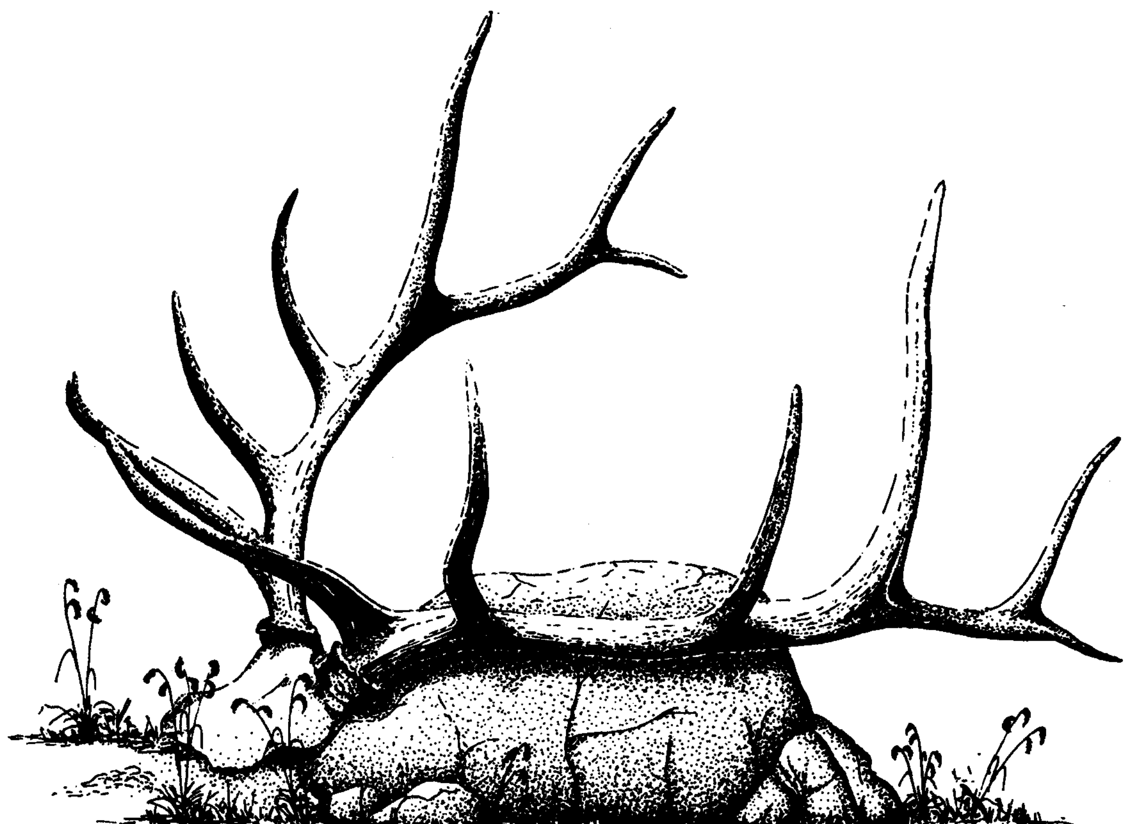
PROCEEDINGS OF THE WESTERN STATES ELK WORKSHOP



FEBRUARY 22-24, 1982

FLAGSTAFF, ARIZONA

PROCEEDINGS
of the
WESTERN STATES ELK WORKSHOP

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Sponsored by: Western Association of Fish and Wildlife Agencies and Arizona Game and Fish Department

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PREFACE

The 1982 Western States Elk Workshop was held at the Holiday Inn in Flagstaff, Arizona on February 22-24, 1982. The workshop was hosted by the Arizona Game and Fish Department.

Attendance was excellent despite austere travel budgets which have been common to all agencies in the U.S. and Canada during the past two years. Ninety-seven delegates attended. All the states with significant elk populations and British Columbia were represented. In addition, representatives of five Indian tribes were in attendance. Federal land managing agencies were also well represented.

The business meeting resulted in assigning Mr. Robert Hernbrode, Jr. of Colorado Division of Wildlife to develop a status report questionnaire which would be designed to streamline the state and province reports.

Since all papers presented at the workshop were retyped the Workshop Editors accept responsibility for all typographical errors and omissions.

Special thanks are extended to Ms. Marge Maston and Ms. Norma Sankey of the Arizona Game and Fish Department for handling workshop related correspondence and assistance in publication of the proceedings. Mr. Wayne Anderson, former wildlife manager, Arizona Game and Fish Department, was responsible for scheduling the facilities and banquet. A special thanks is extended to Wayne for his tireless services. Ms. Lauren Porzer Kepner assisted in manuscript edit and publication. Her efforts are greatly appreciated. Finally, my appreciation is extended to Mr. John Gisi, Commissioner, Arizona Game and Fish Department and Mr. Bill Burbridge, U. S. Forest Service for their presentations.

