bunchgrass and shrub foraging areas. A combination of broadcast and strip slashing was used to add fuel to the available ground fuels. The prescribed burn was scheduled for fall 1986.

Slashing was completed during the fall and winter 1985. Broadcast slashing was used over most of the area, but most heavily on the southwest portion. Strip slashing was used in areas with dense patches of lodgepole pine, especially the northwest corner of the area.

A field review of the area in 1986 resulted in revision of the wildlife prescription for the area. Consensus during the review was that the prescribed burn should be planned to remove more of the remaining conifers than was originally planned so the burn prescription was revised to accomplish this. In addition, the review team decided to burn this unit and the South Stonehill unit at the same time. Moisture content of slash in summer 1986 indicated that a 2 year drying time was required.

Field reconnaissance in 1987 identified concerns about potential adverse effects on soil and bunchgrasses by high intensity fire with a fall burn on the southwestern slope so a decision was made to burn the unit in 2 sections. The lower elevation, southwestern, and western slopes would be burned in the spring and the remainder in the fall.

In April 1987 the southwestern and western slopes were aerially ignited. In August 1987 the remainder of the unit and the adjoining South Stonehill unit were aerially ignited.

South Stonehill

This area, a west- to northwest-facing slope within the 1958 Stonehill burn, is approximately 75 acres of dense regeneration. The treatment designed for the area was strip slashing followed by prescribed fire.

The area was slashed during November and December 1985. Aerial ignition took place in August 1987.

Lower Sutton Face

This area was a 100 acre bench between Koocanusa Reservoir and Highway 37 characterized by an extensive stand of mixed shrubs with encroaching conifers. The treatment prescription was a spring burn.

To reduce conifer regeneration, the area was opened to commercial Christmas tree harvest during December 1986 and 1987. The unit was burned in mid-April 1988 using drip torches.

Stonehill Fertilization

Several areas throughout the sheep range contain stands of bunchgrasses. The majority of these stands are on steep, rocky slopes unsuitable for most habitat enhancement techniques such as prescribed fire. In an attempt to improve these stands it was decided to experiment with aerial application of fertilizer. A 25 acre trial plot plus seven other areas were selected for fertilization treatment.

The Stonehill Fertilization plot is about 25 acres on a flat bench with a mixed grass/shrub community. Its location, accessibility, and vegetative community made the area a good site for this experimental plot.

In 1985 soil samples were taken from the area and analyzed to determine the best fertilizer composition to apply to the area. In early June 1986 the fertilizer (21-0-0 nitrogen) was aerially applied at a rate of 223 kg/ha. Good rainfall during the remainder of the month ensured that the fertilizer was available to plants.

Preliminary monitoring indicated no response to fertilization 2 years after treatment so fertilization of the other 7 areas was dropped from the treatment schedule.

## Vegetation monitoring

### Monitoring transects

Vegetation monitoring transects were established in selected treatment and paired control areas. Treatment and paired control areas were in close proximity and had similar habitat and topographic elements. Vegetation data collection was completed within as short a period of time as possible.

Where possible, transects crossed to form an X in each treatment/control area. Transect segments extended diagonally from one corner of the treatment/control area across the unit to the opposite corner. Because treatment and control areas were of different sizes and shapes, lengths of the segments/transects varied. End points of the transect segments were located to maximize the area of coverage, but at least 15 m from the corner of the treatment/control area. This design allowed for monitoring the vegetation across the entire treatment/control area, including variation due to changes in elevation and topography, while eliminating the effect of treatment edge. This sampling technique was developed using a combination of methods described by several authors (Anonymous 1977, Chambers and Brown 1983, Floyd and Anderson 1984, Nudds 1977, U.S. Dept. Inter. 1978) and consultations with personnel from Montana State University, University of Montana, and the U.S. Forest Service. Plant nomenclature follows Hitchcock and Cronquist (1973).

Several modifications were made to conform sampling methods to a given situation. Modifications due to topography, vegetation and/or configuration of the treatment/control area were made. Where changes in methods were needed, the same modifications were made in both the treatment and paired control area. For example, the Rocky Gorge Peninsulas were small areas adjacent to Lake Koocanusa. In these units, transects were located parallel to the off shore side of the unit. They were approximately mid-distance between the high water mark and the off shore side of the unit. Within the North Stone Hill Unit the series of rough, rocky benches precluded completing the transects in an X across the unit. Instead, a series of transects were completed along selected benches located within three elevational zones.

Sampling was conducted between the second week in June and mid-August. During this period, grasses matured to at least the boot stage and the majority of forbs were flowering. As the sampling period progressed, grasses matured to seed ripe and then cured. Forbs developed, flowered, and matured to seed ripe and began to desiccate by the end of the sampling period. The goal for data collection was to conduct vegetation surveys 2 years prior to treatment and for 2 years following treatment. Two years of pre-treatment data would provide a suitable data base for future comparisons and 2 years of data following treatment would document the initial plant response to the treatment. Because of the lack of vegetation after burning, treatment areas were not monitored the year of treatment. Based on consultations with the various cooperators involved in the project, only 2 years of baseline data were planned from the control areas. After that, data were gathered in the control areas only if data collection occurred in the paired treatment area. In some treatment areas there was at least a 2 year lag period between slashing and the follow-up prescribed burn. This created a corresponding gap in the data available for analysis.

Ground cover, plant composition, and understory canopy composition in the treatment and control areas were estimated from 100 sampling points located approximately equidistant along the transect segments - 200 points/transect (Chambers and Brown 1983, Floyd and Anderson 1984, Hays et al. 1981, Nudds 1977, and U.S. Dept. Inter. 1978). To determine the distance between sampling points, the length of the transect segment was estimated and then divided by 100 (the number of sampling points/segment). The investigator would walk along the transect and stop at the pre-determined distance between points. The sampling point was a point directly in front of the toe of the investigators boot/shoe. At each point, ground cover (vegetative, litter, soil, rock, etc.) was recorded as well as the understory canopy components in each layer to a height of 1.0 m above the sampling point.

At every tenth point along each segment the following were completed using the point as the center of the plot unless otherwise noted: (Note: Due to topographic and vegetative features of both the North Stone Hill and McGuire/Tweed treatment areas, fixed plots were selected throughout the units in a systematic manner and monitored on an annual basis using the standard sampling techniques.)

1. Frames of 0.22 $m^2$ (61 cm X 36.5 cm) were used to estimate grass and forb production (U.S. Dept. Inter. 1978). Beginning with the 1988 sampling season, a 0.27 $m^2$ (61 cm X 44.5 cm) frame was used; an error when constructing the new frames resulted in a different size. The rear, left-hand corner of the plot frame was placed over the sampling point and vegetative production (grams/species) was ocularly estimated. In addition, at 4 of the 20 plots, randomly selected prior to starting, the production (by species) was estimated and then the plots were clipped with the individual species weighed. A correction factor was then calculated to convert the estimated weights to actual weights (estimated weight/actual weight). Because of the number of samples and logistics of sorting and drying the number of clipped samples, the green weights were used with no conversion to dry weights. Green weights (grams/0.22 $m^2$ for 1985-87, grams/0.27 $m^2$ for 1988 to date) were converted to kg/ha. General phenology of the vegetation in the area of the transect was recorded.
2. A shrub characterization/volume plot was centered on the sampling point. Plot size varied according to species. A 13.5 $m^2$ plot (2.1 m radius) was used for high frequency species within a plot: rose, shiny-leaf spirea (*Spiraea betulifolia*), common snowberry, huckleberry (*Vaccinium spp.*), raspberry (*Rubus spp.*) and any species with similar growth form. A 40.5 $m^2$ plot (3.6 m radius) was used for serviceberry, redstem ceonothus (*Ceonothus sanquineus*), shiny-leaf ceonothus (*C. velutinus*), oceanspray (*Holodiscus discolor*), ninebark (*Physocarpus malvaceus*), antelope bitterbrush (*Purshia tridentata*) and other shrub species which were generally larger and less numerous within a plot.

The first 10 plants of each species, encountered along a clockwise arc beginning at a random point, were characterized by age and form class. Height (up to 2.0 m), length (the longest portion of the plant) and width (perpendicular to the length) were used to estimate shrub volume - an indicator of production. Heights >2.0 m were not measured because they were considered to be out of reach of browsing animals. Cylindrical shrub volumes were calculated using the following (Lyon 1984):

$$\text{Volume} = \pi h l w/4$$

$\pi = 3.14$ $\quad$ $l$ = length

$h$ = height $\quad$ $w$ = width

Plant frequency was also calculated for each of shrub species (number of plants/ha). Average shrub volume and frequency were used to calculate total volume ($m^3$/ha) for each shrub species.

Analysis of changes in shrub volume, shrub frequency, herbaceous production, and understory plant composition was accomplished by comparing the pre- to post-treatment change to that measured on control plots as follows:

$$(\bar{x}_{post\text{-}trt} - \bar{x}_{pre\text{-}trt}) - (\bar{x}_{post\text{-}control} - \bar{x}_{pre\text{-}control}).$$

## Wildlife use of treatment areas

### Immobilization and trapping

Free-ranging bighorn sheep were immobilized using an intramuscular injection of xylazine hydrochloride (Rompun[R]) and ketamine hydrochloride (Vetalar[R]). The standard 3.0 cc dosage was 2.0 cc xylazine (100 mg/ml) and 1.0 cc ketamine (100 mg/ml) administered with hypodermic syringe darts propelled from a Palmer powder charged Cap-Chur gun. Sheep were approached to within 15-30 m at mineral licks and grassy roadcuts adjacent to Highway 37.

A corral trap, set up around a mineral lick, was used to capture bighorn sheep and mule deer. This mineral lick received use throughout the year by mule deer and bighorn sheep. Sheep use of the trap site was greatest during periods when they concentrated in the area (ie. early winter and spring).

Since 1987 clover traps (Clover 1954) were used to capture mule deer and bighorn sheep. Most traps were set at locations frequented by both mule deer and bighorn sheep. This provided the opportunity to capture either species. Due to topography and lack of access roads, much of the project area was inaccessible to trapping. Therefore, most of the traps were located in areas adjacent to Highway 37, but somewhat concealed from the public. Traps on Stone Hill and McGuire Creek were located along available access roads.

Sampling efforts were spread over the entire winter range until 1989. Sampling after that time was concentrated on the core area from Tenmile to Rocky Gorge.

**Marking**

Depending on age, sex, and body size, captured animals were fitted with radio transmitters, individually-marked vinyl neck bands, colored ear streamers, or ear tags. In general, radio collars were placed on all bighorn sheep 1+ years of age. Female lambs (6-12 months old) were fitted with radio collars if their neck girth was ≥28 cm. Neck bands were placed on female lambs and adults not fitted with radio collars. Male lambs were fitted with colored ear-streamers because their necks were not large enough (<33 cm) to accommodate a radio transmitter or neck band without future adjustment. Combinations of streamer color were used to provide identification of individual animals.

Radio collars were placed on adult female mule deer and female fawns with neck girths of ≥28 cm. Fawns with <28 cm neck girth were marked with color coded neck bands. After the desired number of radio collars were deployed in a winter range segment, the remainder of the female mule deer were marked using neck bands. Captured males were fitted with expandable neck bands or ear tagged. Large or extremely aggressive males were released without handling if only one person was conducting the trapping. Radio collars and neck bands were individually color coded - solid color or a combination of collar color and colored symbols - for ease in identifying individual animals.

All captured animals were marked with only colored earstreamers beginning in winter 1992 and continuing through winter 1994. Yellow was used in 1992, blue in 1993, and orange in 1994. This strategy was used to provide a large enough sample of marked animals to calculate population estimates.

**Animal movements and distribution**

Systematic ground and aerial relocation surveys of instrumented animals were conducted to determine seasonal distribution and habitat selection. Ground surveys were supplemented with aerial surveys through 1986. In 1987 aerial surveys were used as the primary method to obtain animal relocations. Since 1987 ground surveys and observations of animals obtained during daily field activities were used to supplement the data base. I used locations of instrumented animals to determine animal home ranges, seasonal distribution patterns, and habitat selection.

Locations were recorded using Universal Transverse Mercator (UTM) coordinates. Group size, composition, and activity were recorded for visual observations. Based on the judgement of the observer, all observations were placed into 1 of 5 categories.

- Category 1 - visual observations - included incidental observations and relocations where the animal(s) were observed.
- Category 2 - telemetry relocations where, in the judgement of the observer, the animal(s) was within a 100 m radius of the recorded UTM coordinates.
- Category 3 - similar to Category 2 except a 250 m radius was used to delineate potential error in the relocation.
- Category 4 - general telemetry relocation with an error radius of 500 m from the UTM coordinates.
- Category 5 - general telemetry relocation where only the drainage or sub-drainage could be determined.

Home range and habitat analyses utilized only the Category 1 to 3 observations, combining aerial and ground relocations for each year and season. Observations were combined again into composite home ranges and lifetime home ranges. Composite home ranges were made up of observations from >1 animal during a season, year, or group of years. Lifetime home ranges were constructed by combining several years' observations of 1 animal for one season.

Mule deer distribution was displayed using relocations from the entire study area. Mule deer movement and home range patterns were analyzed for relocations obtained from the entire area and from relocations just from the core area.

Relocations were analyzed using the CALHOME computer program (Kie et. al. 1994) to calculate adaptive kernel home ranges (Worton 1989). The adaptive kernel is a probability density function and calculates home range based on the density of points which varies over the landscape. Because sheep have seasonal home ranges which cover most of the study area, this method was chosen to capture the variation in intensity of use which results from such a pattern. Differences in pre- and post-treatment winter home range sizes were analyzed using a t-test and a Mann-Whitney U test.

**Treatment use analysis**

Relocations of radio-collared deer and sheep were pooled separately for winter and spring. Distance to the nearest treatment was measured for each point using a PC GIS package, EPPL7, and an average was calculated for each species, season, and year. The same process was followed for an equal number of random points during each season and year. The resulting average observed distances and average random distances were compared by season and year using a 2-sample t-test.

Use of treatment areas was evaluated using chi-square goodness-of-fit tests following Byers et al. (1984). Comparison of pre- and post-treatment expected use was accomplished with a Mann-Whitney test.

**Browse utilization**

Browse utilization transects were established to monitor ungulate use on treatment and adjacent control areas (Anon. no date, Stickney 1966) along the same general transects used to monitor the vegetation composition and structure. Browse utilization data were collected during April and May prior to the growing season. Utilization was determined by counting the number of annual leaders browsed out of 10 leaders examined. This number was the utilization class and was then converted to a percentage. For example, if the utilization class equaled 5, then utilization was 50%. Percent utilization was averaged over the individual shrubs of each species resulting in one estimate for each species for each treatment or control area.

Analysis was accomplished by comparing the difference of the mean pre- and post-treatment utilization with the difference of mean pre- and post-control utilization. A larger estimate of percent utilization on the treatment than on the control was called a positive response and vice versa. The formula for this comparison was:

$$(\bar{x}_{post\text{-}trt} - \bar{x}_{pre\text{-}trt}) - (\bar{x}_{post\text{-}control} - \bar{x}_{pre\text{-}control}).$$

### Pellet group surveys

Pellet group transects - again corresponding to the general vegetation monitoring transect - were established in each of the treatments/controls. Pellet group transects were completed in early spring in conjunction with browse utilization data collection. They were repeated again in the summer in conjunction with the vegetation diversity and production data collection. At every tenth point along the respective transect, a circular plot (13.5 $m^2$) was searched for deer or bighorn sheep pellet groups. A total of 20 plots per treatment/control per season of collection were completed. I assumed that pellets decomposed in less than 12 months, therefore, during the annual pellet group surveys only groups which had been deposited during the preceding 12 months were counted.

Change in pellet group densities over time was done using the same formula as that for browse utilization.

## Population response of mule deer and bighorn sheep

### Population surveys

Early and late winter helicopter surveys (Bell 47 and Hughes 500D) were conducted to estimate size and composition of the two populations. Flights were conducted during late afternoon and evening when the animals were more active and the sun was behind the observer. Generally, the entire sheep range was covered during each of the surveys. During 1985 a sheep survey was attempted during the spring while the ewes were more concentrated during lambing. This attempt was not productive due to lack of snow cover and topographic and vegetative conditions. Prior to the winter of 1987-88, helicopter surveys were conducted primarily for bighorn sheep. Mule deer observed during the surveys were recorded; however, much of the area occupied by mule deer was not systematically searched. Additionally, until the overstory canopy was opened by the Whirlybird timber sale, observability of mule deer was limited. Thus, until the winter of 1989, survey results for mule deer were minimal at best.

### Population estimation calculations

Mark-resight estimates (Rice and Harder 1977) were calculated from annual helicopter surveys in the winter or spring, usually December or April. At least one survey was completed every year for both sheep and deer.

### Age/sex ratios

Age ratios were calculated from annual age and sex classification surveys (both aerial and ground) conducted in winter (Dec. 1 to Mar. 31) and spring (Apr. 1 to May 31). Observations were pooled separately for sheep and deer for those periods and a ratio was calculated from those pools. A composite age ratio was calculated for pre- and post-treatment periods. Pre- and post-treatment ratios were compared using a proportion test (Zar 1974:395).

### Survival

Survival estimates were calculated for radio-collared sheep and deer using the MICROMORT (Heisey and Fuller 1985) and modified Kaplan-Meier (Pollock et al. 1989) procedures. Mortality dates were established and pooled into pre-treatment (1985-90) and post-treatment (1991-95) periods. Sample sizes were too small to analyze by year. In addition, data were further divided into winter/spring and summer/fall periods. Tests of significance between treatment periods were calculated following the procedures of Sauer and Williams (1989).

**Big game hunter check station**

The Koocanusa Bridge check station was operated during the general big game seasons from 1987 to 1990. During 1987 and 1988 project personnel operated the station for the first 15 days of the season and weekends thereafter. During the second week (days 9 - 13) of the 1987 and 1988 season, hunters and animals checked per day was minimal, 47.3 and 5.2, respectively. Consequently, the station was operated only during the first 8 days of the general season and on weekends thereafter during 1989 and subsequent years. In addition to the number of successful and non successful hunters, data collected included species, gender, age and diastemal length of harvested animals. Antler characteristics - basal diameter, length and maximum inside spread of the main beams, and number of antler points - were measured for all males 1.0+ years of age. For mule deer, dressed weights, heart girth and thickness of subcutaneous fat at the xiphoid process (Austin 1984) were obtained.

Data were obtained from all other Region 1 check stations and analyzed by hunting district. Because the study area falls within HD 101, age structure and physical measurements from HD 101 were compared to all other hunting districts to determine if there were specific trends happening in 101 that could be related to habitat enhancement. If trends in HD 101 suggest a healthier population than other hunting districts then one might conclude the enhancements were beneficial.

# Vegetation Monitoring - Results and Discussion

Four variables were measured on the 8 paired treatment/control transects to assess vegetation response to the treatments. These variables were shrub frequency (# shrubs/ha), shrub volume ($m^3$/ha), forage production (kg/ha), and change in understory cover composition.

## Shrub frequency

Number of serviceberry plants increased on all treatment transects except two, West Sheep Creek and Rocky Gorge (Table 2). Over all treatment transects, serviceberry plants increased by 151 plants/ha relative to the control transects.

The number of rose plants increased by 167 plants/ha, but this was due to a very large increase on the Tenmile treatment transect. All other treatment transects had fewer plants than their adjacent control transects.

The number of spiraea plants increased by 130 plants/ha over all treatment transects. Again, this was due to a large increase on both the Tenmile and Rocky Gorge treatment transects.

The treatment transects produced 323 fewer snowberry plants than their adjacent control transects.

Tenmile, East Sheep Creek, and Rocky Gorge treatment transects had more plants/ha than their adjacent control transects, Tenmile having the highest number. North Stonehill had the fewest number of shrubs relative to its adjacent control transect.

**Table 2. Change in shrub frequency (plants/ha) following treatment relative to changes observed in control plots.**

| Area | Species | | | | $\bar{x}$ |
|---|---|---|---|---|---|
| | AMAL | ROSA | SPBE | SYAL | |
| Tenmile | 445 | 2734 | 5147 | -114 | 2053 |
| E. Sheep Crk. | 1139 | -53 | -420 | 193 | 215 |
| W. Sheep Crk. | -1129 | -294 | -2220 | 273 | -843 |
| Rocky Gorge | -486 | -524 | 2945 | -1564 | 93 |
| Lower Stonehill | 643 | -1030 | -198 | -405 | -248 |
| North Stonehill | 292 | | -4477 | | -2093 |
| $\bar{x}$ | 151 | 167 | 130 | -323 | |

Merrill et al. (1982) observed an increase in shrub densities, especially spiraea, following fire in Idaho. Serviceberry, rose, and spiraea on this study area increased in number in response to manipulation while snowberry decreased in number. Fifty percent of the treatment areas responded to manipulation with increased numbers of shrubs.

## Shrub volume

Shrub volumes of all 4 browse species declined on treatment transects relative to the control transects (Table 3). The average volume of browse species declined on every treatment transect relative to its adjacent control transect.

Merrill et al. (1982) also reported a significant increase in shrub biomass, especially serviceberry, following prescribed burning. Habitat manipulation did not appear to result in a higher volume of shrubs on the treatment areas along Lake Koocanusa. However, only 1 or 2 years of post-treatment data exist for the treatment transects. A longer post-treatment monitoring period is necessary to determine the volume response.

Table 3. Change in shrub volumes ($m^3/ha$) following treatment relative to changes observed in control plots.

| Area | Species | | | | $\bar{x}$ |
|---|---|---|---|---|---|
| | AMAL | ROSA | SPBE | SYAL | |
| Tenmile | -312 | -1 | -6 | -83 | -101 |
| E. Sheep Crk. | -263 | -22 | 2 | -132 | -104 |
| W. Sheep Crk. | -239 | -8 | -3 | -8 | -65 |
| Rocky Gorge | 52 | -38 | 0 | -76 | -16 |
| Lower Stonehill | 90 | -155 | -211 | 228 | -12 |
| North Stonehill | -75 | | 14 | | -45 |
| $\bar{x}$ | -125 | -45 | -34 | -14 | |

## Herbaceous plant production

Both grass and forb production increased overall, although results were variable (Table 4). Grass production actually decreased on Rocky Gorge and North Stonehill relative to the increased production documented on control transects. Over all treatments, grass and forb production increased an average of 421 kg/ha. With 533 ha treated during this study (Table 1), there were 224,393 kg more forage produced than would be expected without treatment.

Production responded positively to treatment on 5 of the 7 areas. Herbaceous production increased on some areas immediately after burning in a Ponderosa pine stand (Anderiese and Covington 1986). Production of grass and forbs on Tenmile clearly increased, especially the first year following treatment. Production on the East and West Sheep Creek treatments exhibited the greatest responses to manipulation.

## Change in plant composition

Canopy coverage of grasses and forbs increased over all treatment transects relative to control transects (Table 5). However, the amount of bare ground also increased on treatment transects. Understory coverage of shrubs and other plants (ferns, moss, and lichens) decreased relative to control transects.