Alberta has agreed to host the next Western States Elk Workshop in 1984.

T. L. Britt

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PROVINCIAL, RESERVATION AND

STATE STATUS REPORTS

ELK STATUS IN BRITISH COLUMBIA

V. ROSS PECK, British Columbia Fish and Wildlife, Ft. St. John, British Columbia

Elk populations throughout the province appear to be holding their own or increasing somewhat. Recent provincial estimates suggest 24,000 ± 20%. This breaks down into roughly 3,000 Roosevelt elk (Cervus elaphus roosevelti), and 21,000 Rocky Mountain elk (C. e. nelsoni). Objectives of the most recent elk management plan for British Columbia (B.C.) are to:

1. Increase elk populations to a minimum of 36,000 (32,500 Rocky Mountain, 3,500 Roosevelt) animals distributed in traditional habitats throughout B.C.
2. Provide opportunities for people to view elk in their natural habitat.
3. Provide 140,000 hunter days of recreation and an annual sustained hunter kill of about 3,500 animals.

The most recent figures available indicate that approximately 1,400 animals are harvested annually, the pursuit of which provides 66,000 hunter days of recreation. Hunters were estimated to have numbered 4,000 in 1980.

Three main areas of elk concentration exist within the province, as well as a number of small, scattered, isolated herds. The population of approximately 3,000 Roosevelt elk on Vancouver Island appears to be increasing somewhat, resultant of a series of mild winters. These are small herds, watershed specific, in areas with lots of logging access. All harvest is on a limited entry (draw) basis. Allocation of permits is going up, with 212 permits issued in 1981. Success is estimated to be in the 65-75% range. A large illegal and native kill is thought to exist. An early male season restricted to spikes, or bulls with 5 points or greater is followed by a late antlerless season.

There is some concern on the northern part of the Island with increasing wolf predation. In a couple of watersheds it appears that the wolves have almost completely decimated the deer herds and are switching to elk. Late winter flights in 1981 indicated a decline in cow:calf ratios in specific watersheds. Vancouver Island is in the second year of a five-year research program on forestry/wildlife interactions. One-third of this project is concerned with elk. The research is examining the effects of differing logging practices upon habitat and monitoring population responses.

The majority of the 5,000-6,000 Rocky Mountain elk in north-eastern B.C. are concentrated in 3 management units on the eastern slope of the Rocky Mountains, west of the Alaska Highway. This relatively remote population has traditionally been selectively harvested for trophy bulls by nonresident guided hunters. Within the past 5 years, less selective resident hunters have gained access to these herds and harvests have more than doubled. The annual kill is thought not to exceed 5% of the total population and remains restricted primarily to bulls. Liberal hunting seasons have been characteristic in the north with a 3-month (Aug. 15 to Nov. 15) any-bull season and a 2-week open antlerless season in early October. Spike restrictions and antlerless closures are anticipated in 1982.

Small isolated herds and remnant populations are scattered throughout the northeastern part of the province. A number of programs are proposed or are currently underway to expand these low density populations. Prescribed fire is being used as a habitat improvement tool on winter ranges. Season closures are in effect for a number of herds. Transplants are anticipated in areas where elk numbers are thought to be too low to maintain viable populations. Predator control programs are being considered.

Currently, approximately 300 elk are being harvested annually in the north. Management goals are to increase elk numbers and subsequent harvest by at least doubling the current population. To help meet this goal, 25,000 acres were burned in the spring of 1981.

The south-central part of the province is characterized by small low density herds which support limited hunting seasons. Short, week long seasons restricted to 3-point minimum bulls are found in a number of management units. A relatively stable population of approximately 1,500 animals is found in the west Kootenay region of the province. Fifty-day seasons on 3-point minimum bulls are in effect, with limited entry options on antlerless, and special seasons on elk causing depredation problems. Annual kill is slightly less than 10%.

Over two-thirds of B.C.'s elk population is thought to inhabit the east Kootenay region in the southeast corner of the province. Elk harvest in the Kootenay region accounts for 80% of the provincial total. Overwinter populations estimates for 1981-82 suggest 15,000 animals, which can be compared to 1980 estimates of 12,000 and 7,750 in 1975. Regional biologist, Ray Demarchi, indicates that selective harvesting is the only route to follow. In the late 1960's, long either-sex seasons and harsh winters have left a population characterized by a young age structure and skewed sex ratios. A continued shortening of the cow season had little effect and in 1970 antlerless seasons were shut off completely. A spike closure was implemented in 1973, which was raised to a 3-point minimum in 1976. In 1977, a limited entry season was implemented for cow/calf and calf-only limited entry was introduced in 1981.