Table 4. Changes in herbaceous plant production (kg/ha) following treatment relative to changes observed in control plots.

| Area | Category | | | $\bar{x}$ |
|---|---|---|---|---|
| | Grass | Forb | Other | |
| Tenmile | 566 | 279 | -35 | 270 |
| E. Sheep Crk. | 633 | 839 | 0 | 755 |
| W. Sheep Crk. | 652 | 103 | 0 | 755 |
| Rocky Gorge | -74 | 243 | 119 | 288 |
| Lower Stonehill | 470 | 284 | -11 | 743 |
| North Stonehill | -207 | 145 | -27 | -89 |
| Stonehill Fert. | 511 | 186 | -1730 | -1033 |
| $\bar{x}$ | 364 | 297 | -241 | |

Additional grass and forb plants in the understory was likely a result of resprouting after treatment. Shrubs did not appear to respond as readily as grasses and forbs. In the short-term, there was a positive response, at least by grasses and forbs. The long-term response by plants to manipulation is unknown.

**Table 5. Change in understory canopy cover (%) following treatment relative to changes observed in control plots.**

| Area | Category | | | | | | $\bar{x}$ |
|---|---|---|---|---|---|---|---|
| | Bare Grd. | Grass | Forb | Shrub | Tree | Other | |
| Tenmile | 35 | 14 | 5 | -15 | -1 | -6 | 5 |
| E. Sheep Crk. | 4 | 6 | 17 | 7 | 1 | -4 | 5 |
| W. Sheep Crk. | -1 | 13 | 13 | -15 | -1 | 1 | 2 |
| Lower Stonehill | 15 | 2 | 8 | 0 | -2 | -7 | 3 |
| North Stonehill | -2 | -5 | 0 | 2 | 0 | -2 | -1 |
| Stonehill Fert. | -22 | 22 | 3 | 0 | 0 | 8 | 2 |
| $\bar{x}$ | 5 | 9 | 8 | -4 | -1 | -2 | |

# Wildlife Use of Treatment Areas - Results

## Bighorn sheep responses

A total of 54 bighorn sheep, 38 females and 16 males, were marked between December 1984 and February 1993. Capture effort was spread out from Sheep Mountain in the Fivemile Creek drainage to Stonehill until 1989. Subsequently, effort was focused on the core area. Radio-collared animals, 20 females and 8 males, were all captured between Tenmile Creek and Stonehill. A total of 1,783 relocations was obtained. Radio-collared sheep provided a sample to assess seasonal distribution and movement patterns.

**Distribution**

During pre-treatment winters, ewes used lower elevations and were distributed evenly across the area. A shift occurred in pre-treatment springs when ewes moved to slightly higher elevations and utilized steep, rocky habitat (Figure 3). Ewes were found on all planned treatment areas in winter and spring during pre-treatment years. Females did not use Sheep Mountain along Fivemile Creek and used upper portions of McGuire Creek only lightly during the summer and fall.

Distribution of ewes during post-treatment years was very similar to pre-treatment with one exception (Figure 4). No use occurred on Stonehill in winter and spring during post-treatment years.

During pre-treatment years, rams were widely distributed over the study area (Figure 5). Rams were more concentrated on Stonehill, south of Tenmile Creek, and on Sheep Mountain along Fivemile Creek than ewes. All radio-collared rams died or their radios stopped working before any post-treatment data were collected. Consequently, a comparison to pre-treatment was not possible.

Distribution of all collared animals over time indicated a shift to the southern end of the study area. Stonehill and the north side of Sutton Creek received high use from 1985 to 1988 and very little use after that. McGuire Creek was used heavily early on with utilization decreasing after 1988, although not to the same degree as Stonehill.

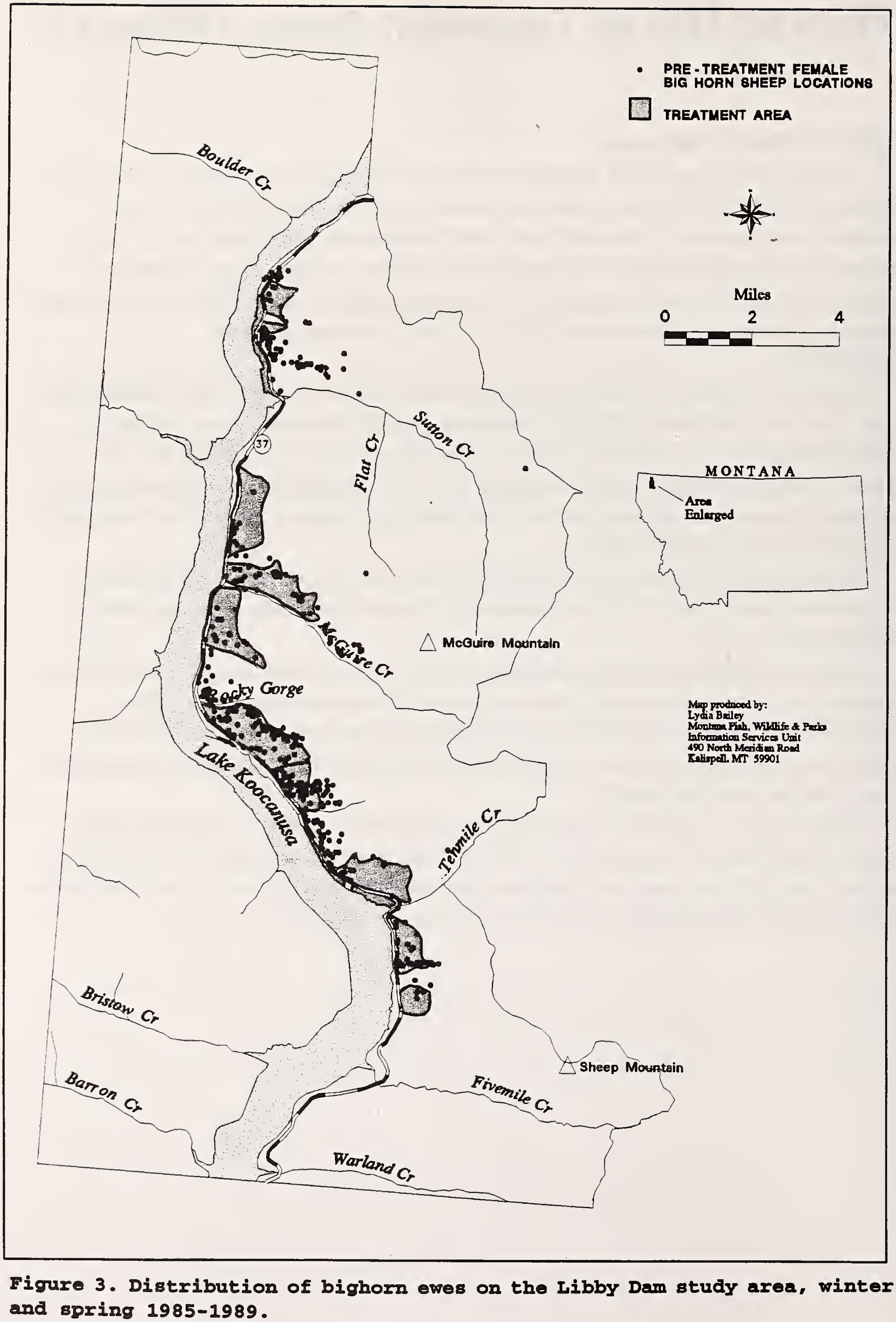


**Figure 3. Distribution of bighorn ewes on the Libby Dam study area, winter and spring 1985-1989.**

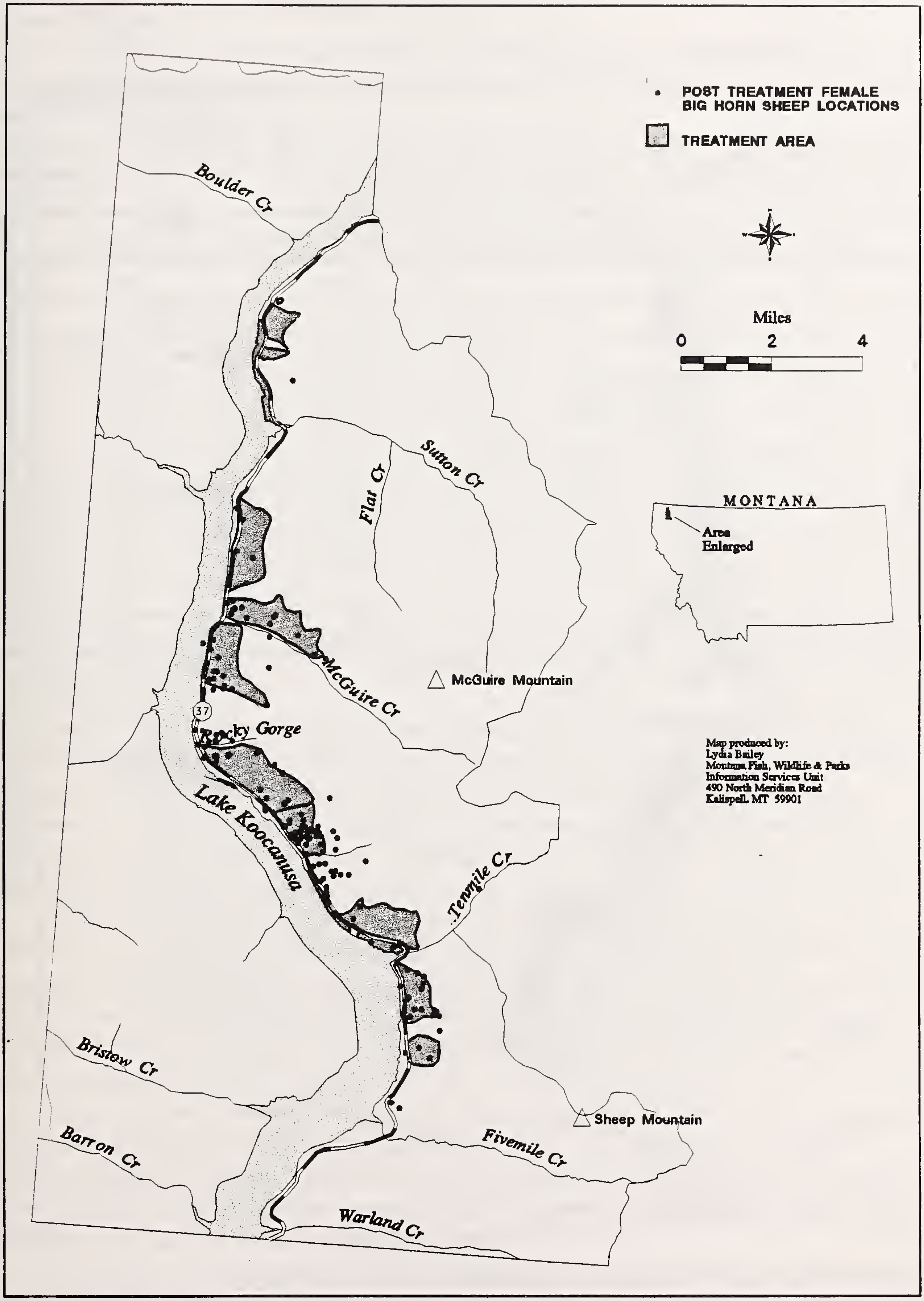


**Figure 4. Distribution of bighorn ewes on the Libby Dam study area, winter and spring 1990-1995.**

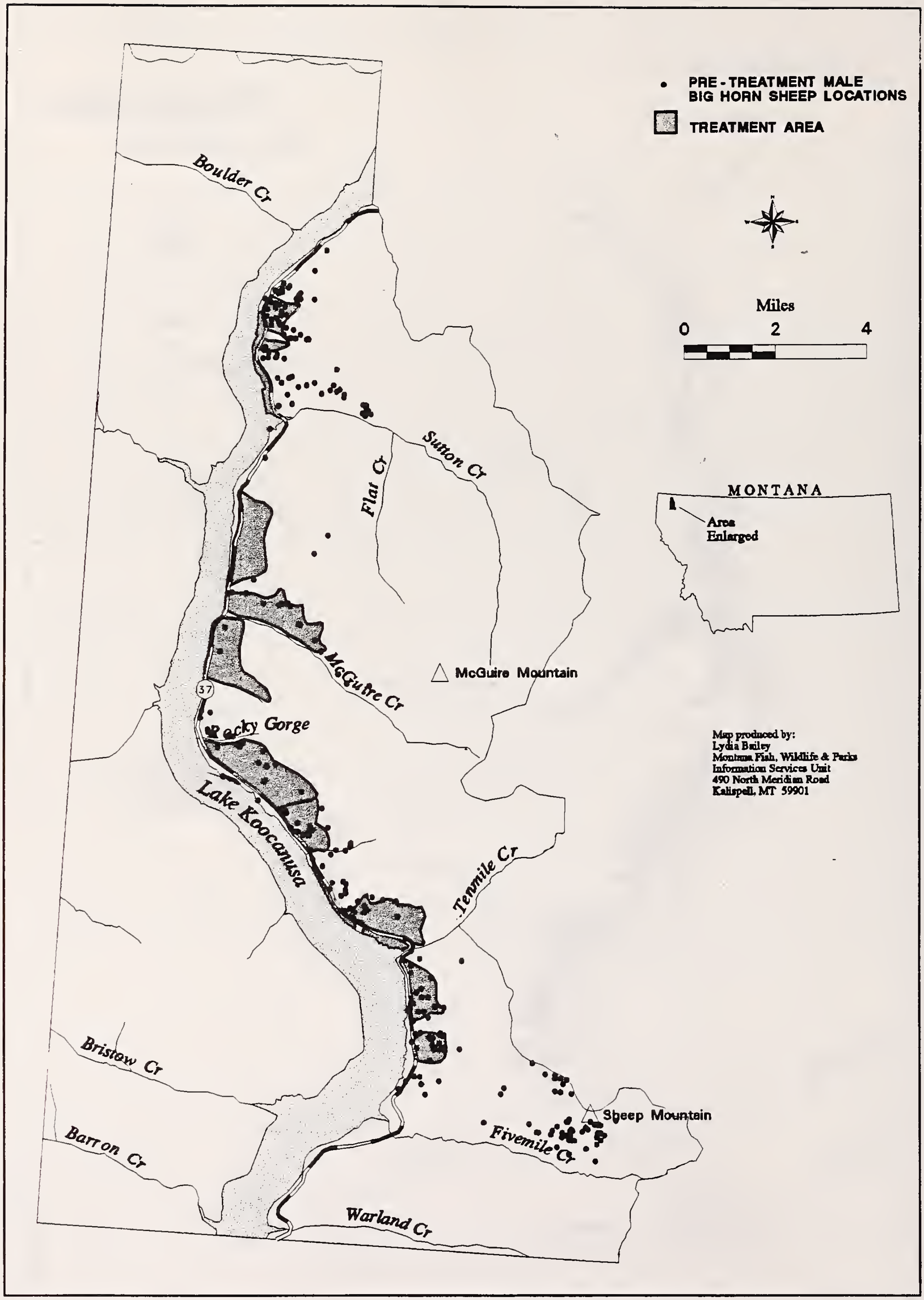


Figure 5. Distribution of bighorn rams on the Libby Dam study area, winter and spring 1985-1989

**Home Ranges**

Composite winter home range sizes for radio-collared ewes were variable between years (Table 6). There was no significant difference between pre- and post-treatment home range sizes (Z=-1.57, p=0.12).

Table 6. Composite winter home range sizes, number of animals, and number of points of radio-collared ewes on Libby Dam study area, 1985-94.

| Year | Home Range (ha) | No. of Animals | No. of Pts. |
|---|---|---|---|
| 85 | 100.0 | 2 | 21 |
| 86 | 153.9 | 5 | 35 |
| 87 | 234.0 | 10 | 106 |
| 88 | 210.7 | 10 | 60 |
| 89 | 91.5 | 10 | 38 |
| 90 | 100.1 | 8 | 32 |
| 91 | 176.5 | 4 | 8 |
| 92 | 81.9 | 8 | 30 |
| 93 | 31.1 | 7 | 13 |
| 94 | 51.1 | 5 | 11 |

**Treatment Use**

Average minimum distance to treatment areas was large (300 to 400 meters) for the winters of 1985 and 86. The distance varied from about 50 to 150 meters from 1987 to 1995 (Figure 6). There was no significant difference between observed distances and random distances for 1985, 86, 91, and 93 (p>0.05). Distances were significantly different for all other years (p<0.05). Average distance for the post-treatment period was not significantly different than the pre-treatment period (p=0.08).

Distance to treatment areas during spring varied widely among years (Figure 7). A distance of nearly 300 meters was observed in 1994 and an average distance of less than 10 meters occurred in 1995. There was no difference between observed and random distances for 1991 and 1994. In all other years these differences were significant (p<0.05). Average distance for the post-treatment period was significantly smaller than the pre-treatment period (p<0.01).

Observed sheep use of treatment areas was low in the winters of 1985 and 86 then increased significantly in 1987 and continued to increase until 1989 (Figure 8). Use fluctuated until the present. Treatments were used more than expected in all years except 1985 and 1986 (p<0.05). Observed use during the pre-treatment period was not significantly different from the post-treatment period (p=0.13).

Observed use during spring was quite variable among years (Figure 9). Use was higher during 1985 and 1986 during spring as compared to winter and slightly higher in the latter years. Treatments were used more than expected in all years (p<0.05). There was essentially no increase in observed use during the post-treatment period (p=1.00).

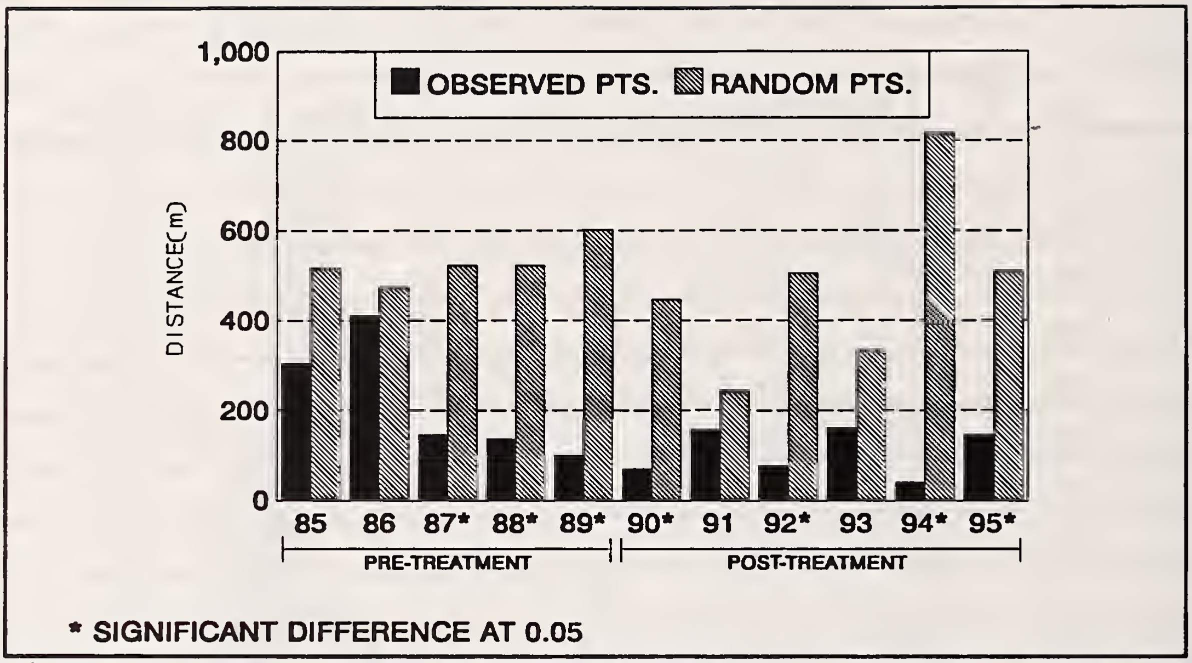


Figure 6. Average minimum distance(m) to treatment areas of bighorn sheep relocations and random points for winter, 1985-95.

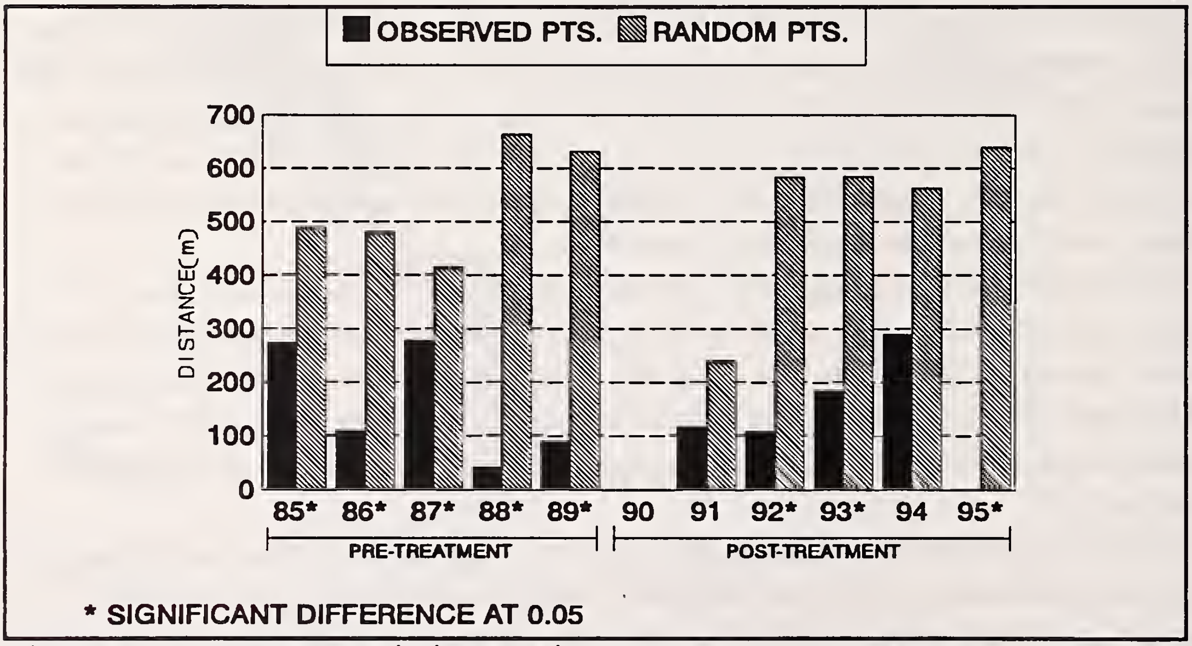


Figure 7. Average minimum distance(m) to treatment areas of bighorn sheep relocations and random points during spring, 1985-95.