During the 1981 season the following elk seasons were available in the east Kootenay:

1. One thousand calf permits, specific to management unit (M.U.), calf only. In 1981 only 650 permits were subscribed, with an estimated 15-20% harvest.
2. Three hundred and fifty antlerless (cow/calf) permits, specific to M.U., cow or calf only. Heavily subscribed, 17:1 odds in some M.U.'s, estimated 40-50% success.
3. Five hundred any sex/age permits restricted to designated areas with depredation problems. Sept. 10 to Oct. 10 season, estimated kill, 112 animals (22%).
4. Open bull season, 3-point minimum, Sept. 10 to Oct. 30.

Proposed 1982 seasons are:

1. Increase in calf permits (doubled) which would enable hunter to take a bull instead during the open season.
2. Antlerless permits (doubled) cow/calf but no bull.
3. Five hundred any elk permits, depredation areas.
4. Open bull season.

Elk populations in the east Kootenay appear to be increasing at a rate of 15% annually. The area is surrounded by 5 national parks in Canada, Glacier

National Park in the U.S.A., and 3 states all of which have elk. Data suggests that the population being harvested is larger than the over-winter population in the area. The population appears to now have a healthy age class, but sex ratios are still somewhat skewed due to small numbers of cows being harvested. Estimated bull:cow ratios are 30-35:100, with a goal to increase it to 40-45:100. Harvests are now running at 7% of the total population, and aims are to increase this to 12.5%, mostly by increasing harvest in the juvenile category.

In 1980, a harvest questionnaire was developed in the east Kootenay. This is a voluntary tooth collection program with harvest data cards handed out with tag or license purchased. The card asks the hunter to record species, sex, antler tines, and kill location and return the card with an incisor from his kill. In conjunction with the program, game checks have been abandoned, and there are indications that the system may go province-wide.

ELK STATUS IN ARIZONA

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By the late 1800's native elk (Cervus elaphus merriami) were believed to have been extirpated from Arizona. Consequently, Arizona's current elk herds are a result of reintroduction efforts which took place in the early 1900's. In 1913 the B.P.O.E. Lodge in Winslow succeeded in obtaining 86 animals from the Yellowstone herd. The animals were transported by rail to Winslow. From Winslow they were transported south by horse drawn wagon some 40 miles and released near Cabin Draw, in what is now the Apache-Sitgreaves National Forest (White 1968). Several additional reintroductions took place between 1913 and 1928. These early efforts are credited for reestablishment of elk in Arizona.

The transplanted animals rapidly expanded their range. In 1935 Arizona's newly formed Game and Fish Commission authorized the first hunt and issued 276 permits to Arizona sport hunters. The first hunt was a success. Hunters reported harvesting 145 bulls. Annual seasons continued until 1944. During the two year span of 1944-45, elk season was closed in Arizona. Sport hunting resumed in 1946 and has been continued to date without interruption.

Population Status

All historical elk habitats are currently occupied in Arizona. In general, most ranges are either near or at carrying capacity. Some major ranges in eastern Arizona are capable of supporting more animals than are currently present and management efforts are underway to encourage herd expansion. Elk are, in some instances, becoming numerous in previously unoccupied habitat. This is the case along the south rim of the Grand Canyon where herds of up to 40 animals have been observed recently feeding adjacent to the runway at Grand Canyon Airport. Populations transplanted to marginal ranges such as the Hualapai mountains near Kingman appear to be hanging on, but only barely.

Currently we estimate 10,000 to 12,000 elk inhabit 6,884 square miles of habitat in Arizona. Most of the elk habitat, 83% to be exact, is under jurisdiction of the U.S. Forest Service. This estimate does not include elk found on the Fort Apache, San Carlos, and Hualapai Indian Reservations.

During the past 3 years, statewide prehunt calf survival has averaged 57 calves per 100 cows. During this same period, prehunt bull:cow ratios have averaged 34:100. At the present the majority of Arizona's elk herds are healthy and very productive.

Management Problems

Timber Harvest. Commercial timber harvest practices in Arizona have been based primarily on a shelter wood, modified shelter wood, or strip cut harvest techniques. The overall effect of saw log harvest to date appears to have been beneficial to elk, however, other associated silvicultural practices such as precommercial thinning and commercial thinning have an undefined status. The loss of concealment cover is accelerating annually. The importance of this cover is not fully understood in the ponderosa pine forests of Arizona. The Department is presently active in assisting the U.S. Forest Service in development of Land Management Plans. Hopefully adequate safeguards can be written in these plans to adequately protect elk habitat until additional information on habitat preferences is available.

Grazing. In general elk range conditions are fair to good at present. Several livestock permittees in the Flagstaff area have become critical of our elk management program. They contend permit reductions on their allotments resulted from over use of forage by elk. These criticisms will no doubt increase in the future.

Encroachment. Many valuable meadow lands were lost to summer home development during the 1960's. The rate of loss slowed as a result of rising energy costs and tougher zoning laws during the mid 1970's. Recently there appears to have been a rejuvenation of demand for remote homes and at present several critical areas are either in jeopardy or have been recently lost. The department land purchase program is inactive at present because of an austere budget.