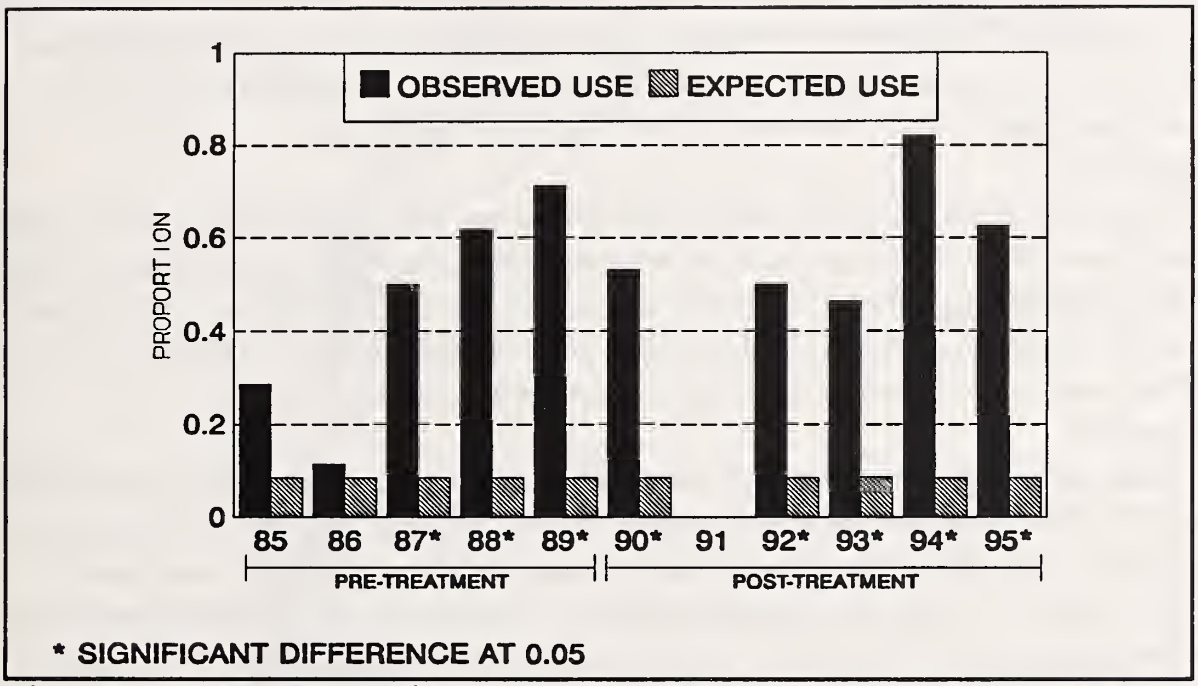


Figure 8. Use vs. Availability analysis of treatment areas for winter, 1985-95.

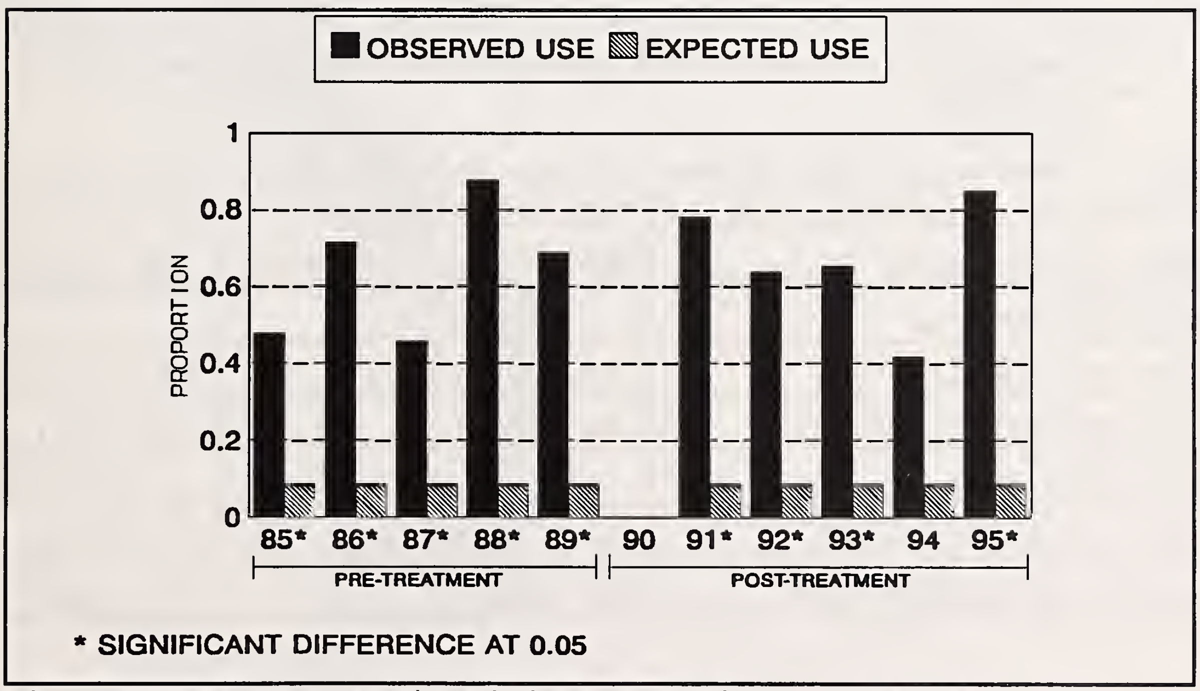


Figure 9. Use vs. Availability analysis of treatment areas for spring, 1985-95.

## Mule deer responses

Three hundred and fifty-two mule deer, including 249 females and 103 males, were captured and marked on the east side of Lake Koocanusa between January 1987 and February 1994. Eighty-one female mule deer were radio-collared on the entire winter range from January 1987 to February 1994. Sixty-seven females were radio-collared on the core area during the same time period. A total of 3,273 relocations have been obtained for all radio-collared deer, 2,546 relocations for deer inhabiting the core area.

**Distribution**

During pre-treatment years, radio-collared deer were distributed widely over the winter range (Figure 10). Use was concentrated between Rocky Gorge and Tenmile, Mcguire Creek, and Stonehill. Post-treatment distribution showed less concentration immediately adjacent to the lake shore and more use of uplands than pre-treatment distribution (Figure 11). In addition, deer use decreased on Stonehill and increased along Tenmile Creek.

**Movements**

Three categories of deer were delineated based on distances separating seasonal ranges (Pac et al. 1991). Deer with indistinct seasonal ranges (ISR deer) occupied the same home range year-round. Deer with adjacent seasonal ranges (ASR deer) occupied winter and summer ranges that were clearly distinguishable, but no more than 2.0 km from each other. The last category, deer with distinct seasonal ranges (DSR deer), had winter and summer home ranges separated by 2.0 km or more.

Following habitat treatments (1990-94), there were more deer that followed the DSR movement pattern and fewer deer that followed the ASR pattern compared to pre-treatment (1987-89).This change was consistent on both the core area and entire study area (Table 7).

Table 7. Percentage and number of deer that followed 3 movement patterns for different time periods and geographic areas.

| AREA & TIME PERIOD | DSR %(n) | ASR %(n) | ISR %(n) |
|---|---|---|---|
| Entire Study Area | | | |
| Pre-treatment(87-89) | 51.9 (28) | 16.7 (9) | 31.5 (17) |
| Post-treatment(90-94) | 88.2 (15) | 0 | 11.8 (2) |
| Core Study Area | | | |
| Pre-treatment(87-89) | 54.8 (23) | 21.4 (9) | 23.8 (10) |
| Post-treatment(90-94) | 88.2 (15) | 0 | 11.8 (2) |

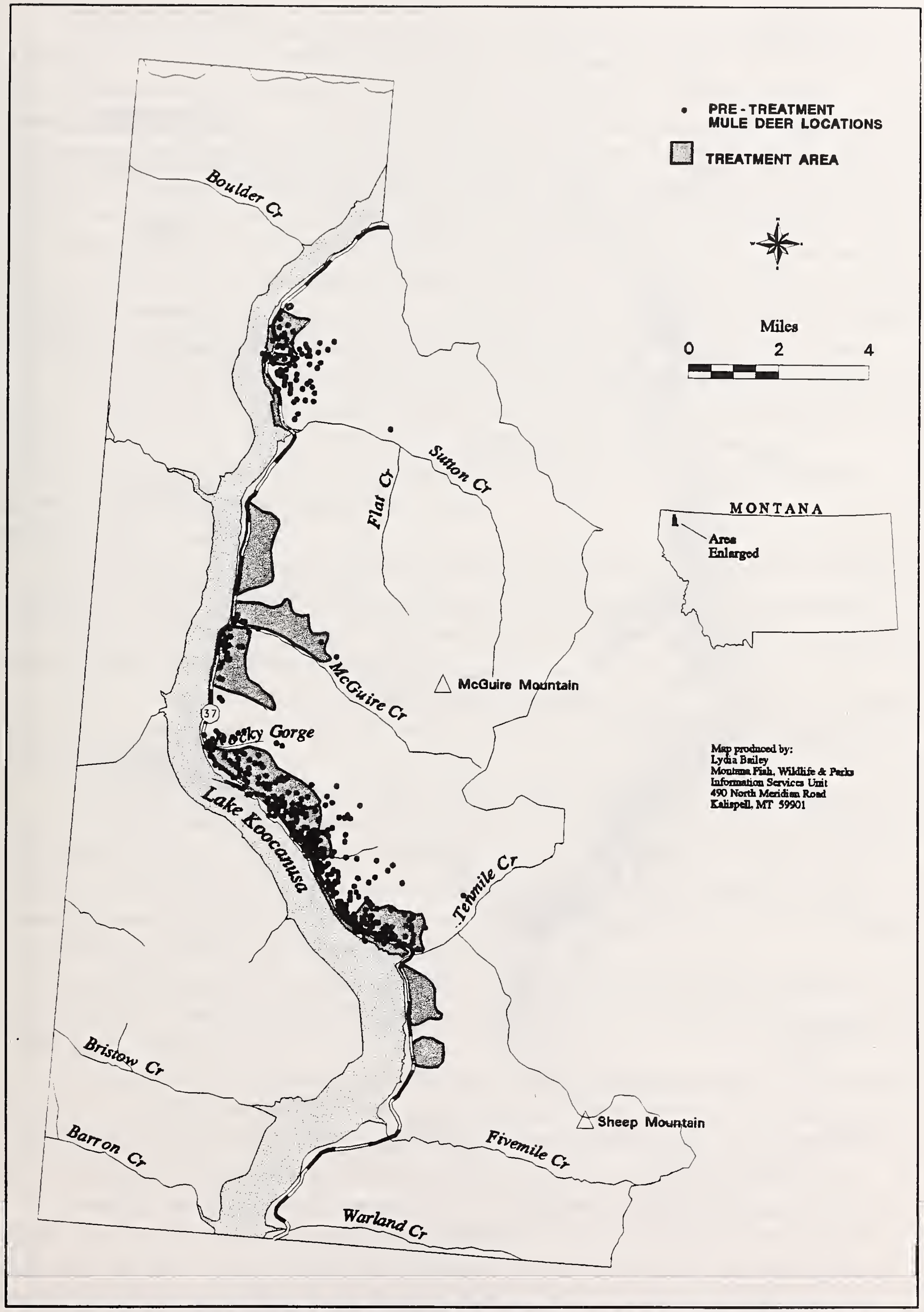


**Figure 10. Distribution of mule deer does on the Libby Dam study area, winter 1987-1989.**

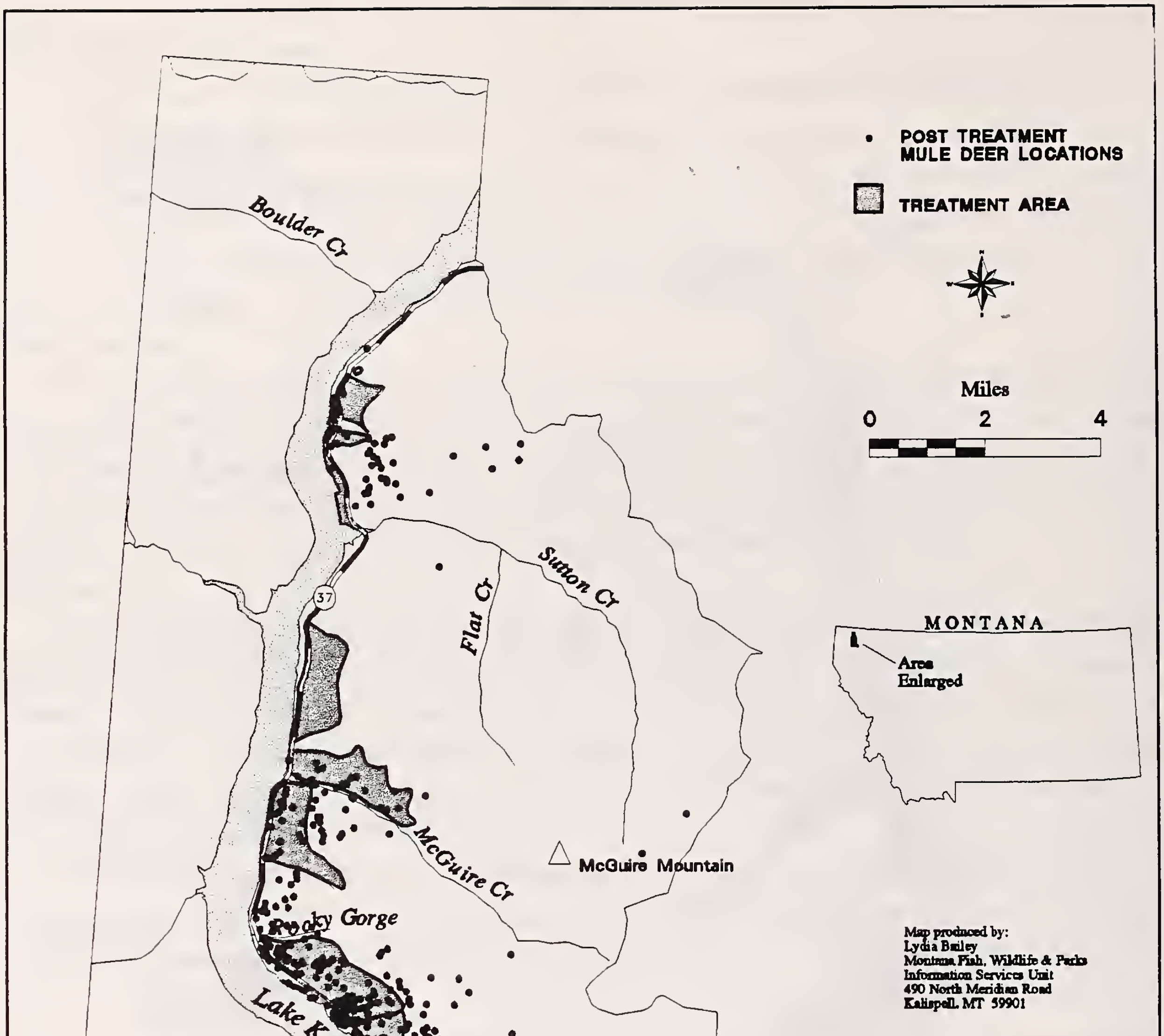


**Figure 11. Distribution of mule deer does on the Libby Dam study area, winter 1990-1994.**

Another component of individual movement patterns was the use of accessory areas (Pac et al. 1991). Distances between accessory areas and seasonal ranges varied between 0.4 and 35 km. Overall, 50% of ISR deer, 42% of DSR deer, and 8% of ASR deer occupied accessory areas. Among deer that used accessory areas, 50%, 39%, and 11% used fall, spring, and summer accessory areas, respectively. Deer spent the least amount of time on spring and summer accessory areas irrespective of movement patterns. Deer spent the most time on fall accessory areas with ISR>DSR>ASR deer in the amount of time spent on fall areas.

Accessory areas were generally at different elevations than seasonal home ranges. All were higher than winter home ranges. Summer and fall accessory areas were higher than summer home ranges and spring accessory areas were in between winter and summer home ranges. For ISR deer, spring accessory areas were lower than their annual home ranges.

Two deer within the core area, MD31 (age=6.0) with a DSR pattern and MD29 (age=7.0) with an ASR pattern, stopped migrating and adopted an ISR pattern in the spring of 1990. In spring 1993 another core area ASR deer (MD75, age=9.0) exhibited no migration behavior. A DSR deer (MD79, age=1.0) outside of the core area adopted an ISR movement pattern at the beginning of spring migration 1990.

**Home ranges**

For all collared deer inhabiting the core area each year, winter home ranges increased in size from 1988 through 1991, decreased slightly, but remained relatively high through 1994 (Table 8). Winter home range size on the core area increased significantly from pre- to post-treatment years (Z=-2.24, p=0.03).

Table 8. Composite winter home range size(ha) for collared deer inhabiting the study core area and entire area. Number in () indicates the number of deer used to calculate the composite home range.

To minimize differences from tracking different deer through time, 3 subsamples of deer from the total core area sample were chosen. Group 1 is a cohort of the same 4 deer tracked each year from 1987 to 1989. Group 2 is a sample of 14 deer tracked from 1989 to 1994. Group 3 is a sample of 23 deer tracked from 1993 to 1994. The general pattern of home range size remained similar to that of the total sample of core area deer except that group 2 deer indicated declining home range sizes from 1992 to 1994.

Composite winter home ranges of deer on the entire area exceeded 100 ha except for 1987 and 1994. There was no significant difference between pre- and post-treatment home range sizes (Z=-0.45, p=0.65).

Lifetime winter home ranges were largest for DSR deer followed by ISR and ASR deer (Table 9) during both pre- and post-treatment periods. DSR deer also had the greatest variability among all groups. Mean home range size increased from pre- to post-treatment for all movement patterns, but not significantly (DSR:p=0.88, ASR:p=0.56, ISR:p=0.53).

Several instances of home range shifts occurred. Deer #19 (age=7.5) shifted her winter range from Tenmile Creek to the north side of McGuire Creek (PHU 2) in 1994. Deer #91 (age=5.5) moved to Tenmile Creek from McGuire Creek in winter 1992. Deer #85 (age=3.5) shifted her winter range from Rocky Gorge to Packrat Gulch the winter of 1991 and then shifted back to Rocky Gorge in 1992. Only one deer shifted her summer home range. Deer

#50 (age=4.5) shifted from Sutton Creek/Pink Creek divide to upper Sutton Creek below McGuire mountain during 1990 or 1991.

Table 8. Composite winter home range size(ha) for collared deer inhabiting the study core area and entire area. Number in () indicates the number of deer used to calculate the composite home range.

| MARKED ANIMAL GROUP | YEAR 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 |
|---|---|---|---|---|---|---|---|---|
| CORE AREA | | | | | | | | |
| All Deer | 12.6(6) | 29.9(19) | 28.9(39) | 47.0(36) | 62.4(31) | 62.2(38) | 56.9(34) | 57.3(26) |
| Group 1[a] | 12.3 | 21.4 | 37.4 | | | | | |
| Group 2[b] | | | 27.0 | 41.8 | 39.4 | 78.3 | 36.2 | 33.0 |
| Group 3[c] | | | | | | | 45.8 | 59.4 |
| ENTIRE AREA | 12.6(6) | 103.4(26) | 136.2(53) | 132.5(49) | 113.9(43) | 119.8(43) | 136.1(36) | 57.3(26) |

[a] Sample of 4 collared deer tracked consecutively from 1987 to 1989.
[b] Sample of 14 deer tracked consecutively from 1989 to 1994.
[c] Sample of 23 deer tracked consecutively from 1993 to 1994.

Table 9. Mean lifetime winter home range size (ha) during pre- and post-treatment periods for deer inhabiting the study core area.

| Movement Pattern | PRE $\bar{x}$(n) | PRE S.D. | POST $\bar{x}$(n) | POST S.D. |
|---|---|---|---|---|
| DSR | 15.38(13) | 12.4 | 16.36(15) | 21.2 |
| ASR | 9.51(8) | 5.1 | 12.48(5) | 12.9 |
| ISR | 11.59(11) | 6.6 | 14.61(9) | 11.1 |
| All | 12.61(32) | 9.2 | 15.01(29) | 16.9 |

**Treatment use**

Average minimum distance of deer locations to treatment areas increased over time for winter relocations (Figure 12). In fact, the average distance from the pre-treatment years (87-88) was significantly smaller ($p<0.01$) than the average for the post-treatment years.

Average distance was significantly less than that for random points for all years ($p<0.05$).

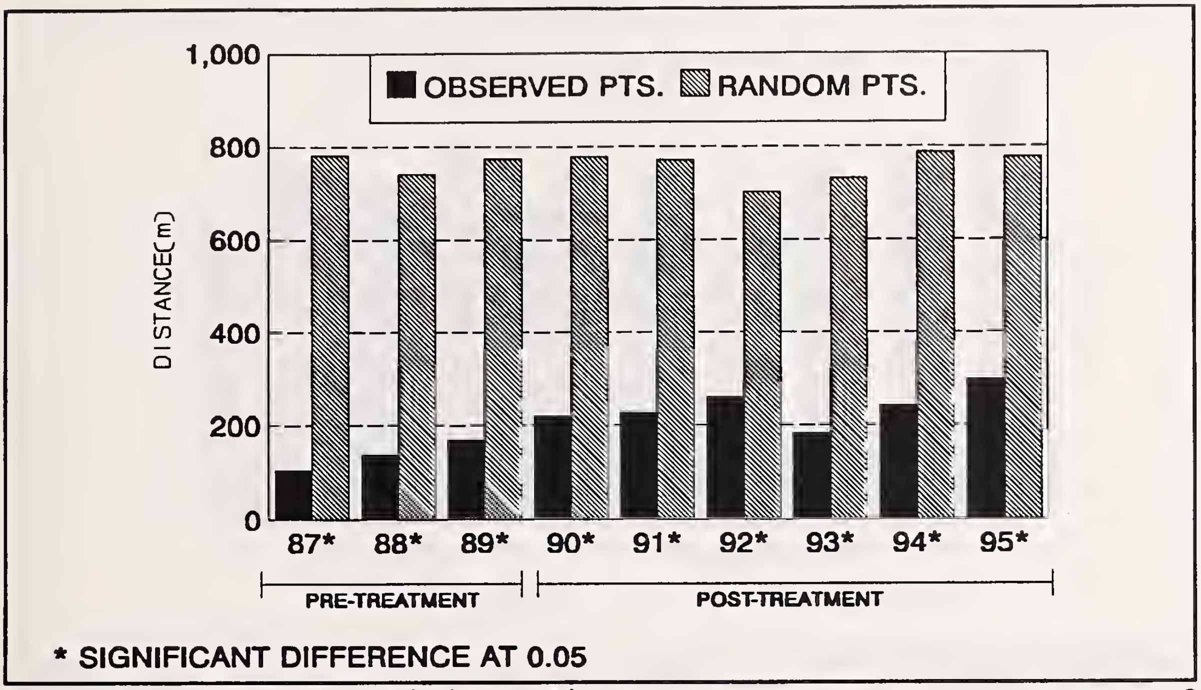


Figure 12. Average minimum distance(m) to treatment areas of mule deer relocations and random points for winter, 1987-95.

Average minimum distance of deer locations during spring increased until 1992 and then varied the last three years (Figure 13). The average pre-treatment distance was smaller than the post-treatment distance, but this difference was not significant (p=0.22). Again, observed distances were significantly less than random distances for all years (p<0.05).

Comparison of pre- and post-treatment expected use showed no difference between these 2 periods for winter (p=0.77). Observed use of treatment areas increased gradually through 1989, declined through 1991 and showed an increase until 1995 (Figure 14). Use vs. availability analysis indicated that treatments were used significantly more than expected for all years (p<0.05).

As during winter, there was no significant difference between pre- and post-treatment expected use for spring (p=0.46). Observed use during spring varied during 1987 to 1989 then declined to a low in 1992. Use increased the next 3 years with the highest level of use among all years occurring in 1995 (Figure 15). Similar to winter, observed use during spring indicated treatments were used more than expected for all years (p<0.05).

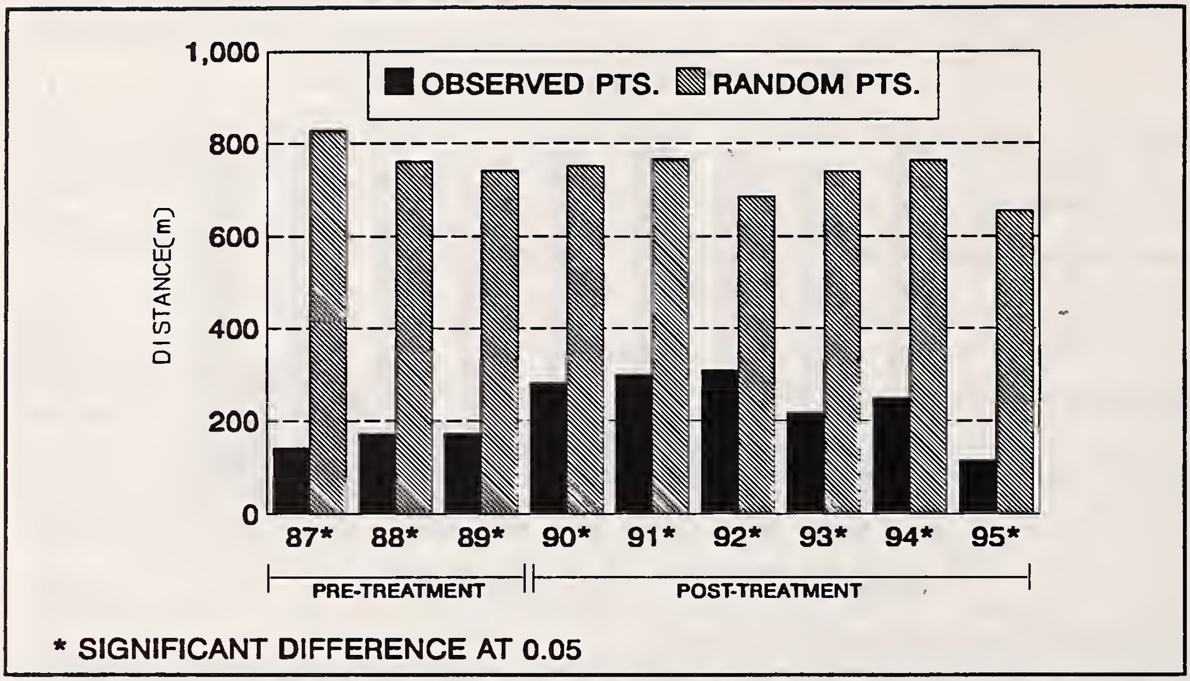


Figure 13. Average minimum distance(m) to treatment areas of mule deer relocations and random points during spring, 1987-95.

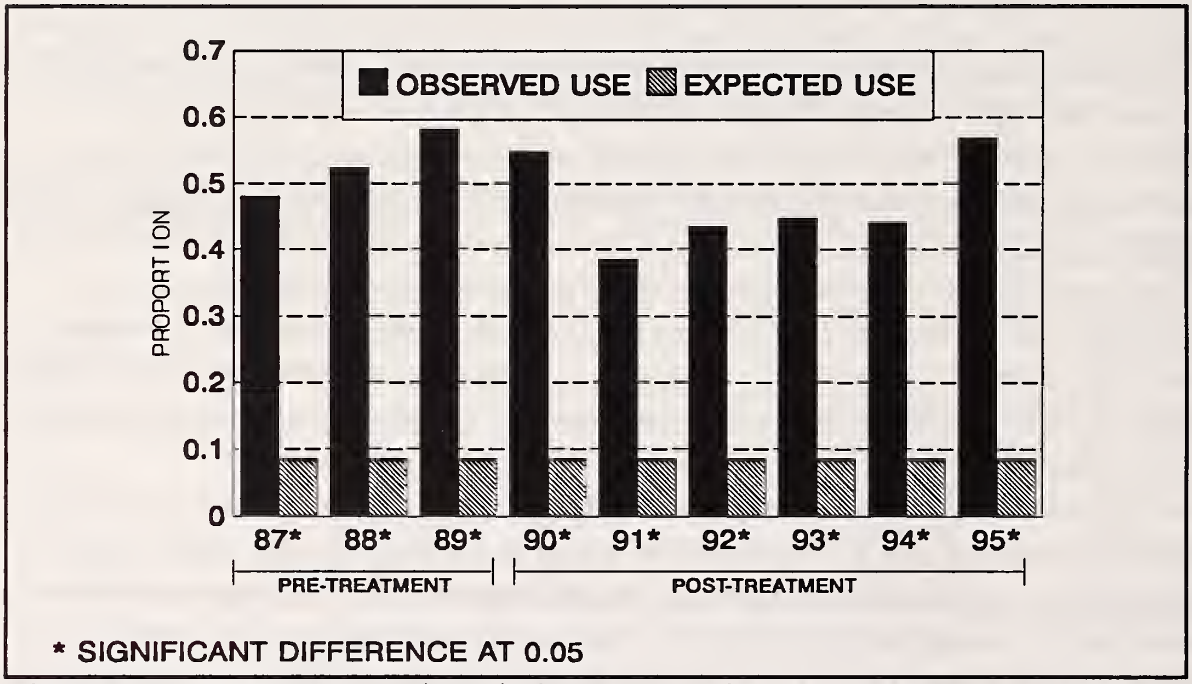


Figure 14. Use vs. Availability analysis of treatment areas for winter, 1987-95.

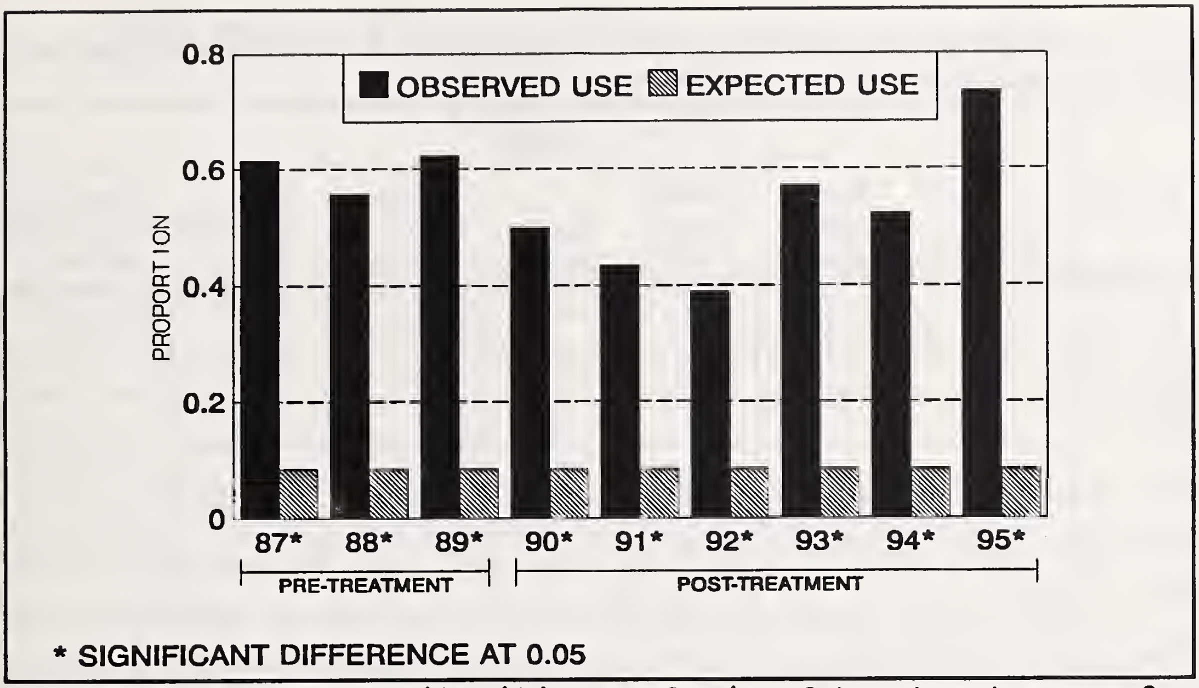


Figure 15. Use vs. Availability analysis of treatment areas for spring, 1987-95.

## Browse utilization

Browse utilization was measured for all paired treatment and control transects from 1985 to 1989 (Table 10). The McGuire/Tweed treatment did not have a paired control unit. The number of browse species measured ranged from 11 at Rocky Gorge to 18 at Tenmile and East Sheep Creek.

Percent change in browse utilization on treatment transects relative to percent change on control transects was variable for each browse species. For example, relative change in utilization of serviceberry varied from -5% at Rocky Gorge to +24% at Stonehill fertilization.

Browse utilization for all species combined decreased on the Lower Stonehill treatment transect by 7% relative to the control transect. Browse utilization increased on all other treatment transects relative to control transects.

## Pellet group counts

Pellet group counts were conducted on paired treatment/control areas from 1985 to 1990 (Table 11). Estimates from spring and summer counts in the same year were averaged. As with the browse utilization transects, McGuire Creek did not have a control area. Rocky Gorge, East Sheep Creek, West Sheep Creek, and Stonehill Fertilization plot did not have pre-treatment data for the treatment transects. Rocky Gorge and Stonehill Fertilization plot did not have pre-treatment data for the control transects.

Pellet group density increased on 6 of 7 treatment transects relative to control transects. Pellet group density decreased on Stonehill Fertilization transect relative to its adjacent control transect. Pellet group density increased by more than 1500 pellet groups/ha on Tenmile, Sheep Creek East, and Sheep Creek West relative to control transects.

Table 10. Percent change in browse utilization relative to percent change in paired control plots.

| SPECIES | AREA | | | | | | |
|---|---|---|---|---|---|---|---|
| | Tenmile | Sheep Creek East | Sheep Creek West | Rocky Gorge | Lower Stone-hill | North Stone-hill | Stone-hill Fert. |
| AMAL | 12 | 13 | 5 | -5 | -3 | -1 | 24 |
| CESA | | | -1 | | -23 | -1 | -2 |
| CEVE | 20 | | | -10 | | 20 | |
| HODI | 39 | 4 | 31 | | | | |
| PHLE | | | -1 | | | | |
| PHMA | | | -13 | | | | 8 |
| POTR | | | | 7 | | | |
| PRVI | | 5 | 10 | | | | |
| PUTR | | | | | 1 | 7 | 8 |
| ROSA | -10 | -13 | 32 | 2 | -6 | | |
| RUID | | | 9 | | | | |
| SALIX | | | 13 | | -6 | | 49 |
| SHCA | | 26 | 10 | 22 | -13 | | |
| SPBE | 15 | 5 | 4 | 1 | 2 | 0 | 6 |
| SYAL | 26 | 9 | 6 | 2 | | | |
| $\bar{x}$ | 17 | 7 | 9 | 3 | -7 | 17 | 15 |

Table 11. Change in pellet group density (#/ha) on habitat enhancement areas following vegetation manipulation.

| Transect Area | Net Change in Density |
|---|---|
| Tenmile | 1613 |
| Sheep Creek East | 2755 |
| Sheep Creek West | 1878 |
| Rocky Gorge | 518 |
| Lower Stonehill | 326 |
| North Stonehill | 252 |
| Stonehill Fertilization | -85 |

# Wildlife Use of Treatment Areas - Discussion

## Bighorn sheep

Distribution of ewes changed very little between pre- and post-treatment years. Ewes did not use the Stonehill area at all post-treatment and McGuire Creek very little post-treatment. This suggests ewes preferred treatments on the southern end of the study area. However, ewes were not radio-collared on Stonehill during the post-treatment period which may explain the lack of use on this area.

Overall, benches on Sheep mountain are more heavily timbered and provide low security, habitats usually avoided by ewes especially those with lambs. During the pre-treatment period, collared rams used Sheep mountain and ewes did not, indicating an avoidance of this area by ewes. Gionfriddo and Krausman (1986) reported this sexual segregation pattern for desert bighorn sheep as did Tilton and Willard (1982) for Rocky Mountain bighorn sheep.

Home range sizes for bighorn sheep have been demonstrated to be dependent on changing habitat conditions (Krausman et al. 1989, Leslie and Douglas 1979). No change in home range size was observed for radio-collared ewes pre- to post-treatment, suggesting no response to habitat manipulation. However, no change of home range sizes in response to treatments may be due to other factors influencing home range size such as age, status in dominance hierarchies, and possibly interspecific competition with mule deer (Krausman et al 1989).

Four studies documented increased use by bighorn sheep of burned areas following prescribed fires (Riggs and Peek 1980, Bentz and Woodard 1988, Easterly and Jenkins 1991, Cook et al. 1989). Observed distance to treatment areas and observed use showed increasing use of treatment areas. In 1985 and 86, before any treatments were completed, there was not a highly significant level of use of treatment areas. Following treatment, there was a statistically significant amount of use almost every year.

Distance and use measurements for spring show a high use of treatment areas for nearly every year including 1985 and 86.

A marked decrease in average distance occurred from the pre- to post-treatment period for winter (significant) and spring indicating a positive response to treatment. A slight increase in expected use was detected in winter while expected use remained stable in spring. Sheep appeared to respond positively to treatment at least during winter.

## Mule deer

### Distribution

Comparison of pre- and post-treatment distribution plots indicated higher use of uplands rather than right along the lake shore. The treatments extended into these uplands, suggesting a positive response by deer. Klinger et al. (1989) observed spatial shifts by blacktail deer in response to prescribed burning on chaparral. Increased use on the north side of Tenmile Creek also indicates a response to the Whirlybird unit located there. It seems that the treatments allowed mule deer the opportunity to expand their winter range use upward from the lake shore where use was concentrated pre-treatment.

**Movements**

The higher proportion of DSR deer post-treatment might be attributed to fawns recruited into the population following their mothers' movement pattern. In this case, does following a DSR pattern were the most successful. However, this may also be indicative of increased numbers on the core area. The summer range available to deer following an ASR movement pattern may have been saturated forcing these deer into following a DSR pattern. Because of a higher density of deer on the core area, the amount of habitat available to potential ISR deer decreased forcing these deer to follow a DSR pattern as well.

No accessory areas were detected for deer collared on the core area between 1990 and 1994. During the period 1987-1989, 69% of accessory area users wintered on the core area. It is possible that the increased quality of the winter range post-treatment made accessory areas unnecessary. Deer were not forced to meet their requirements in other areas during early spring or late fall.

ISR deer made up the highest proportion of accessory area users during 1987-1989. Even though ISR deer made up a smaller proportion of collared deer during 1990-1994, it would be reasonable to expect some of these deer to utilize accessory areas. None did, suggesting the winter range quality was high enough to allow year-around occupation without the need for accessory areas.

Contrary to the decreased proportion of deer following an ISR pattern discussed above, 4 migratory deer stopped their migratory behavior during 1990-1993. This suggests that habitat improvements were sufficiently beneficial to preclude the need to migrate to alternate summer ranges. This contrasts with the change in proportions of different movement patterns. However, changes in individual behavior are probably more indicative of populations because individuals are not subject to the bias resulting from a new marked sample.

A migratory deer from PHU 2 also adopted an ISR movement pattern. The majority of her resulting year-round home range was on the south side of McGuire Creek and the treatment areas were directly across the creek on the north side. It appears that the close proximity of improved habitat allowed some deer to hold in one area rather than migrate.

**Home range**

Home range size is inversely related to habitat diversity (Loft et al. 1984). Habitat treatments created habitat diversity in 2 ways: a more diverse landscape from interspersion of openings in previously closed canopies and increased structure within treatments resulting from increased biomass of browse and herbaceous species. An increase in the winter home range size on the core area suggests that deer were not responding to treatment by shrinking their home ranges. However, composite home ranges are sensitive to new animals being added over time and the number of relocations used to calculate them.

Larger lifetime winter home ranges post-treatment indicated that treatments did not increase habitat diversity, preventing deer from meeting their requirements on smaller home ranges. Lifetime home ranges of ISR and ASR deer were smaller than DSR deer during both time periods. This may be due to the juxtaposition of habitat components within resident home ranges and an ability by resident deer to use these components more efficiently than DSR deer.

**Treatment use**

Average minimum distance from deer relocations to treatments from observed points was significantly less than random points for all years during both winter and spring. During winter, the observed distance was least prior to and during treatment compared to post-treatment suggesting heavy utilization. Six to 7 years later observed distances increased indicating a decreased preference by deer. This conclusion suggests a short-term response to treatment.

Observed distances in spring did not follow the same pattern. Distance from treatments peaked in 1991 and 1992 and then decreased the last 3 years. This may reflect a difference in habitat requirements or preferences between winter and spring or simply annual differences in phenology, quality, and availability of forage. During spring deer are keying in on green-up areas. Perhaps the treatments did not provide this habitat component during the spring until 5 or 6 years post-treatment.

Observed use during winter and spring was more than expected during all years. Level of use varied among years, but showed an increase in later years. This suggests a preference for treated areas that exceeds pre-treatment preference for these areas. Deer utilization increased after fertilization on deer range in New Mexico (Anderson et al. 1974). However, Roosevelt elk in the Oregon Coast Range did not increase utilization of habitat following treatment (Stussy 1993).

A significant level of use during the first several years when all treatments were not complete suggests that deer already selected these areas prior to treatment. One can argue, then, that the treatments really didn't increase the amount of the winter range. However, the fact that deer were selecting this area because of its physiographic features indicates that this is optimal winter range. This optimal range would be the best place for effective enhancements.

## Browse utilization

Utilization of a variety of browse species increased on all but one treatment transect indicating a positive response by ungulates to treatment. An estimate of utilization by ungulates other than deer and sheep was not made. This could account for a proportion of the increased utilization observed.

Increased utilization indicates that the habitat treatments created smaller browse plants which made them more palatable, succulent, and possibly more available. Keay and

Peek (1980) reported that unpalatable species, like ninebark, were selected more frequently on burned sites than on unburned sites. Either way, these results are consistent with the treatment use results that indicated significantly greater use by deer and sheep.

## Pellet group counts

Increased pellet group densities suggest that deer and/or sheep used the treatment areas more after treatments were done. The results are consistent with the treatment use data and browse utilization data presented above. However, these pellet count data should be interpreted with caution. Collins and Urness (1981) indicated that the pellet group count technique does not always accurately estimate deer preferences for specific habitat types. They reported that the use of one habitat type inferred from the pellet count technique was exactly opposite of the actual amount of time spent in that habitat type. A review of other pitfalls of this method can be found in Neff (1968).

# Population Response of Mule Deer and Bighorn Sheep - Results and Discussion

## Population estimates

### Bighorn sheep

Historic information on the sheep population in this area dates back to the early 1930's (Ensign 1937, Brink 1941). From 1930 to 1940, the estimates of numbers of sheep fluctuated between 100 and 150 animals (Figure 16). The population continued to grow until the early 1960's when it stabilized at 150-200 animals (U.S. Dep. Inter. 1965). A sharp decline in number of sheep took place from the mid 60's into the 70's to an estimated 20 to 25 animals in 1979 (Brown 1979). This decline took place prior to and during dam construction and filling of the reservoir. The population increased after 1979 until 1986 when the first estimate of this study was calculated.

Brown (1979) gave several factors potentially contributing to the decline of the population from 1965 until 1979. First, habitat loss due to Libby Dam. Second, successional stage of the remaining winter and spring range the sheep were forced to occupy. Last, a lungworm epizootic that also caused sharp declines in Canadian sheep herds in the mid 60's. In addition, increased competition with other ungulates, mainly mule deer, on a much smaller range resulted in lower productivity and lamb survival.

Standard mark-resight estimates (Rice and Harder 1977) were calculated for sheep during winter 1986 through 1995 excluding 1992. Spring estimates were calculated for the

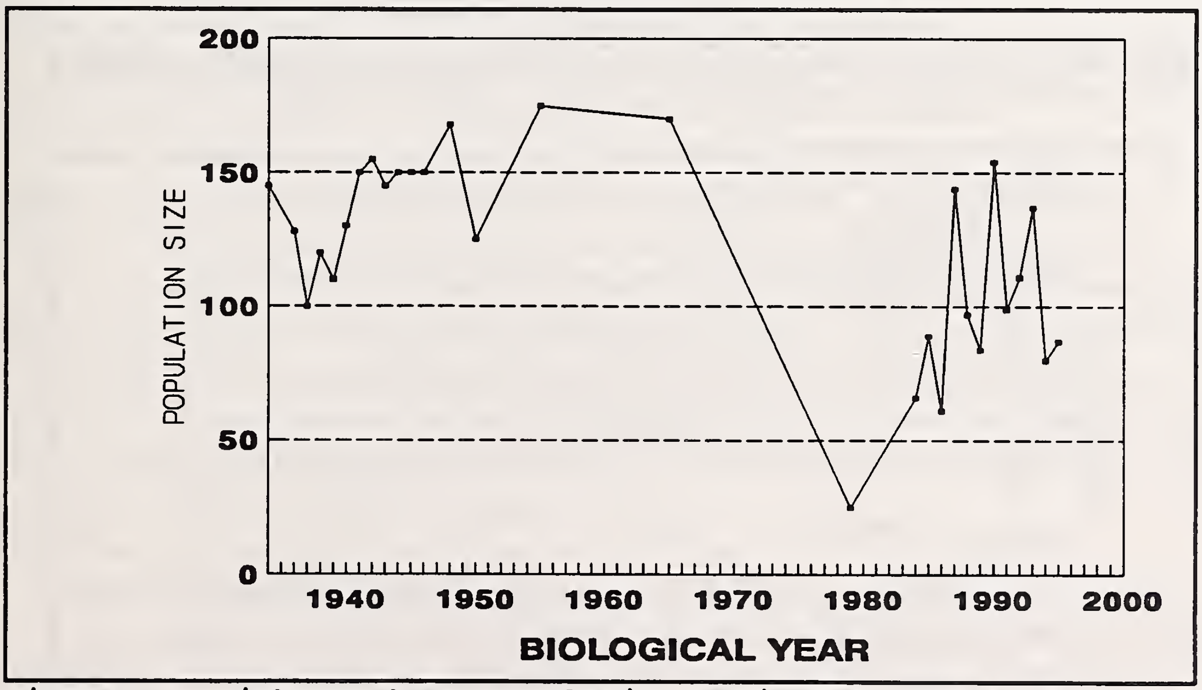


Figure 16. Bighorn sheep population estimates from 1934 to the present.

following years: 1985, 91, 92, 93, and 95. Years without estimates were due to no surveys being conducted or insufficient data collected during the surveys.

Population estimates increased during winter 1986 to 1993 then decreased in subsequent years to 89±77 sheep in 1995 (Figure 17). Population estimates during spring were variable over the course of the study (Figure 18). However, the data clearly do not support the assumption of an increasing population.