Illegal Taking. Illegal taking was on the upswing in the early 1970's, but appears to have stabilized in the late 1970's. It is still a significant problem, especially in light of the upswing in the numbers of remote homeowners.

Predation. Predation does not appear to be an important factor in Arizona elk herds. The presence of remote subdivisions and associated dogs are a greater threat to elk than native predators.

Disease. Blindness in elk produced by the blood parasite *Elaeophora schneideri* is a problem in Arizona elk herds. Smith (1969) reported infection rates as high as 85%. More recent information from eastern Arizona, where the problem appears to be most severe, resulting from trapping operations in 1974 through 1978, indicates 7% of 213 yearling or adult elk exhibited external symptoms of the disease. In contrast, the rate in north-central Arizona has been less than 1%.

Seasons and Harvest

All elk hunts held in Arizona are on a permit basis. Permits are obtained through a computerized drawing administered by the Arizona Game and Fish Department. Permits are equally available to both residents and nonresidents.

Firearm (including muzzleloader) hunters are eligible to apply every third year after obtaining a permit. Archery hunters are eligible to apply each year; however, an archer must wait 3 years to apply for a firearms permit after obtaining an archery permit.

Several seasons are available for hunters to choose from. An early firearms season in early October (6 days in length), a late firearms season beginning on Friday after Thanksgiving (10 days in length), and an archery season during the last 2 weeks of September (13 days in length) provide a wide selection.

Firearms Hunt Statistics. During the period of 1979-81 a mean of 5,705 firearm elk permits were issued annually. Hunter numbers during this period averaged 5,368. These hunters harvested an average of 1,494 elk (1,010 bulls, 407 cows, and 77 calves) annually during this period and the harvest resulted in an average annual hunt success of 31%.

Archery Hunt Statistics. Archery elk hunting was initiated in 1972. Archery elk permit numbers have increased from the initial 750 bull permits in 1972 to 3,450 bull and any elk permits in 1981. The harvest also has increased from 22 bulls in 1972 to 221 bulls, 91 cows, and 9 calves in 1980. Our 5-year Elk Strategic Plan (1980-85) dedicates 15% of the total elk harvest to archers by 1985. Archers claimed 17% in 1980 and 11% in 1981.

Research Status

At present only one elk research project is active in Arizona. This project will be detailed in presentations given by Jon Rodiek and Glenn Delguidice.

A second investigation has met with serious financial problems recently. This investigation, begun in 1973, involves the capture and marking of elk to determine herd discreteness within specific wildlife management units. To date, in excess of 650 elk have been marked in 8 locations utilizing both permanent corral traps and portable clover traps. Trapping has occurred on both summer and winter ranges, with summer range trapping so far being the more efficient method.

During the past 2 years 20 elk have been radio instrumented. At present 14 are being monitored in the Flagstaff area. Austere budgets and unforseen emergencies have severely limited monitoring efforts and nearly curtailed trapping efforts. The future of this investigation is uncertain at present.

Prospects for the Future

Arizona like many western states is enjoying productive elk populations at present. The continuation of the condition depends primarily on being able to manage habitats which are to become targets for exploitation during the upcoming decade. To our knowledge we have no energy resources in our elk habitats, however, our elk habitats do support large quantities of timber and range forage, and possess potential for recreational development.

Overcoming the "get more quick" hysteria now prevalent to insure proper use of elk habitats will be the challenge of the 80's. Properly utilized Arizona's elk habitats can continue to produce timber, forage, recreation, and elk indefinitely if we can overcome the stigma of short term gains at the expense of long term production.

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THE STATUS OF ELK IN CALIFORNIA

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Distribution and Abundance

There are 3 subspecies of elk in California, the Roosevelt (*Cervus elaphus roosevelti*), the Rocky Mountain (*Cervus elaphus nelsoni*), and the Tule (*Cervus elaphus nannodes*). They are generally found in isolated herds.

The Roosevelt elk is the largest of the 3 subspecies. Bulls may weigh up to 1,200 pounds. Originally found along the North Coast, from San Francisco to the Oregon border, these native elk, presently numbering approximately 2,500 are found in northwestern Humboldt and western Del Norte counties.

Rocky Mountain elk are slightly smaller than the Roosevelt subspecies (bull live weight goes to 1,000 pounds), but are much larger than the Tule subspecies. The Rocky Mountain subspecies is not a native. Most were introduced from Yellowstone National Park in the early 1900's. They are now established in northeastern Shasta County, in the Santa Lucia Range of Monterey and San Luis Obispo counties, in the Tehachapi range of Kern County, on Santa Rosa Island of Santa Barbara County, and on the King Elk Ranch of Marin County. The total Rocky Mountain elk population in California is presently estimated at 1,150 animals.

Tule elk are the smallest subspecies in California. The adult bulls weigh 700 pounds or less. These native elk originally were found throughout the Great Central Valley and adjacent foothills. They have been called valley or dwarf elk at various times; however, the name "Tule" is now the accepted common name. During the late 1800's serious crop damage by Tule elk, market hunting, competition with domestic livestock, and the tallow industry led to almost complete elimination of this once very numerous animal. In 1934 the Tupman Elk Refuge was established in Kern County and since then has supported one of the 3 viable populations remaining in California. The other two established populations were started from transplants of Tule elk into the Owens Valley of Inyo County and the Cache Creek area of Lake and Colusa counties. In recent years, several transplants have been made from the Tupman Refuge and Owens Valley herds to start new herds at San Luis Island, Merced County; at Concord Naval Weapons Station, Contra Costa County; at Grizzly Island, Solano County; at Mt. Hamilton, Santa Clara County; at Lake Pillsbury, Lake County; at Jawbone Canyon, Kern County; at Fort Hunter Liggett Military Base, Monterey County; at Camp Roberts Military Base, San Luis Obispo County; and at Laytonville, Mendocino County. A few additional Tule elk are located in California zoos. The total estimated population of Tule elk in California is about 950-1000 animals.

Habitat

Because of human encroachment, elk have been forced into habitats that must be considered "marginal". Historically, Roosevelt elk were found in oak-fir glades along North Coast rivers. They now inhabit cutover redwood-Douglas fir forest and associated brush. Rocky Mountain elk once may have used open prairies, but in California have adapted to mountainous areas, using woodlands interspersed with open meadows. Similarly Tule elk once roamed the open grassland savannahs that historically surrounded the marshland of the Great Central Valley. Presently, the Tule elk survive in habitats such as sagebrush scrub (with river bottom and irrigated pasture lands) in Owens Valley, Inyo County; riparian-grassland habitat of San Luis Island, Merced County; and mixed chaparral and open grasslands in the Cache Creek area of Lake and Colusa counties.

Despite the elk's adaptability to marginal habitats for subsistence, they still have special habitat needs for breeding and calving. Meadows and grassy swales near streams with adjacent patches of brush or copses of small trees are preferred for spring calving and some open areas are needed where bulls can gather the cows into breeding harems in the early fall.

Elk are very popular as game animals and have high interest for viewers and photographers. As with most wildlife, the interest in elk is expected to increase with time. The uses of the various subspecies are summarized as follows:

a. Roosevelt Elk - Sightseers often stop at Prairie Creek State Park north of Eureka to view this herd of elk. Hunts have been held in the past and the demand for permits was consistently high. The last hunt was held in 1976 and over 13,000 hunters applied for the 50 permits. Land ownership has changed and future hunts would necessitate involvement by the National Park Service.
b. Rocky Mountain Elk - All of the Rocky Mountain elk herds were established by private citizens. Some wanted them for hunting; others merely wanted to have them around. The public use of these elk is limited because the access is restricted by private property or extremely rugged terrain. Hunts have been held on the Mt. Shasta and Tehachapi herds. In 1978, 10 permits were issued for the Tehachapi herd. Successful applicants paid a $1,000 access fee. Only 1 elk was taken but the fee is indicative of the intense interest in elk hunting.
c. Tule Elk - Tupman Tule Elk Reserve State Park records about 27,000 visitor days annually. Annual tours are held in the Owens Valley. Numerous school groups have excursions to view and discuss elk. Tule elk hunts have been held in the past and were quite popular with the hunters. In 1971 a state law was passed by the legislature prohibiting the Fish and Game Commission from authorizing a Tule elk hunt until the statewide total exceeds 2,000 or until it is determined by the Legislature that suitable areas for additional animals cannot be found in California. Recent efforts have greatly expanded the herds and it now apppears that the figure of 2,000 will be reached. Since the Tule elk habitat is so limited, removal of animals will be necessary eventually. This may be done by culling by Fish and Game personnel, public hunting, or some other means.

Management

The Roosevelt elk have been hunted in special hunts and will probably be hunted again. The expansion of the Redwoods National Park has, however, reduced the potential for elk hunts. The Department of Fish and Game is evaluating a proposal to transplant Roosevelt elk to the Kings Range in southern Humboldt County and transplants have been made twice to the Bear Basin of Del Norte County.

Hunts for the Mt. Shasta herd were held in 1969, 1970, 1971 and 1972. The kill averaged 10 animals per season. Ten permits were issued in 1978 for the Tehachapi herd hunt. Only one elk was taken. The Department has been extremely active in Tule elk management. Tule elk have been transplanted to many areas within their original range and some work to improve elk habitat has been done in the Cache Creek and Owens Valley herds. Annual counts are made on several of the herds. The 4th herd of Tule elk was established in 1974, the 5th and 6th in 1977, the 7th, 8th, 12th in 1978 and the 13th in 1979. From November 1974 to February 1982 over 368 Tule elk were released in new locations. This effort will continue until all suitable locations in California have received elk.