The precision of the standard mark-resight estimates (Rice and Harder 1977) was compromised by failure to follow the intended design of the method. Only one survey was conducted per season during all years rather than the 3-4 surveys required for acceptable confidence intervals. In addition, early population estimates were calculated using samples of marked sheep that were too small to provide a 95% confidence interval of ±0.1N. All

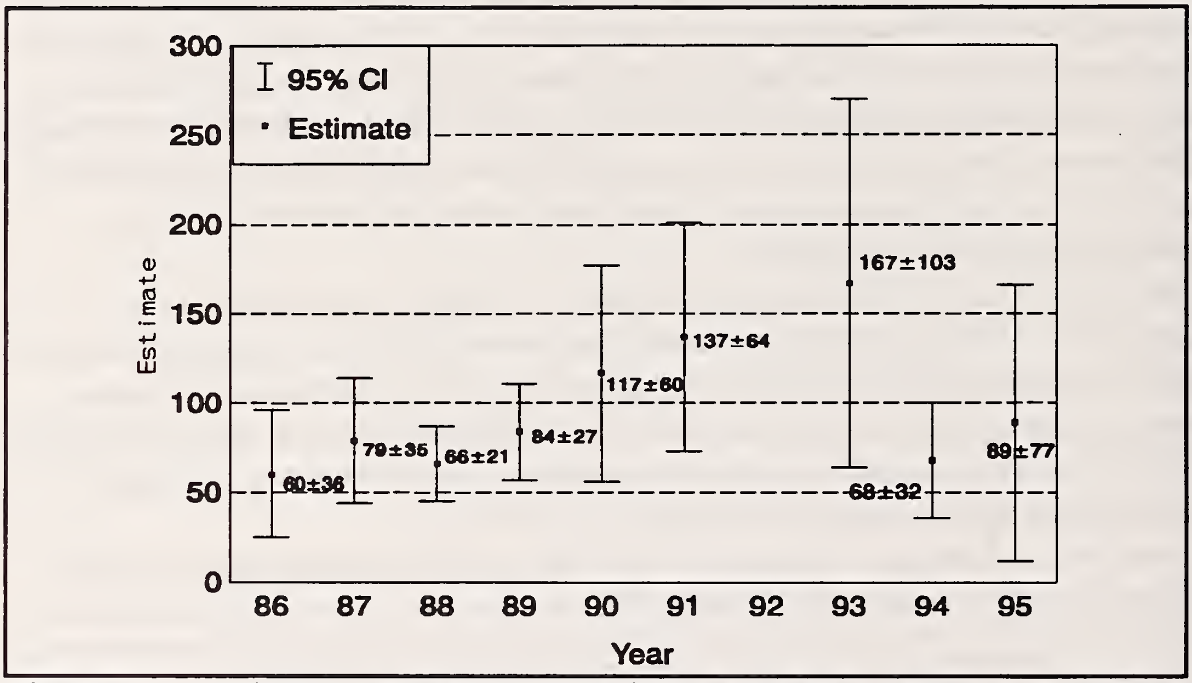


Figure 17. Bighorn sheep population estimates using a standard mark-resight technique during winter, 1986 to 1995.

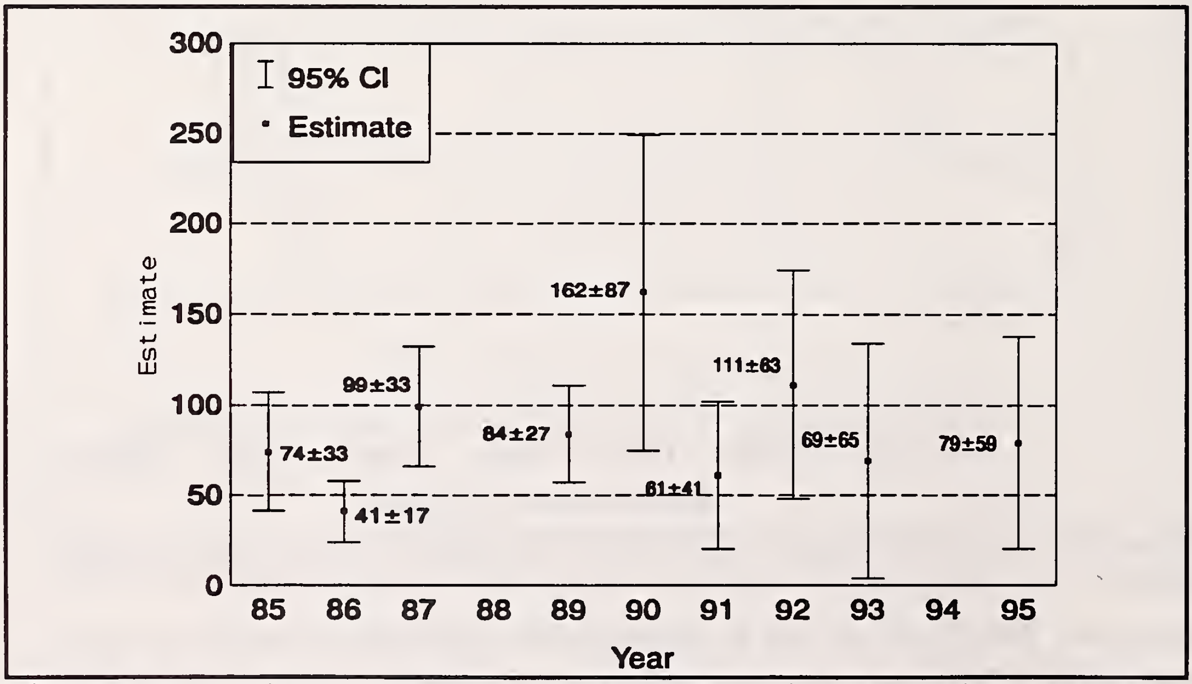


Figure 18. Bighorn sheep population estimates using standard mark-resight techniques for spring, 1985 to 1995.

winter population estimates also suffered from this problem because these estimates depended solely on radio-collared animals which made up a very low proportion of the total population. Winter surveys were conducted in December or early January before trapping and marking occurred. Neckbanded and ear-streamered animals could not be included in the following year's winter survey since this would violate the assumption that all marks were accounted for.

Accuracy of mark-resight population estimates was biased by violation of important assumptions. Small ratios of marked animals to total population and animals observed to total population resulted in biased estimates. Number of marked animals within the survey was not always determined prior to the survey and had to be reconstructed from miscellaneous observation data collected 1-2 months pre-survey. Consequently, estimated numbers of marked animals exceeded the true number of marked animals on the survey area resulting in an inflated population estimate. During spring, neckbanded and ear-streamered animals marked 1-2 months prior to the survey were added to the number of marked animals present. An unknown proportion of these sheep died or lost their marks resulting in a biased estimate, again inflating population estimates.

Behavioral differences of sheep between winter and spring resulted in low reliability of spring estimates. Estimates were conducted in April as close as possible to the period of maximum "green-up" when animals were more visible on the lower portion of the winter range. These conditions occurred in a narrow window at different times each year. Predicting this "window" determined by phenological development of forage was difficult. Therefore, estimates were highly variable from year-to-year. In addition, group size data indicate that average group size was smallest this time of year, making detection of animals difficult in comparison to winter surveys when group sizes were larger.

Between the two seasons, winter observations provided more reliable estimates than spring estimates. In addition, it was the more complete of the two data sets.

Overall, the most reliable information from these data are population trends. The data shows an increase up until 1990 and a decrease through to 1995. Numbers fluctuated between 70 and 155 animals during this time span. This range is typical for this area (J. Brown, pers. comm., 1995). Wide confidence intervals and assumption violations prevent a conclusive statement on the cause-effect relationship between habitat enhancements and sheep numbers. However, sheep population trends since 1984 when enhancements were initiated provide no support for the assumption that treatment activities will result in more bighorn sheep. A similar conclusion was reached for a Wyoming sheep herd after prescribed and wild fires (Cook et al. 1989).

**Mule Deer**

Standard mark-recapture estimates (Rice & Harder 1977) were calculated for mule deer during winter and spring from 1989 to 1995. Insufficient data existed for winter of 1992 and 1994 and spring of 1989 and 1990 resulting in gaps in the estimates. In addition, different areas were censused over the course of the study. The entire area from Fivemile Creek to Stonehill was sampled from 1989-91 and the core area from Tenmile Creek to Rocky Gorge was sampled beginning in 1991 until the present. Reliable spring estimates weren't available until 1991, so all data during spring were derived from the core area.

Winter estimates for the entire area were relatively stable over the 3 years sampled ranging between 650±350 and 820±275 (Figure 19). The winter estimates were variable over the 5 year sampling period for the core area and lacked precision necessary to detect population trend. Spring estimates for the core area from 1991 to 1995 showed a similar trend to the winter estimates for the same time period, although there is a stronger indication of a decline in population size (Figure 20).

The sources of error discussed in the sheep section apply to the mule deer estimates as well. To review, these included violation of assumptions of both methods and sources of error associated with environmental conditions, especially in spring.

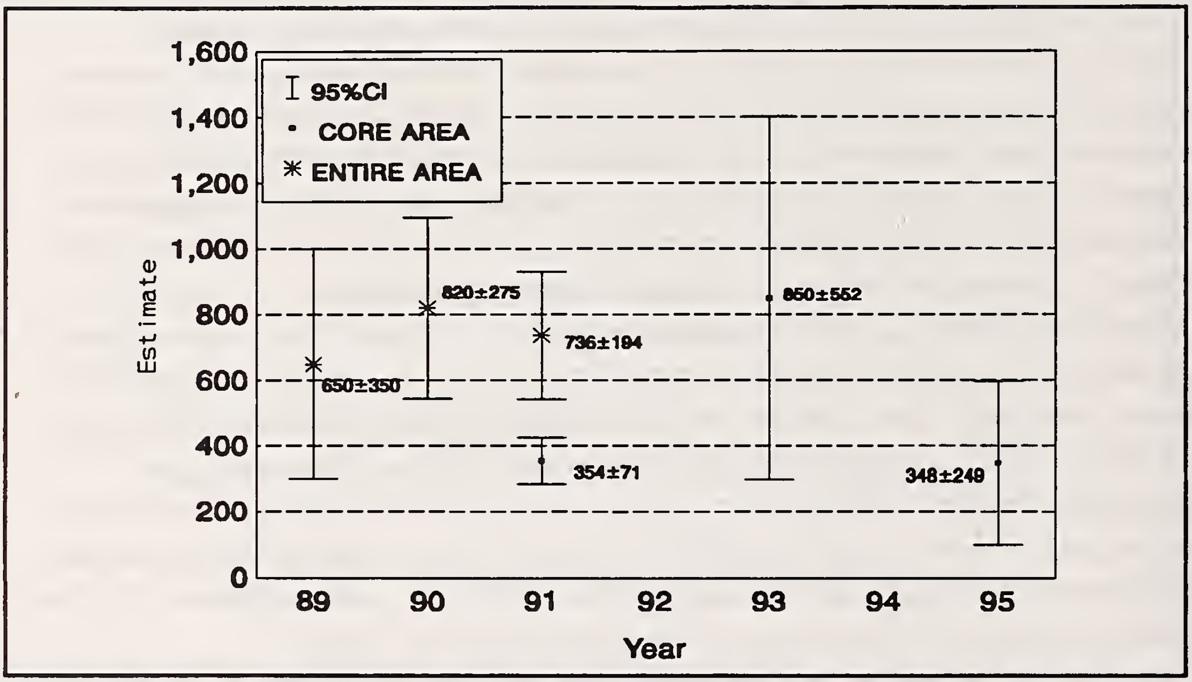


Figure 19. Standard mark-recapture estimates for mule deer during winter 1988-95.

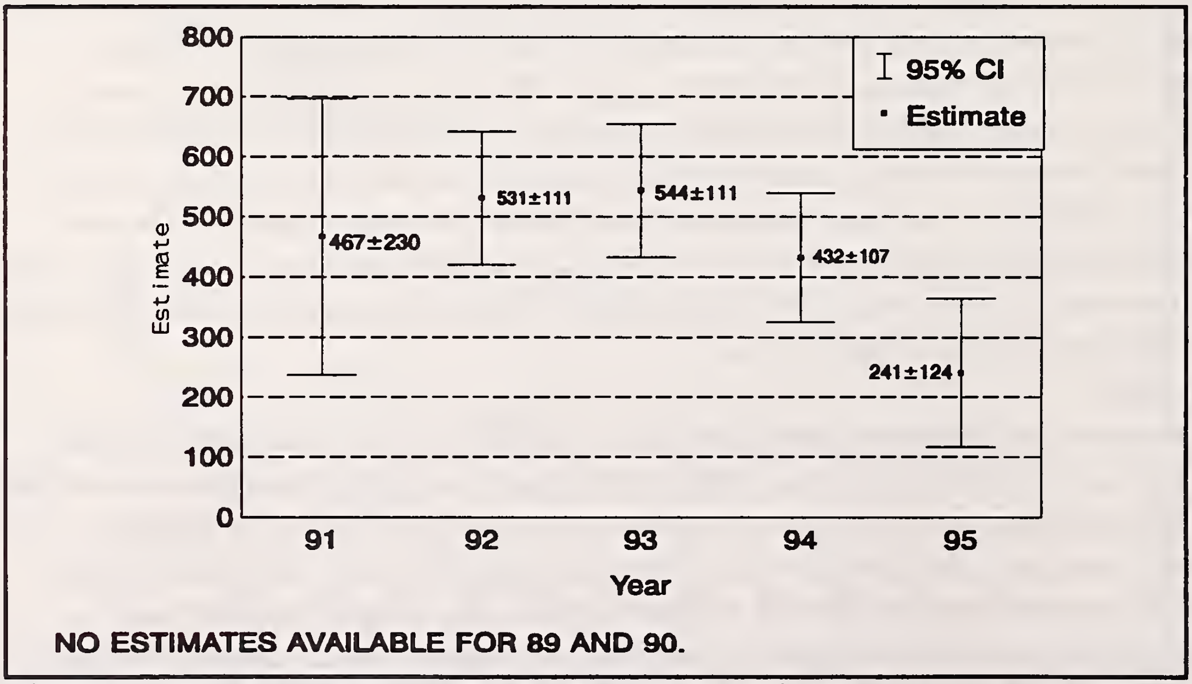


Figure 20. Standard mark-recapture estimates for mule deer during spring 1991-95.

Given the data available, it appears that the trend for the mule deer population during this study was downward. Certainly not the desired response to habitat manipulation. No population increase of black-tailed deer was observed following prescribed burning of chaparral (Klinger et al. 1989).

## Productivity

### Bighorn Sheep

Lamb:ewe ratios were calculated for 2 different time periods: early winter and late winter. The 2 periods have ratios spanning both pre- and post-treatment years.

Ratios during the early winter period were variable over the course of the study. Lows occurred in 1985, 1989, and 1992 and tended to increase during years following those lows (Figure 21).

Lamb:ewe ratios were also variable for the late winter period. In general, they fluctuated from 1985 to 1987 and made jumps in 1989 and 1990 (Figure 22). A correlation of ratios and year for the late winter period showed an insignificant decline over time ($r=-0.35$, $p=0.35$).

The early winter ratio for the pre-treatment period was 40:100 (Table 12). The post-treatment ratio declined significantly to 24:100 ($Z=5.04$, $p<0.0001$). The late winter count

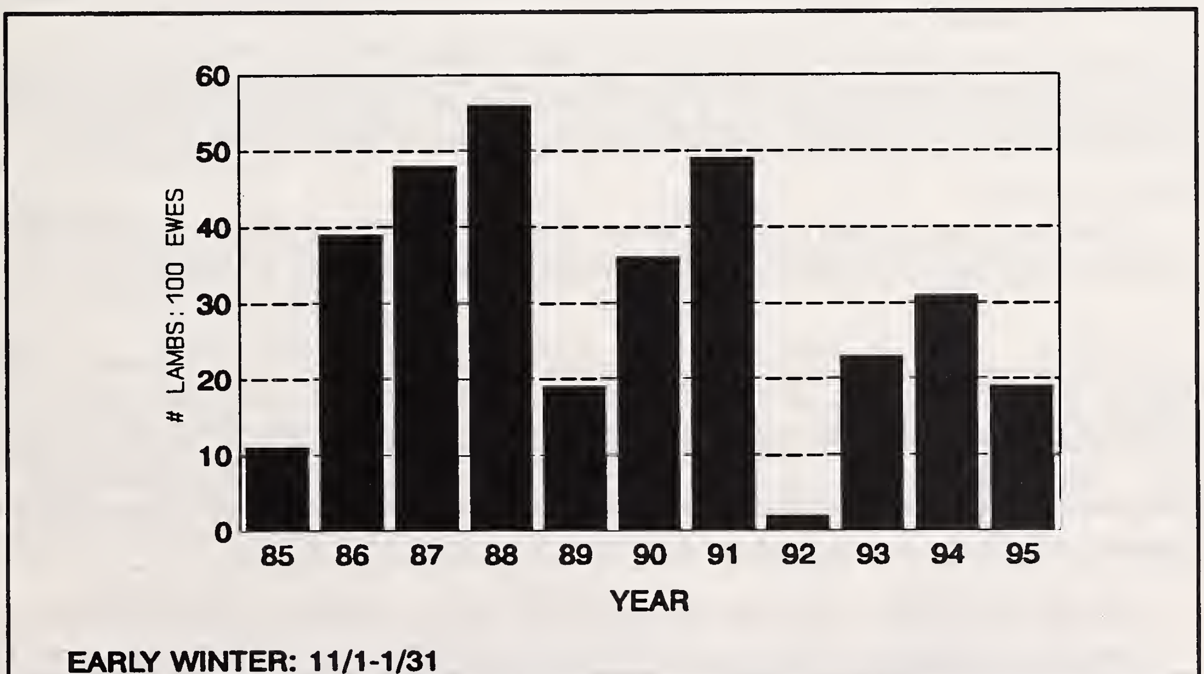


Figure 21. Bighorn sheep lamb:100ewes ratios for early winter, 1985-95.

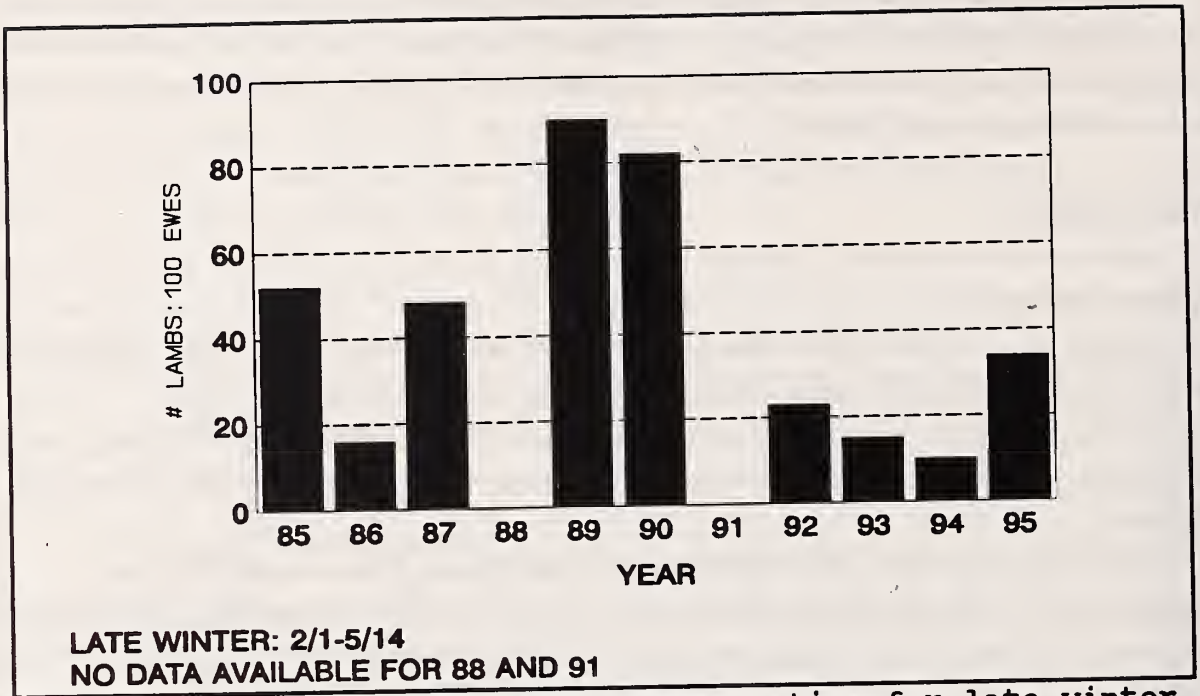


Figure 22. Bighorn sheep lamb:100ewes ratios for late winter, 1985-1995.

also declined significantly from 50:100 pre-treatment to 29:100 post-treatment (Z=5.11, p<0.0001). Wehausen et al. (1987) reported that a lamb:ewe ratio of 20:100 was indicative of a stable to declining population.

Yearling recruitment rates fluctuated over the course of the study (Figure 23), but generally decreased through time (r=-0.62, p=0.14). The average ratio for the pre-treatment years of 22:100, decreased significantly to 8:100 in the post-treatment years (Table 13) (Z=4.54, p<0.0001).

Lamb:ewe ratios for both early winter and late winter declined after treatments were completed suggesting a negative response to the treatments. In 1985, 89, 90, 92, and 95, the

Table 12. Pre- and post-treatment lamb:ewe ratios for early and late winter, 1985-95.

| TIME PERIOD | N | LAMBS:100 EWES |
|---|---|---|
| Early Winter | | |
| Pre-treatment | 334/836 | 40:100 |
| Post-treatment | 71/291 | 24:100 |
| Late Winter | | |
| Pre-treatment | 263/530 | 50:100 |
| Post-treatment | 56/193 | 29:100 |

late winter ratios exceeded the early winter ratios. This phenomenon is both biologically improbable and unexplainable. Nonetheless, no possible explanation should have operated pre-treatment (1985) and not post-treatment (1990, 92, & 95). Thus, while actual ratios may not be accurate the trend still suggests a negative response to habitat treatments. Lamb:ewe ratios similar to this study following fire on Wyoming sheep winter range were indicative of

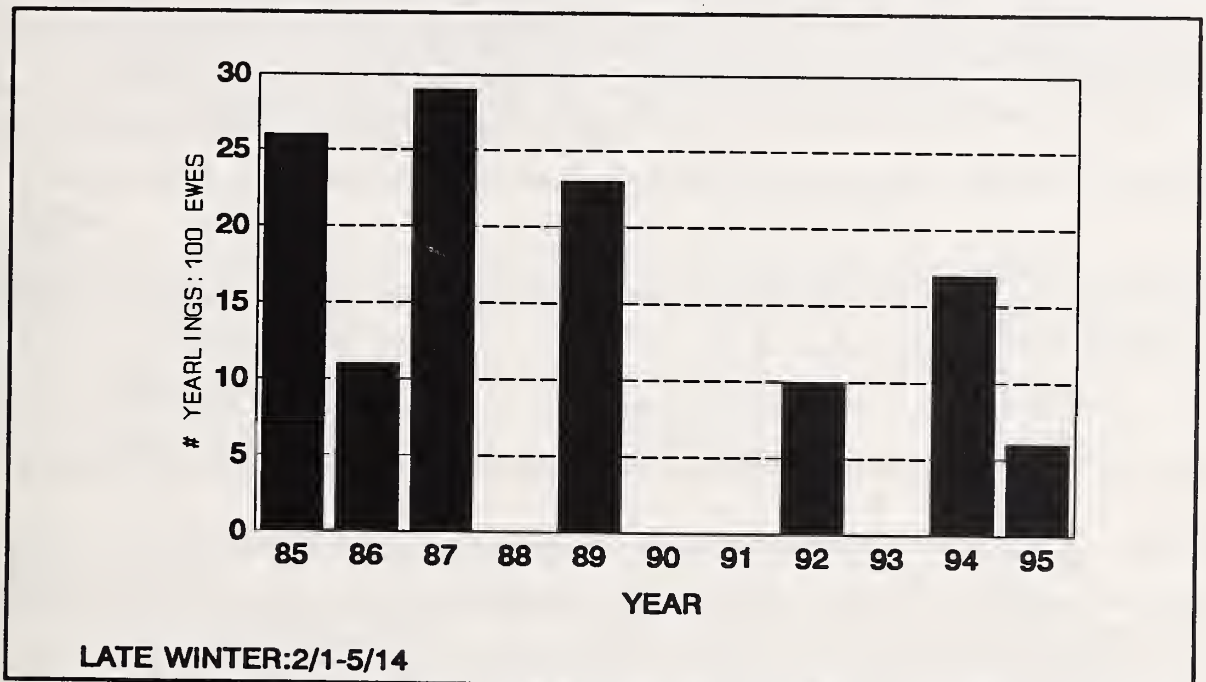


Figure 23. Bighorn sheep recruitment(yrlngs:100 ewes) for late winter, 1985 to 1995.

a stable to declining population (Cook et al. 1989). Yearling recruitment rates also decreased after treatments were completed which also supports the conclusion of a negative response to enhancement efforts.

**Mule deer**

Fawn:doe and fawn:adult ratios for mule deer were calculated for 2 different seasons and for individual helicopter surveys.

Table 13. Pre- and Post-treatment yearling:ewe ratios, 1985-95.

| TIME PERIOD | N | YEARLINGS:100 EWES |
|---|---|---|
| Pre-treatment | 102/454 | 22:100 |
| Post-treatment | 16/190 | 8:100 |

Numbers of fawns:100 does showed a moderate, steady decline during winter from the first estimate in 1988 until 1995 (Figure 24). The years 1989, 1992, and 1995 had particularly low ratios of about 30:100 or less.

A correlation of fawn:doe ratios and year for the winter period show a decline, though not statistically significant (r=-0.68, p=0.07).

Numbers of fawns:100 adults were quite variable during winter and shows no clear trend. Estimates appeared to hover around 40:100 from 1988 until 1991 and again in 1993 (Figure 25). Ratios during 1992 and 1995 were very low. Ratios for spring increased from

1985 until 1991 and then declined sharply in 1992 and stayed low the remainder of the study. Data were missing for 1987 to 1988 and 1993.

Comparisons of pre- and post-treatment ratios of number of fawns:100 does are contained in Table 14. For winter, the ratio declined significantly from 55:100 to 41:100 (Z=2.77, p=0.003).

Ratios of fawns:100 adults also show a decline between pre- and post-treatment study periods (Table 15). For winter, the ratios were not significantly different between the 2 periods (Z=1.59, p=0.06). A decline in spring from 44:100 pre-treatment to 28:100 post-

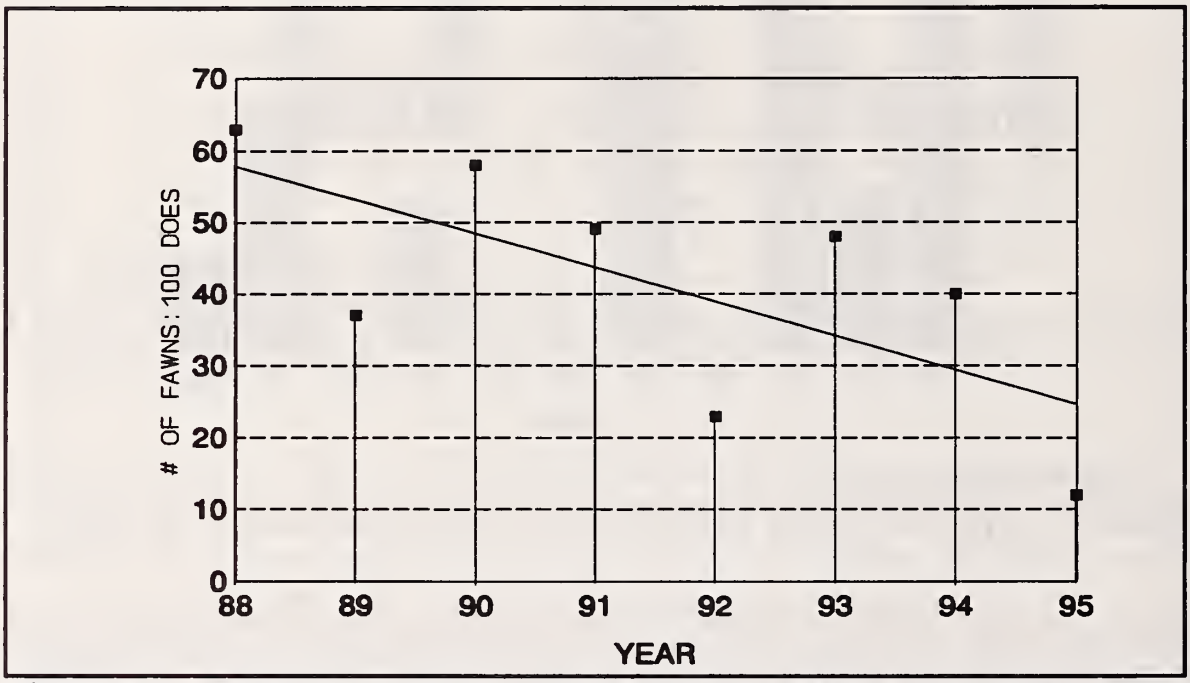


Figure 24. Fawns:100 does ratios for mule deer for winter, 1988 to 1995.

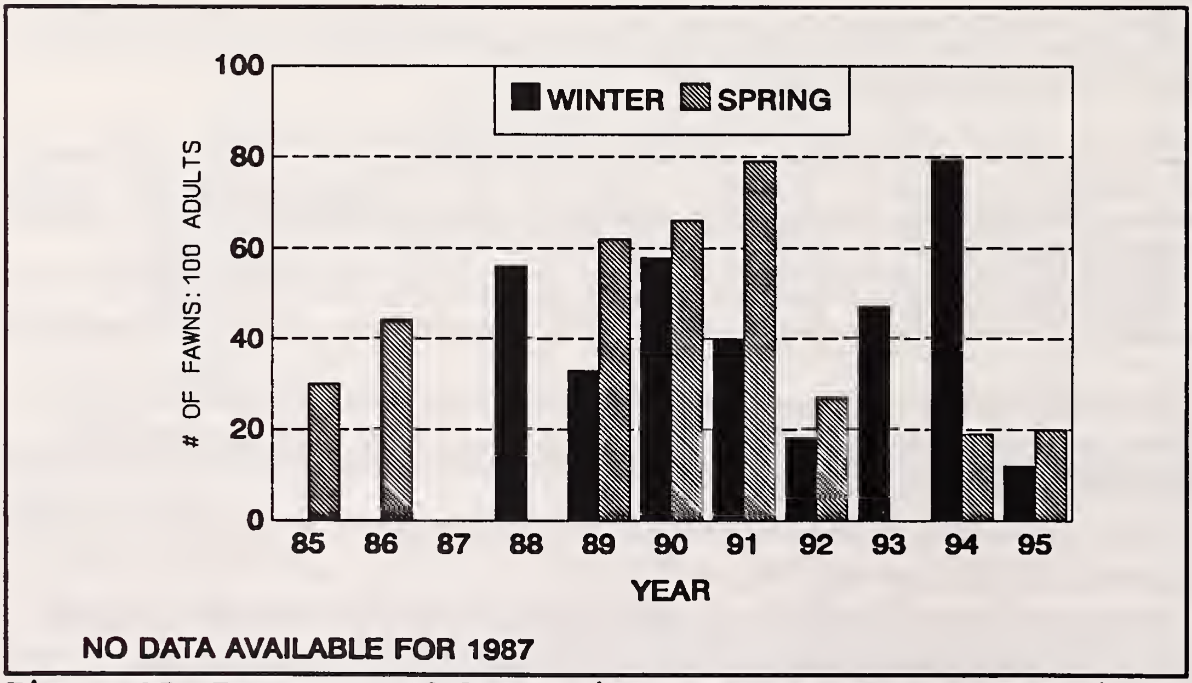


Figure 25. Fawns:100 adults ratios for mule deer for the winter and spring periods, 1985 to 1995.

treatment was significant (Z=4.68, p<0.0001).

Fawn:doe ratios for winter clearly declined during the post-treatment period. This, along with the linear decline described previously, suggests the treatments did not result in more deer being added to the population. Elk calf:cow ratios did not change following various habitat treatments in the Oregon Coast Range (Stussy 1993).

Fawn:adult ratios also declined following treatment in both winter and spring. However, spring ratios were larger than winter ratios in years when both winter and spring data were collected. As with lamb:ewe ratios, several reasons exist for this incongruity and were discussed in the previous section on sheep.

In summary, both fawn:doe ratios and fawn:adult ratios suggest a negative response to treatment.

Table 14. Pre- and post-treatment fawn:100doe ratios for winter.

| TIME PERIOD | N | FAWNS:100DOES |
|---|---|---|
| PRE-TREATMENT(WINTER) | 64/116 | 55:100 |
| POST-TREAMENT(WINTER) | 254/627 | 41:100 |

Table 15. Pre- and post-treatment fawn:100adults ratios for winter and spring.

| TIME PERIOD | N | FAWNS:100ADULTS |
|---|---|---|
| PRE-TREATMENT(WINTER) | 64/149 | 43:100 |
| POST-TREAMENT(WINTER) | 254/710 | 36:100 |
| PRE-TREATMENT(SPRING) | 134/303 | 44:100 |
| POST-TREATMENT(SPRING) | 160/562 | 28:100 |

## Survival

### Bighorn sheep

Survival of female sheep 1-year-old and older for summer and fall was 0.88 for the pre-treatment period and 0.53 for the post-treatment period as calculated by MICROMORT. Survival for winter and spring decreased slightly from 0.78 during the pre-treatment period to 0.73 during the post-treatment period. Survival of all males for summer and fall declined sharply from 1.00 during the pre-treatment period to 0.12 during the post-treatment period; the winter and spring rate increased from 0.79 during pre-treatment to 1.00 post-treatment.

Testing the differences between survival rates was accomplished using the procedure from Sauer and Williams (1989). There was no significant difference between the pre- and post-treatment rates for ≥1-year-old females during summer and fall ($X^2$=2.97, p>0.05) or between pre- and post-treatment rates during winter and spring ($X^2$=0.03, p>0.05). Survival rates for males were compared with a Z-test. Survival declined significantly (Z=4.90, p<0.001) from pre-treatment to post-treatment during summer and fall. No significant difference existed (Z=1.12, p=0.13) between the treatment periods for winter and spring.

For comparison, a modified Kaplan-Meier procedure was used to calculate survival estimates for ≤1-year-old females only. Male sample size was too small for calculations using this method. The survival rate during summer and fall declined from 0.92 pre-treatment to 0.59 post-treatment, however, the difference was not significant ($X^2$=2.37, p=0.12). A decline from 0.78 to 0.60 also occurred during winter and spring; again, this was not a significant difference ($X^2$=0.64, p=0.43).

Both procedures indicated decreasing survivorship among adult females during winter and spring. Assuming that winter and spring forage availability is a major factor in over-winter survival, one must conclude that the enhancement efforts did not increase survivorship.

**Mule deer**

Survival rates were calculated for 3 different age classes of female mule deer: ≥3-years-old, 4-8-years-old, and >8-years-old. A seperate rate was calculated for all mature females ≥2-years-old. Survival rates calculated with MICROMORT during summer and fall are summarized in Table 16.

Survival increased for young females, although not significantly. Survival decreased significantly for all other age classes.

Survival rates during winter and spring decreased for all age classes, but none significantly (Table 17). With the exception of the >8-years-old class, all rates were very close to one another.

The marked decline in survival rates during the summer and fall period appears to be due to a slight increase in hunting mortality and a large increase in natural mortality. Natural mortality was defined as death by predation, disease or old age. Declines measured during the winter and spring period appear to be caused by an increase in natural mortality.

As with bighorn sheep, a modified Kaplan-Meier procedure was used to calculate rates for comparison. Table 18 contains the Kaplan-Meier rates for summer and fall. Similar to

Table 16. Survival rates and p-values for female mule deer pre- and post-treatment during summer and fall.

| AGE CLASS | PRE | POST | PROBABILITY |
|---|---|---|---|
| ≤3 | 0.52 | 0.69 | p=0.52, NO |
| 4-8 | 1.00 | 0.52 | p<0.05, YES |
| >8 | 1.00 | 0.52 | p<0.05, YES |
| ≥2 | 0.90 | 0.56 | p<0.05, YES |

Table 17. Survival rates and p-values for female mule deer pre- and post-treatment during winter and spring.

| AGE CLASS | PRE | POST | PROBABILITY |
|---|---|---|---|
| ≤3 | 0.89 | 0.84 | p=0.78, NO |
| 4-8 | 0.78 | 0.69 | p=0.53, NO |
| >8 | 1.00 | 0.84 | p=0.14, NO |
| ≥2 | 0.85 | 0.74 | p=0.27, NO |

Table 18. Kaplan-Meier survival rates and p-values for female mule deer pre- and post-treatment during summer and fall.

| AGE CLASS | PRE | POST | PROBABILITY |
|---|---|---|---|
| ≤3 | 0.50 | 0.90 | p=0.04, YES |
| 4-8 | 0.50 | 0.51 | p<0.05, YES |
| >8 | 1.00 | 0.53 | p<0.05, YES |
| ≥2 | 0.79 | 0.49 | p=0.04, YES |

Table 19. Kaplan-Meier survival rates and p-values for female mule deer pre- and post-treatment during winter and spring.

| AGE CLASS | PRE | POST | PROBABILITY |
|---|---|---|---|
| ≤3 | 0.94 | 0.75 | p=0.22, NO |
| 4-8 | 0.94 | 0.72 | p=0.56, NO |
| >8 | 1.00 | 0.51 | p=0.16, NO |
| ≥2 | 0.92 | 0.74 | p=0.13, NO |

the MICROMORT estimates, survival increased for young females ≥3-years-old and decreased for the other age classes. All changes were significant.

Kaplan-Meier rates for winter and spring are summarized in Table 19. Consistent with the MICROMORT estimates, all Kaplan-Meier rates declined from the pre-treatment period to post-treatment period, but none significantly.

As with sheep, survivorship of adult females decreased after treatment during the winter-spring period. Once again, enhancement efforts did not improve forage quality and availability enough to decrease mortality and increase the population.

## Age structure - HD 101 mule deer harvest

Age structure data from mule deer harvested from hunting district 101 was collected and analyzed to use as another measure of population dynamics response to enhancement efforts. Hunting district 101 was 836 $mi^2$ and the treatments occupied 1% of that area.

**Females**

Age structure for the mule deer harvest in HD 101 from 1985 to 1994 shows fluctuating numbers of yearlings being harvested (Figure 26). Total harvest was grouped into pre- and post-treatment periods and analyzed using a 2x4 contingency table. The distribution of harvest among age classes was not different between the pre-treatment and post-treatment years ($X^2$=0.42, p=0.81).

**Males**

The proportion of yearlings fluctuated between 30 and 60% from 1985 to 1988 and then declined to less than 20% of the harvest in (Figure 27). It has been increasing since then.

As with females, differences in the age structure between pre- and post-treatment were analyzed using a 2x4 contingency table. Number of animals in each age category was

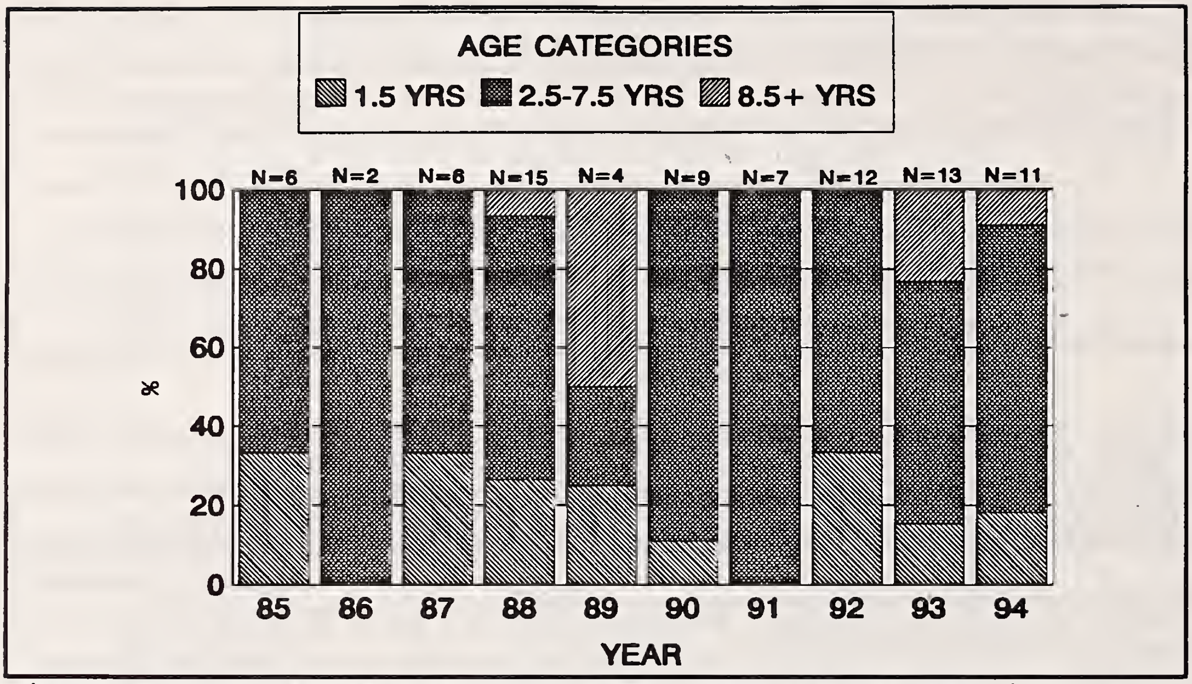

Figure 26. Harvest age structure for female mule deer in HD 101, 1985 to 1994.

significantly different between treatment periods ($X^2$=9.54, p=0.009). There were significantly fewer yearlings killed during the post-treatment period.

**Summary**

Comparison of pre- and post-treatment periods showed that female harvest age structure did not change suggesting no response to the treatments. Harvest age structure for males did change between pre- and post-treatment periods with fewer yearlings occurring in the harvest. This may indicate less recruitment and a negative response to treatment by bucks. On the other hand, this may also reflect a shift of preference to antlerless deer by hunters.

## Age structure - HD 101 mule deer trapping

**Females**

Age structure of the population was also assessed using ages of individual deer trapped for marking (Figure 28). No trapping was conducted in 1990 and 1991 preventing an illustration of a continuous trend. No clear pattern for any age category emerges from the years for which data exist. Analysis of a 2x4 contigency table suggests no significant difference in age distribution between pre- and post-treatment periods ($X^2$=3.722, p=0.29). However, it should be noted that the proportion of fawns and yearlings in the trap sample decreased and the proportion of older animals increased from the pre- to post-treatment period.

**Males**

As with females, data from 1990 and 1991 were collected for males (Figure 29). There appears to be a decline in proportion of fawns and an increase in the number of older males in the trap sample over time. A chi-square test on the pre- and post-treatment periods suggests no significant difference in the distribution of age categories ($X^2$=8.354, p=0.21), but there is an obvious decrease in the number of fawns in the sample and an increase in older bucks.

**Summary**

There was not a significant difference between pre- and post-treatment for the female trapping age structure, but the proportion of yearlings trapped declined and older females

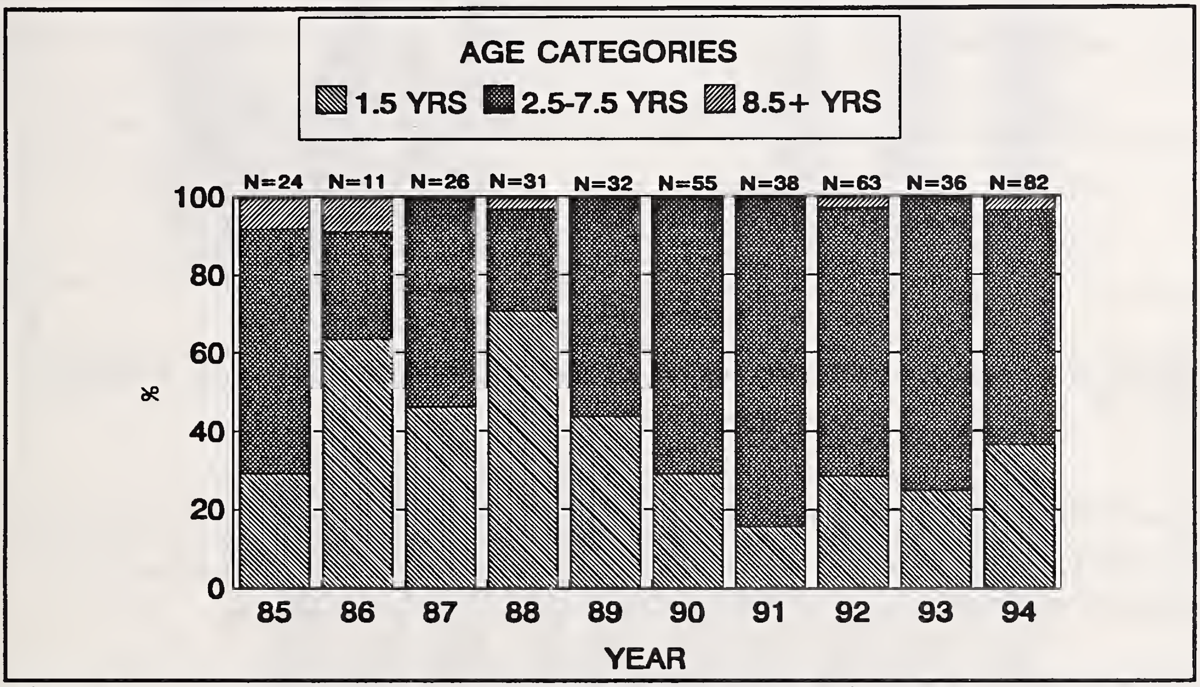


Figure 27. Harvest age structure for males in HD 101, 1985 to 1994.