COLORADO STATUS REPORT

BOB HERNBRODE, Colorado Division of Wildlife, Denver, Colorado

In 1965 Dick Denney wrote "Recent times . . . have seen possibly the greatest population to date, and because of habitat limitations, perhaps the largest elk herd the state will ever know." While he felt statewide estimates were a matter of conjecture, unofficial "guestimates" ran around 50,000 elk (Denney 1965). In 1977 he estimated there were 125,000 elk and stated that we were very possibly in the heyday of elk numbers and could only expect to manage more intensively with lower numbers in years to come (Denney 1977). In 1982 my scenario is the current mandate that we hold elk populations at or slightly below current levels. Hopefully I or my successor will still be making the same optomistic report in 1988.

When we wrote our Strategic Plan in 1977 we were too conservative. By 1983 we said we wanted to harvest 27,300 elk statewide and have 118,500 after that season.

Table 1. Colorado Elk Population Estimate - Hunters and Harvest 1980-1981

Year	Post Season Population Est.	Hunters	Harvested
1980	118,300	160,912	27,623
1981	119,500	174,214	30,309

Between 1977 and 1981 we adjusted our population and harvest estimates downward to deal with reporting and non-reporting bias in our harvest estimate techniques and from a real population reduction that resulted from increased cow harvests in problem areas.

Now that we've so boldly given numbers, we should address the process by which these numbers were generated. Since 1977 we have managed elk using an objective approach. This involves an annual cycle of monitoring and decision-making that culminates each year in a prescribed hunting season (see next page).

Unlike most Wildlife Commissions who review and approve hunting season structures only, our Commission also reviews and approves individual herd objectives. This is possible because of the way they are presented decision packages (Appendix I & II). The Management Objectives form gives short- and long-term herd objectives as well as the harvest objective designed to meet herd objectives. Taken altogether, these forms represent our statewide objectives and hunt structure.

Objective Cycle of Elk Harvest and Management (adapted from Connolly in Wallmo 1981, page 263).

Select Management Objectives
Review and Change as needed

Assess Elk Herd
(DAU) and Habitat

Set Harvest Obj. by DAU
Compatible with Population
Obj. and Herd Status

Set Hunting Regulation as Needed to Achieve Harvest Goal

Hunt Elk

Monitor Harvest,
Compare with Harvest
Objectives

What is a DAU? A Data Analysis Unit (DAU) is our terminology for a herd unit; a DAU is the predetermined geographic area on which we establish long range objectives, management plans, and in which population data is collected. It is assumed that all the population is within the boundaries of the DAU when data are collected (i.e., during hunting season and in the winter). Over the last several years we have made an effort to insure this is true by extensive tagging and banding studies. Several adjustments in DAU boundaries have been made and more will be made as we learn more about movement and distribution of each herd. A DAU is no smaller than a Game Management Unit (GMU) and its boundaries correspond to the GMU's it includes. Example - DAU E-1 includes GMU's 1, 2 and 201 (Appendix III).

Colorado collects much of the same data as other elk states to make hunt recommendations, but each DAU uses computer simulations to store data and make decisions. Over time these simulations have given our managers a tool to align, quantify and reconstruct populations. A very readable discussion on our simulations program was presented by Tom Pojar (1977).

Data used in computer simulations are:

1. Herd composition - Data are obtained from helicopter counts conducted in December and January. During most winters we classify between 15-20 thousand elk. We realize the limitations of this data, but make a conscious effort to get an adequate sample size and collect the data in such a way that it represents the population.
2. Harvest estimate - We consider (a) precision requirements for the (b) specific season and (c) geographic area in order to determine a sufficient sample size of hunter questionnaires. Antlerless license holders are sampled at the 40% level. Antlered license holders are sampled at approximately 20%. Up to 3 follow-ups are sent to non-respondents so that we get an 85-90% return from our questionnaire. We felt that we were getting reports of both deer and elk harvested on the elk questionnaire, especially during the combined deer-elk season. To test this hypothesis, a subsample of reported successful elk hunters was sent a personal letter. We found that, indeed, those hunters who hunted the combined season were so intent on telling us they had killed a deer or elk that they were just as likely to report the killing of a

deer on the elk questionnaire as they were an elk. As a result, we redesigned the questionnaire so that the word "elk" was used in every question on the elk questionnaire. In 1980 we resurveyed respondents on the elk questionnaire and found we had essentially resolved the reporting bias by the revision. To address nonreporting bias we contacted a sample of nonrespondents via a telephone survey. On a statewide basis we could not detect a nonreporting bias. However, our field people have intuitively felt the statewide survey overestimated the elk harvest. Consequently, we conducted an independent postcard survey in a DAU where this seemed to be a problem. Results of that survey yielded essentially the same estimated harvest for the antlerless portion of the harvest, BUT a substantially lower antlered harvest estimate. Similar independent survey in another DAU yielded about the same results in 1981. We suspect that our statewide survey overestimates harvest, but that the overestimate is different for different areas of the State depending on the characteristics of the hunting public, i.e., number of nonresident hunters, rural or urban background, etc. We intend to continue the postcard survey. Jim Olterman from our SW Regional Office has put together a short "how to" memo on it which is available on request.