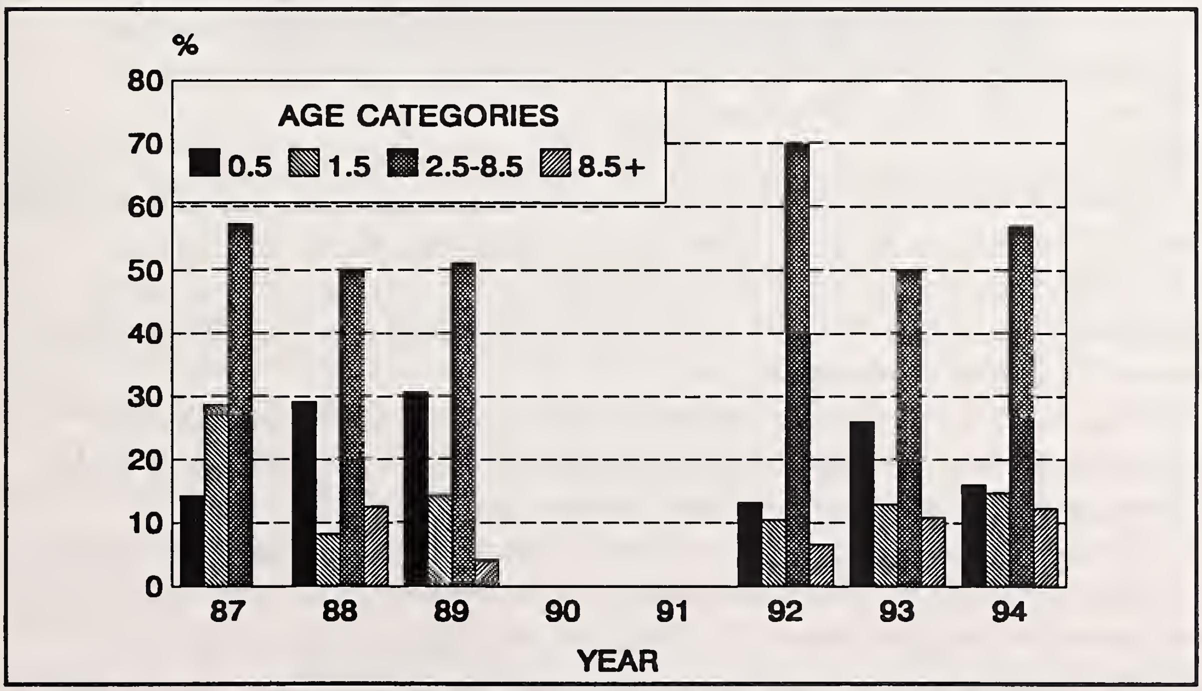


Figure 28. Age structure from trap sample of female mule deer, 1987 to 1994.

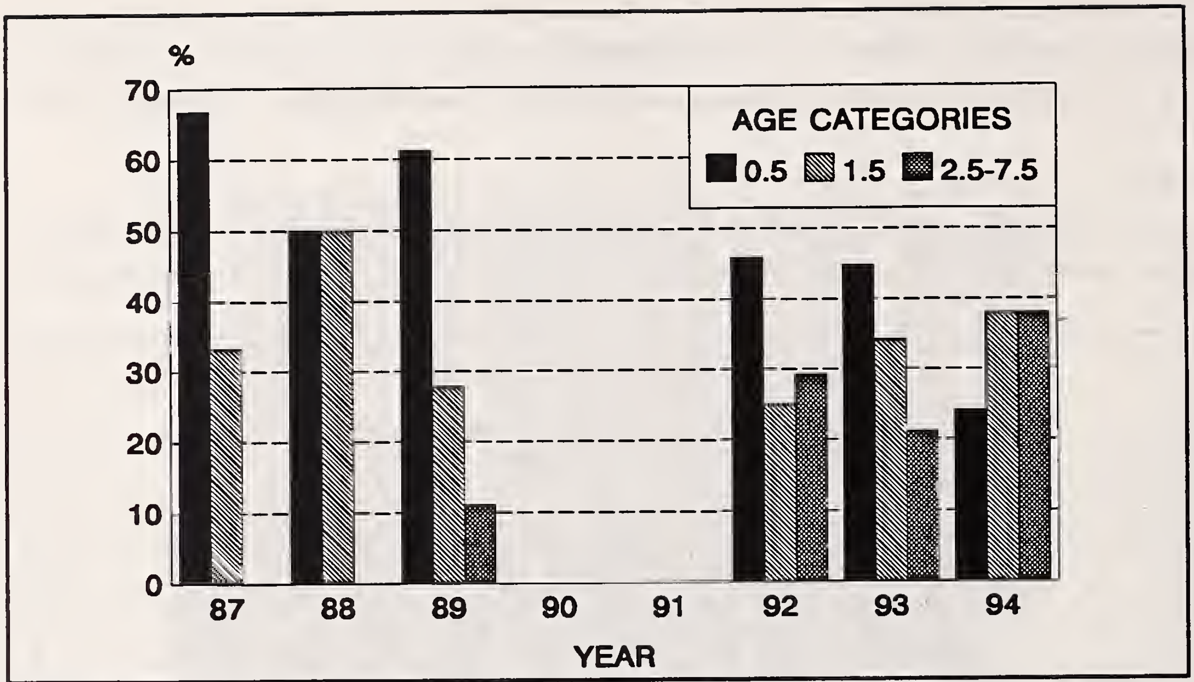


Figure 29. Age structure of male mule deer from trap sample, 1987 to 1994.

increased suggesting an older age population with low recruitment. The same held true for the male trapping age structure with an increased proportion of older bucks, supporting conclusions discussed in the sections on production ratios and survival rates.

## Age structure - R-1 mule deer harvest

Mule deer harvest data was gathered from Region 1 hunting districts other than HD 101 to determine if the trend of lower production and higher adult harvest was reflected in areas surrounding the study area. If the trends in HD101 harvest were different than surrounding hunting districts, this would provide additional evidence that changes in HD101 resulted from habitat enhancements.

**Females**

The hunting districts having harvest data on females included HD's 100, 103, 121, 123, 130 and 140. Preliminary analysis suggested that hunting districts 100 and 103 were similar enough to be grouped together and districts 121, 123, 130 and 140 were similar enough to be combined. Hunting district 101 was then compared to each of these groups to determine if it differed significantly.

Hunting districts 100-103 demonstrated a relatively stable harvest age structure during the study period with slight fluctuations between years (Figure 30). Age structures for hunting districts 121-140 also fluctuated between years.

A chi-square contingency table was used to analyze differences in age structure among the hunting district groups for all years combined. As was stated before, HD's 100-103 were different from HD's 121-140 ($X^2$=16.01, p=0.001). Hunting districts 100-103 had a significantly higher number of yearlings in the harvest than HD's 121-140. There was no significant difference between HD 101 and HD's 100-103 ($X^2$=1.455, p=0.69); in fact, the distribution of the harvest among age categories was essentially the same for these hunting districts. There was no significant difference between HD 101 and HD's 121-140 ($X^2$=1.39, p=0.49), but the same relationship existed between these hunting districts as between HD's 100-103 and HD's 121-140: a higher number of yearlings in HD 101.

A chi-square test was also performed on the pre- and post-treatment periods of the 3 hunting district groups. A comparison of pre-treatment age class distribution suggested a significant difference between HD groups ($X^2$=17.10, p=0.009). Further analysis showed no significant difference between HD's 100, 101, and 103 and a significant difference between the former HD's and HD's 121-140. Hunting districts 100, 101, and 103 had more yearlings in the harvest than all other hunting districts.

There was no significant difference in age class distribution among HD's for the post-treatment period ($X^2$=6.559, p=0.36).

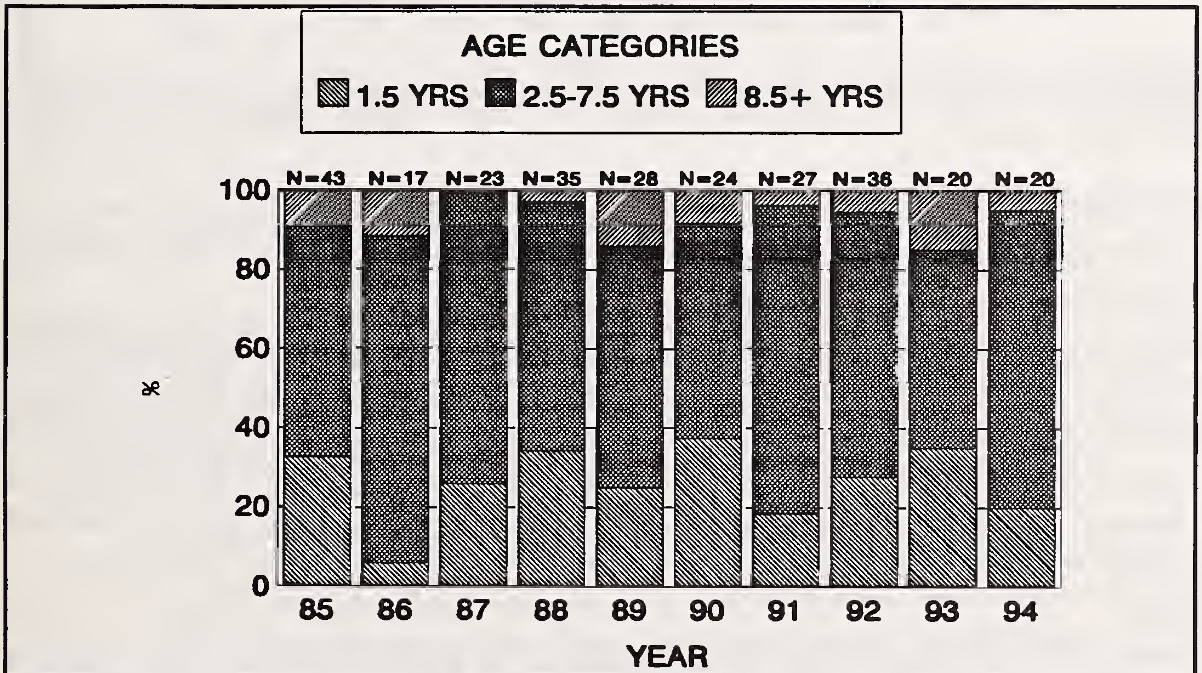


**Figure 30. Harvest age structure of females in HD 100,103, 1985 to 1994.**

## Males

Hunting districts 100 and 103 were the only districts with sufficient sample sizes to display age structure for each year. However, all hunting districts were employed in comparisons of age structures for pre- and post-treatment periods.

The harvest age structure for HD 100 is displayed in Figure 31. Two trends are clearly illustrated: a decline in proportion of yearlings over time and a corresponding increase in the number of older males. A chi-square test shows a significant difference in distribution of harvest among age classes between years ($X^2$=27.61, p=0.001).

Figure 32 illustrates the age structure for HD 103. The same trends are evident in this district as in HD 100, but are not as pronounced. In addition, a chi-square analysis also

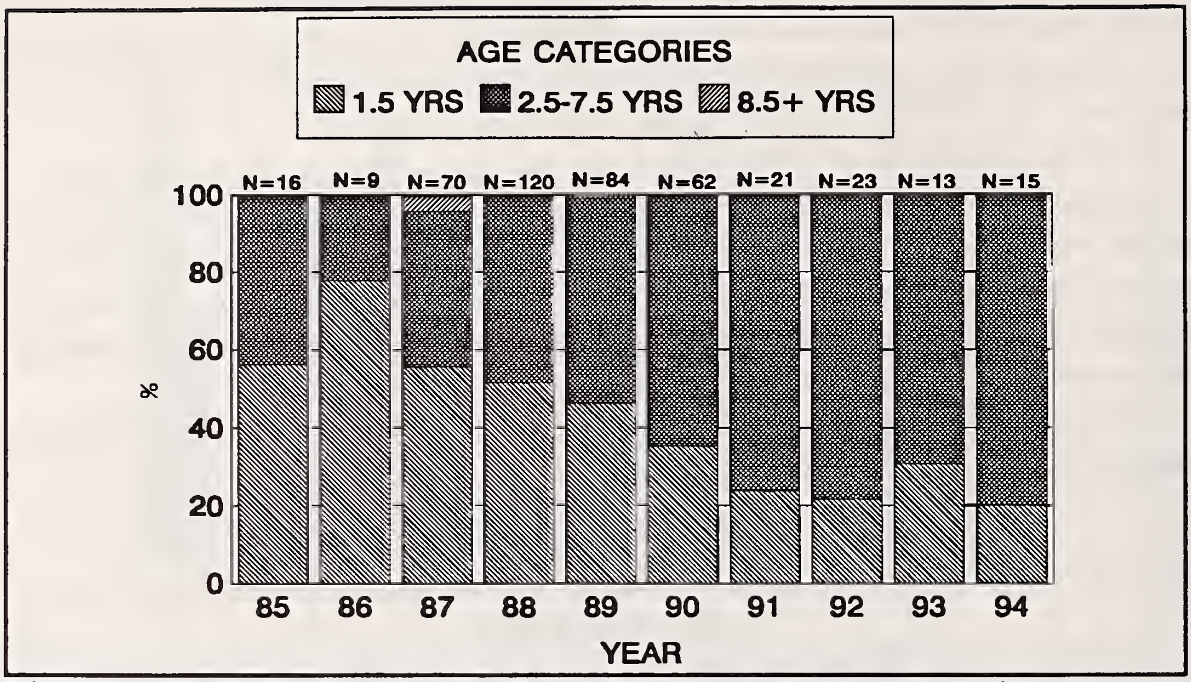


Figure 31. Harvest age structure of male mule deer in HD 100, 1985 to 1994.

shows a significant difference in the distribution of the harvest among age categories as in HD 100 ($X^2$=20.87, p=0.001).

Comparisons between HD 101 and other HD's were made on a one to one basis for both treatment periods. Hunting district 101 was not significantly different than 100 ($X^2$=2.35, p=0.31) and 103 ($X^2$=4.91, p=0.09) for the pre-treatment period. Comparisons of HD 101 with all other hunting districts showed no significant differences for the pre-treatment period.

Hunting district 101 was significantly different from HD 103 ($X^2$=8.93, p=0.01) for the post-treatment period. Hunting district 103 had more yearlings in the harvest for this period. There was no difference between 101 and the other districts.

**Summary**

A comparison of the female age structure from HD 101 and the other 2 hunting district groups showed no significant difference of harvest age structures. However, HD 101 was more similar to HD's 100-103. This is probably due to the closer proximity of these districts and the habitat and environmental conditions that they share.

The decline of yearlings and increase of older bucks in the male age structure of both HD 100 and 103 suggested a decreasing population in these districts. Male age structure in HD 101 showed a similar pattern. Hunting district 101 was following the pattern evident in other districts, therefore, it was not affected by the treatments.

In general, comparison of harvest age structures among R-1 hunting districts, including 101, showed that none had severe differences from the others. Analysis of trapping and harvest data just within HD 101 showed low recruitment and older adults, indicative of a declining population. If one assumes that the habitat treatments influenced the age structure of the hunting district, then one must conclude that the treatments did not result

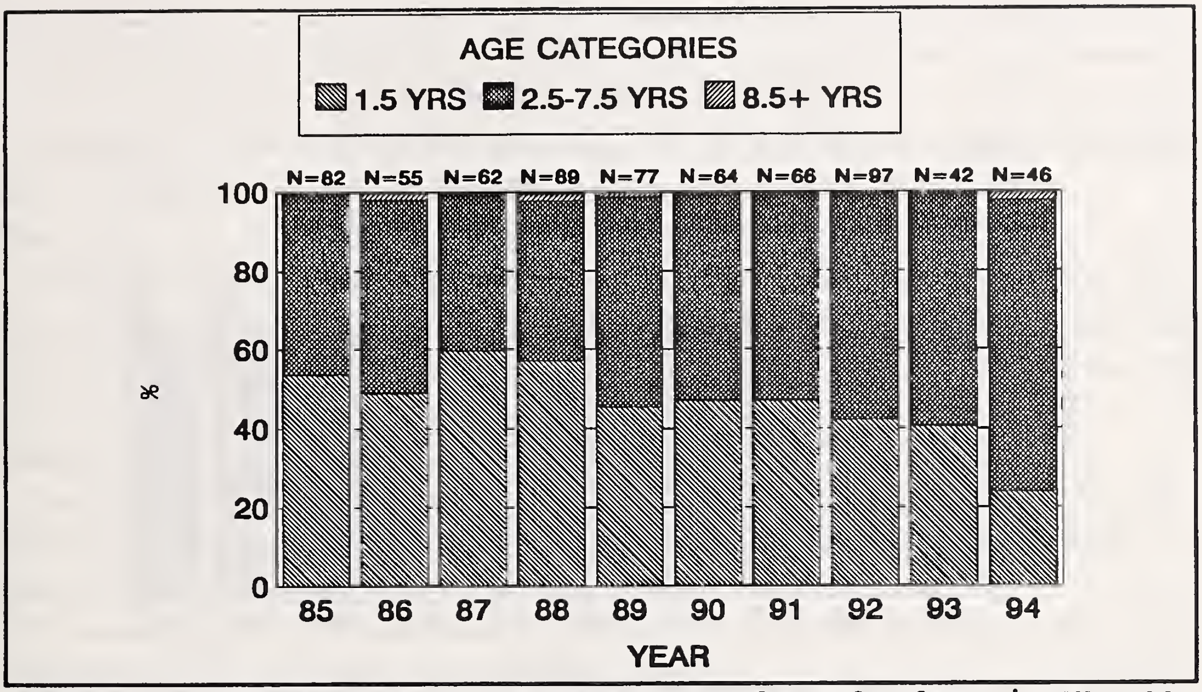


**Figure 32. Harvest age structure for male mule deer in HD 103, 1985 to 1994.**

in an increased population. However, this is a large assumption given that the treatments were only 1% of the total area of HD 101.

## Diastema lengths - HD 101 mule deer harvest

Diastema lengths of both males and females were analyzed to determine physical condition of the herd. Change of this variable in HD 101 and differences between HD 101 and other districts provided another measure of the efficacy of the treatment areas.

**Females**

Diastema lengths were measured for harvested females from 1985 to 1994 (Figure 33). There was very little variation between years for any of the 4 age classes. Measurements for yearlings and 2.5 - 7.5 year-olds remained constant over the period. An ANOVA test indicated no significant differences between years for any of the age classes ($p>0.05$).

**Males**

Diastema lengths for males were also measured over the same time period (Figure 34). Again, there appeared to be little variation between years except for fawns. Average lengths for 1991 and 1994 were smaller than other years. However, ANOVA tests suggested no significant difference between years for any age class ($p>0.05$).

**Summary**

Diastema lengths for both males and females showed no change over the course of the study. Yearlings are the most sensitive cohort to this measure and they showed no response to treatment, either positive or negative.

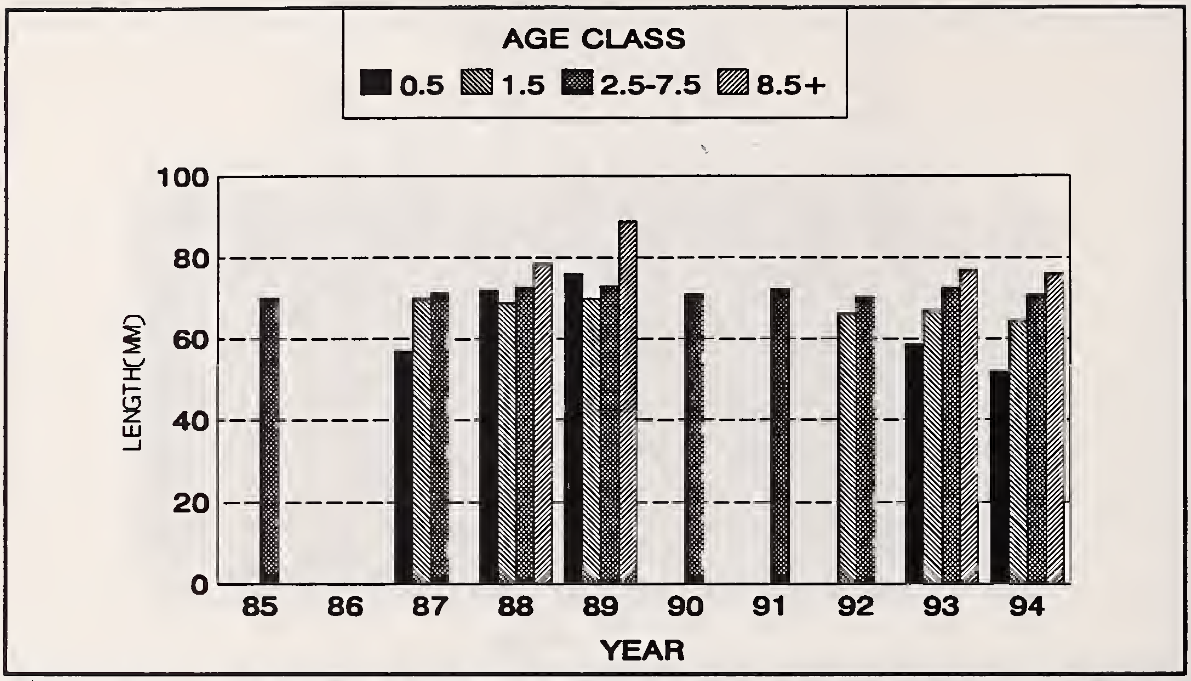

Figure 33. Average diastema lengths for 4 age classes of female mule deer in HD 101, 1985 to 1994.

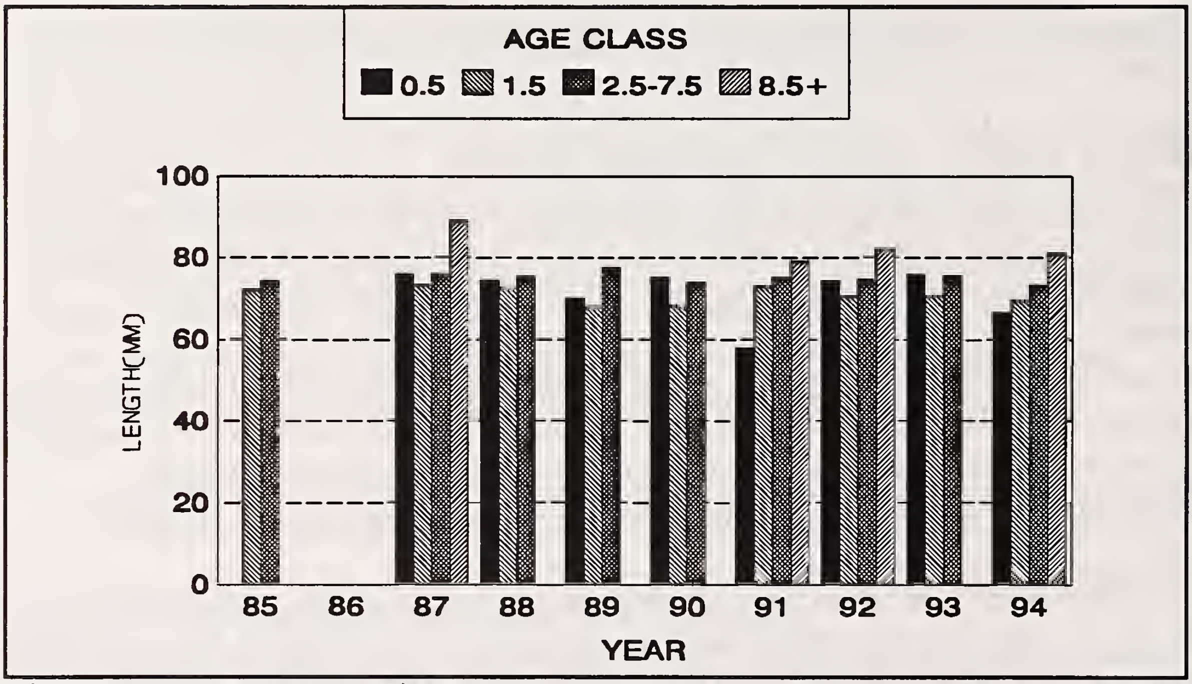

Figure 34. Average diastema lengths for 4 age classes of mule deer males in HD 101, 1985 to 1994.

## Diastema lengths - R-1 mule deer harvest

**Females**

Diastema lengths were combined from all other hunting districts for which data existed because sample sizes were too small for comparisons with individual districts. These were 100, 103, 110, 121, 123, 130 and 140. As with females in HD 101, little variation existed between years for any of the age classes and differences were not significant ($p>0.05$). An ANOVA test indicated no significant difference between hunting districts for age classes 0.5, 1.5 and 8.5+ ($p>0.05$), however, there was a significant difference between hunting districts for age class 2.5-7.5 ($F=2.54$, $p=0.02$). Specifically, HD 103 and 140 were different from one another; HD 101 was not significantly different from the other districts.

**Males**

Diastema lengths were combined for all hunting districts excluding HD 101. For age classes 0.5 and 1.5, animals in HD 101 had significantly larger diastemal lengths than the other HD's. Diastemal length of animals in the 2.5-7.5 age class were significantly smaller in HD 101.

**Summary**

Female deer in HD 101 did not have significantly different diastemal lengths from the other HD's. However, fawn and yearling males in HD 101 had larger diastemal lengths suggesting better physical condition of deer in 101 than other districts.

Diastema lengths for neither males nor females increased from pre-treatment to post-treatment suggesting no positive response to treatment.

## Bighorn sheep group composition

As with mule deer harvest data, bighorn sheep group composition data can show changes in size of different segments of the population. An increase in the frequency of observation of groups with young cohorts and a decline in the frequency of groups with older sheep suggests an expanding population (Leslie and Douglas 1979). This would indicate a beneficial effect from the treatments. The converse would indicate a negative influence from the treatments.

**Group composition distribution**

Observed groups were divided into three categories: ewes with lambs, yearlings, and ewes with juveniles. The ewes with juveniles category included adult females with both sexes of yearlings and lambs.

Distribution among the 3 categories differed significantly between treatment periods ($X^2=18.40$, $p<0.01$). Notable changes in group frequencies were: ewe/lamb groups increased, yearling groups decreased, and ewe/juvenile groups decreased (Figure 35).

**Ram group composition**

Observations of rams were divided by age group for each year. These groups were yearlings, class III, and class IV following Geist (1971). The data were grouped into distributions among the age classes for pre and post-treatment periods.

There was a significant difference in the distribution of age classes between treatment periods ($X^2=28.89$, $p<0.001$). Number of yearlings decreased from pre- to post-treatment periods (Figure 36). The number of class IV rams increased from pre- to post-treatment.

**Summary**

Group composition changed significantly during the post-treatment period. Specifically, ewe/lamb groups were seen more frequently suggesting increased production contradicting

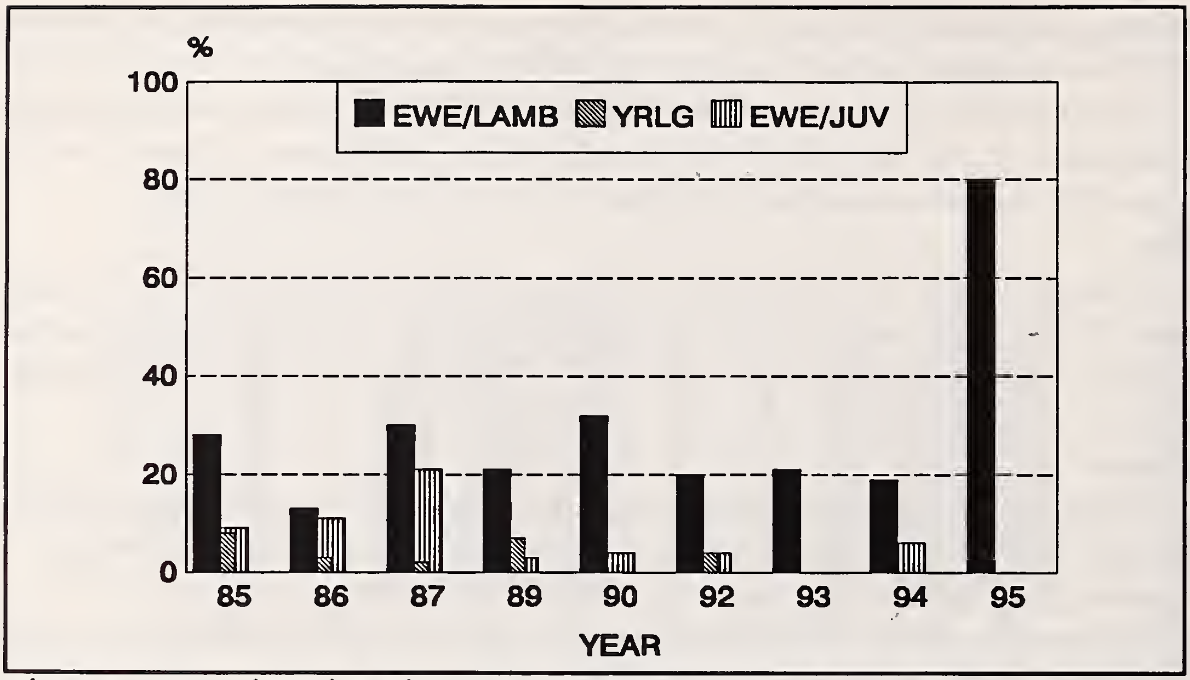

Figure 35. Distribution of observed groups of sheep among 6 sex/age categories, 1985-95.

the declining ewe:lamb ratios reported earlier. Yearling groups were seen less often, consistent with the declining recruitment reported earlier. This composition data suggests that lamb production and recruitment did not increase in response to treatment.

Consistent with the group composition data, yearling ram groups were seen less often compared to other ram age classes. In addition, class IV rams were seen more often during the post-treatment period. These data suggest that the sheep population responded to treatment with depressed recruitment and increasing age.

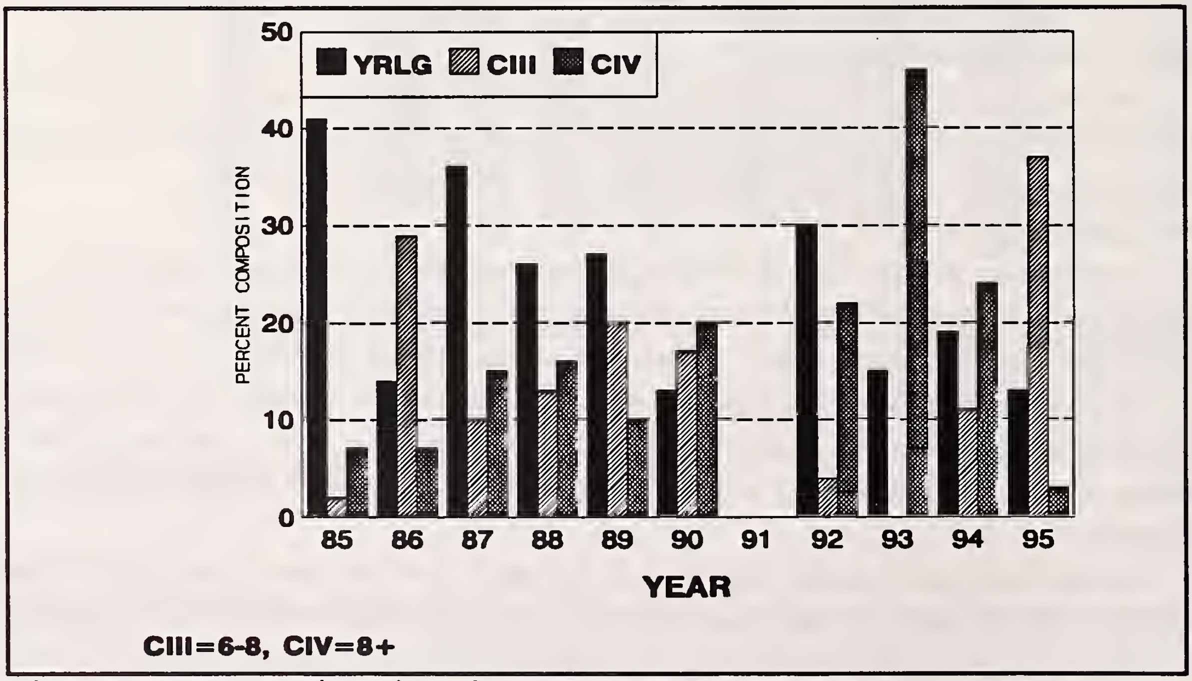

Figure 36. Age distribution of rams among 5 age classes, 1985-95.

## Bighorn sheep group size

Group size was analyzed to provide another measure of treatment success. Increased group size over time indicates improved habitat quality and population health (Simmons 1980).

Group size was averaged for each year and each season for all years. All groups were included regardless of sex or age composition.

Group size for winter increased over time (Figure 37), but the differences between years was not siginificant (F=0.96, p>0.05).

Observed groups were seperated into 5 group size categories by year. Years were clumped into pre and post-treatment periods.

Each year, 60-80% of the groups observed had 2-9 animals (Figure 38). When all years were combined nearly 80% of the groups had 2-9 animals. There was no significant difference in the distribution of groups among the 5 classes between pre- and post-treatment periods ($X^2$=2.22, p>0.05). About the same proportion of groups had 2-9 individuals in the pre- and post-treatment periods.

Group size seems to be most related to resource availability (Krausman et al. 1989) which is related to habitat quality. Increasing group size usually indicates improved habitat quality and improving population "quality." Other studies conducted in Montana, Idaho, Nevada, and Arizona documented proportion of groups in the same group size categories. Proportion of groups in the 2-9 category were very similar for the Montana and Idaho populations. The Nevada and Arizona populations had a much smaller proportion of groups in this category and a higher proportion in the 1 animal category (Figure 39). This was attributed to the scarcity of resources in desert environments.

Group size remained relatively stable on the Libby Dam study area, comparable to that of stable to declining populations. These data do not support any positive response to treatment.

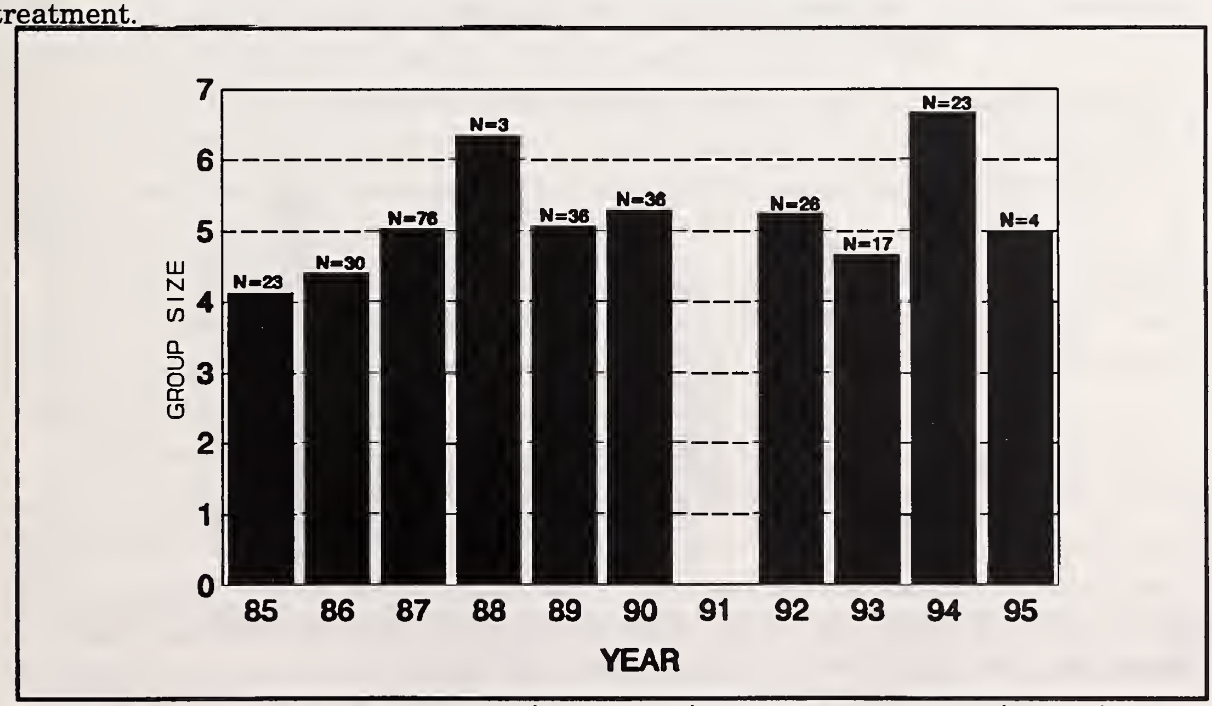


**Figure 37. Average group size of bighorn sheep during winter, 1985-95.**

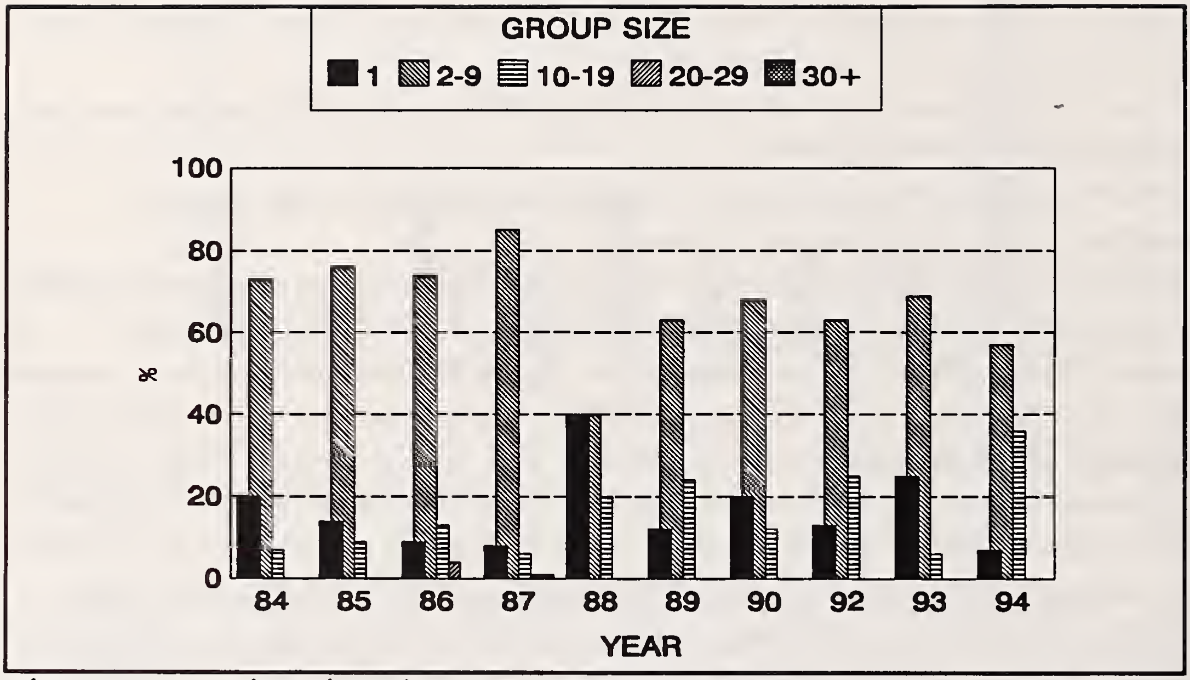


Figure 38. Distribution of observed sheep groups among group size categories, 1985-95.

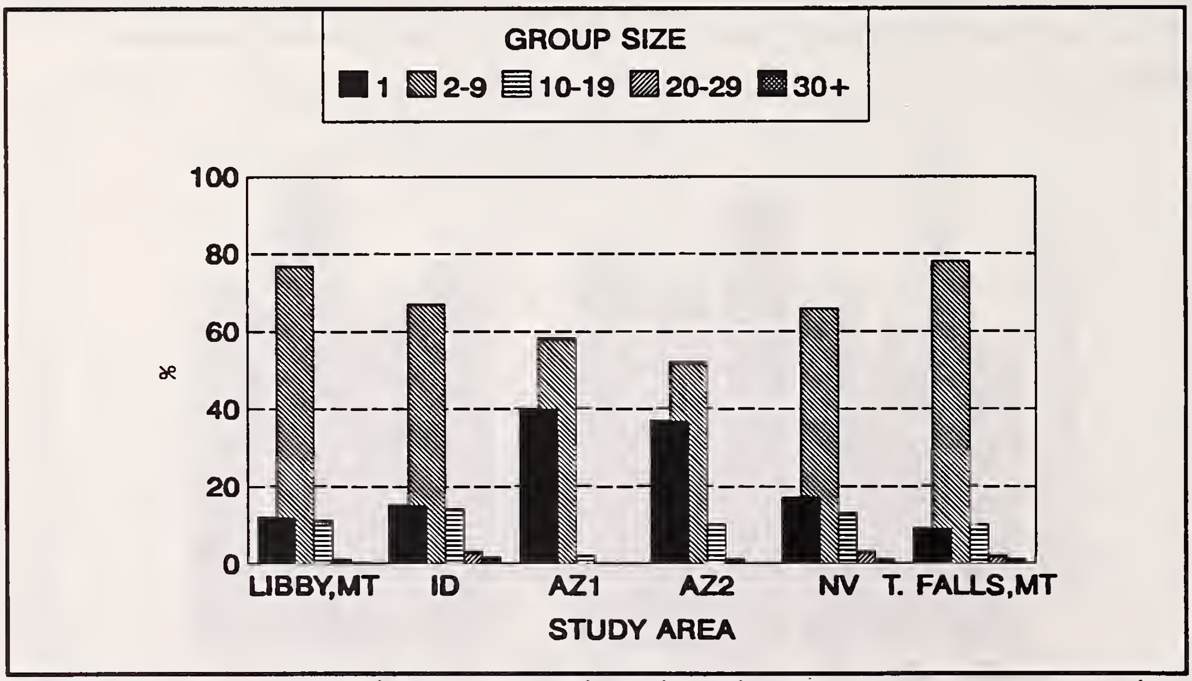


Figure 39. Comparison of distributions among group size categories for 6 bighorn sheep populations.

# Conclusions and Management Recommendations

Data collected since 1984 are inconclusive regarding the feasibility of enhancing bighorn sheep and mule deer habitat along Koocanusa Reservoir to support larger ungulate populations.

Vegetative response was mixed and varied among treatment areas and individual plant species. Shrub frequency and volume generally decreased. Herbaceous production increased initially then declined to pre-treatment levels. Understory coverage of shrubs, grasses, and forbs also increased, apparently the result of resprouting and seed germination.

A positive ungulate response to treatments was suggested by distance measures and habitat analyses. The shifts in movement patterns and winter home ranges by mule deer indicate a positive response to the treatments. A subtle shift by bighorn sheep to the southern end of the treatment area where treatments are more concentrated suggests a positive response to enhancement. Pellet group counts and browse utilization measures also indicate increased use of the treated areas.

On the other hand, population parameters indicated negative responses. Although population estimates are inconclusive, they do not support an increase in numbers of sheep or deer. Natality shows a decline for both sheep and deer. Recruitment for sheep indicates a declining trend over time. Survival rates for both species declined from the pre-treatment to post-treatment.

Mule deer harvest data for HD 101, which contained the study area, exhibited an age structure with fewer yearlings and more older aged animals through time; an indication of a stable to declining population. Comparison to adjacent hunting districts showed no difference so the phenomenon could be region-wide and habitat enhancements along the reservoir apparently had no impact on these broader regional trends.

Diastema lengths of mule deer were slighlty larger in HD 101 compared to other districts. However, the treatments were on such a small scale compared to the size of HD 101 that perturbations in the age structure or physical measurements could not be attributed to the treatments themselves.

Group composition of sheep indicated declining recruitment and a shift to an older-aged population that is stable or declining. Group size increased slightly suggesting a possible increase in habitat quality. This was consistent with the positive distributional response exhibited by sheep.

Synthesis of the monitoring data and vegetation data suggests that even though it appears forage production was increased and use may have increased, few if any animals were added to the population and production and survival both decreased. These results, while not definitive, are also not surprising. Other studies have unsuccessfully attempted to document an increase in ungulate populations in response to habitat manipulations (Cook et al. 1989, Klinger et al. 1989, Stussy 1993). Numerous studies have shown a positive spatial response to habitat manipulation (Klinger et al. 1989, Riggs and Peek 1980, Hurley and Irwin 1986, Bentz and Wooderd 1988, Anderson et al. 1974), but to our knowledge, no study has ever demonstrated a positive ungulate population response to habitat "enhancement" projects.

The goal of a 33% increase in both bighorn sheep and mule deer populations through habitat enhancement is probably not acheivable. Even if it were probable, it would be virtually impossible to document a cause-and-effect relationship, and thus the net benefit to big game populations, resulting from habitat enhancements. The original mitigation goals of enhancing habitat to support an additional 485 mule deer and 66 bighorn sheep (Northwest Power Planning Council 1987) were logical calculations based on current knowledge at that time (Yde and Olsen 1984, Mundinger and Yde 1985). However, given that there have been no scientific studies that have been able to document a positive ungulate population response to vegetation manipulation, such mitigation goals are unachievable.

Vegetation monitoring objectives as established with the initiation of this project and smaller scale ungulate monitoring may be more realistic and obtainable. In addition, the scientific community, governmental and private organizations, and the general public are becoming increasingly aware of the need to focus on entire communities rather than individual species. Maintenance of biological diversity requires that we manage so as to keep common species common while simultaneously sustaining and increasing the abundance of rare species (Finch and Ruggiero 1993). This focus on biological diversity is also reflected in Montana Fish, Wildlife & Parks goal to "manage with a focus on ecological systems to reflect the diversity of all wildlife and their habitats." The wildlife mitigation program for Libby Dam has evolved since the 1987 goals for sheep and deer were adopted. The relative importance of all species was recognized in the 1992 wildlife mitigation program plan by defining the mitigation program in a way that gave high priority to species in need, and emphasis to non-hunted species over game species. Rare habitats with limited distribution were also considered high priority for program emphasis. However, new, measurable, and achievable goals have yet to be defined.

The results of this study, while inconclusive, clearly did not support the hypothesis that mule deer and bighorn sheep populations increased as a result of habitat manipulations. This conclusion is also supported more generally by the current scientific literature on ungulate ecology and management. Managers should reconsider the original mitigation goals and formulate new, measurable objectives that more directly address wildlife habitat losses at Koocanusa Reservoir.

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