3. Age of harvest - Hunter-returned tooth mailers and collections made by our personnel during the hunting seasons supply information to determine age or harvest. We found that check station collections were expensive and did not provide an adequate sample from some areas and none from others. Our lab ages all teeth using dental cementum techniques. Pre-season numeric objectives are set by DAU to insure adequate sample sizes.

We are in the process of formalizing and clarifying a system for the management that has evolved over the last several years. Every step is subject to peer review and refinement. Simulations are used to organize, quantify, and reinforce the knowledge and experience of wildlife managers. We acknowledge the shortcomings of our system and are working to make it better.

The major shortcoming, in our view, is that we do not have a second independent method to estimate elk numbers over large geographic areas. Our goal is to develop a reasonable quantifiable method and to check the computer simulation against it for validation. Given that, we can set priorities and implement a system that tracks elk populations through time.

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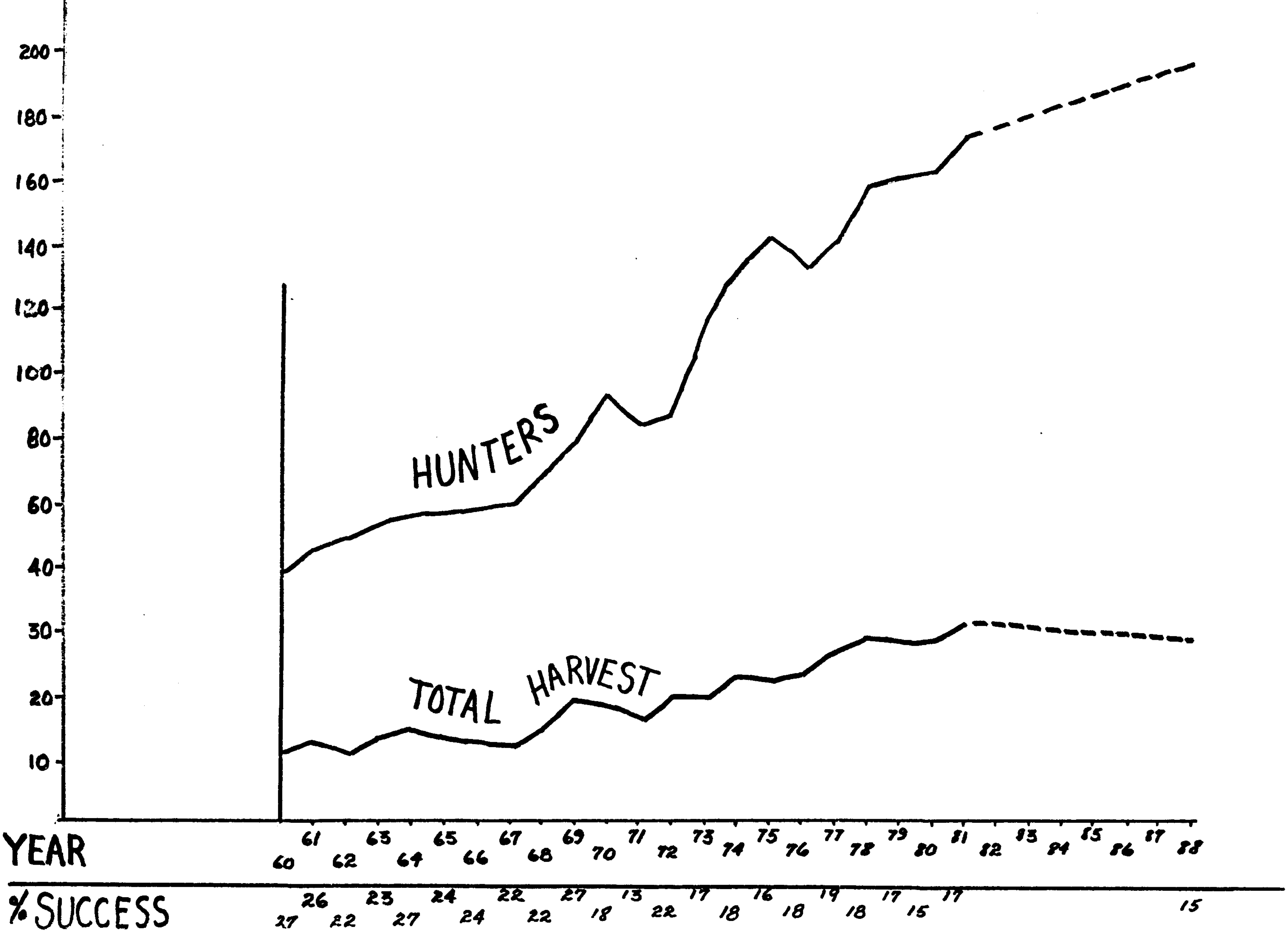
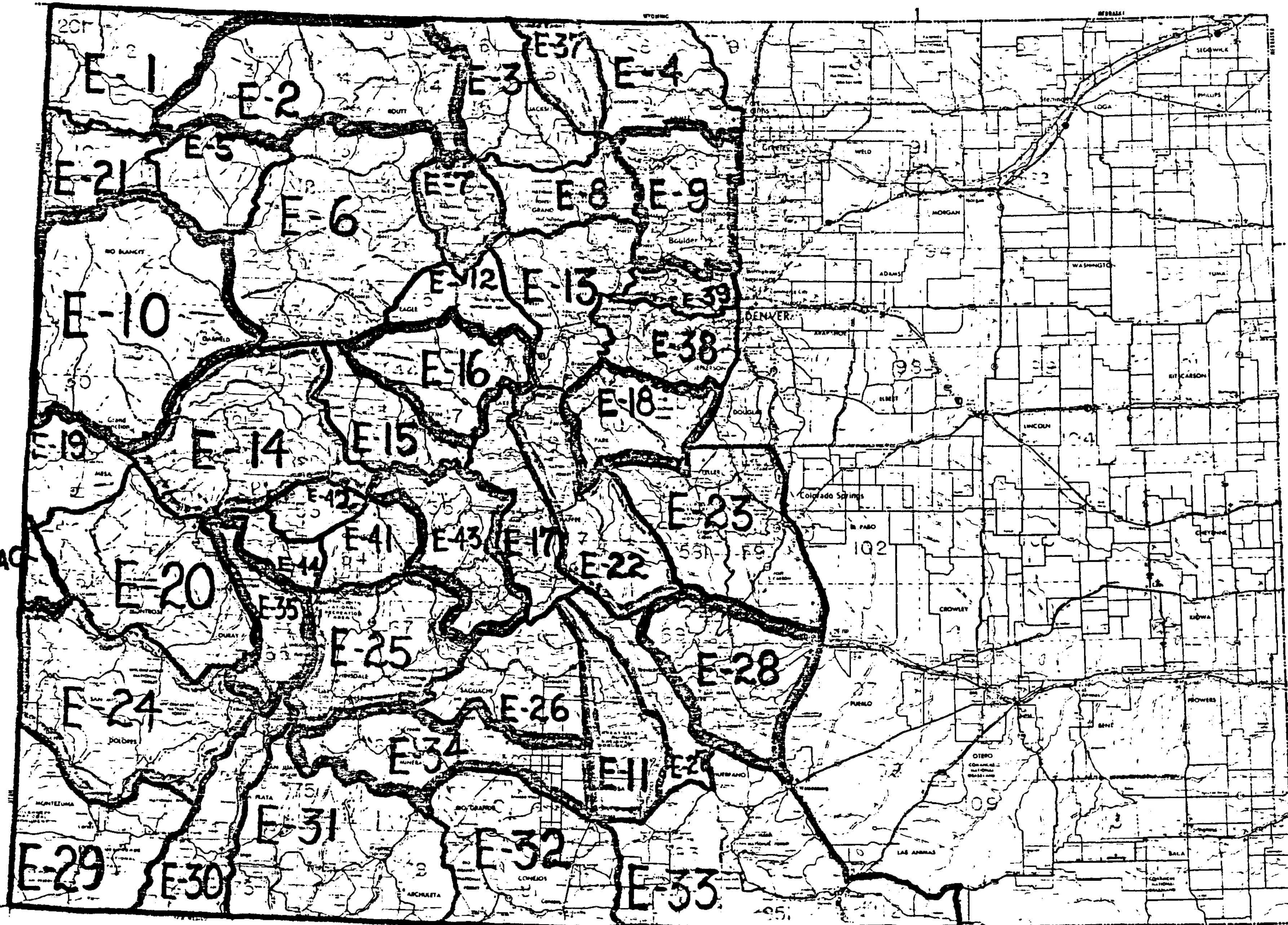
Figure 1. Elk hunting season data - hunters, harvest 1960-81 with projections to 1988



APPENDIX I

COLORADO



BIG GAME MANAGEMENT UNITS

30-82

ELK DAU's '82

APPENDIX II

1982 DAU MANAGEMENT OBJECTIVES

SPECIES________________________________ DAU________________

MAX. HISTORIC POPULATION SIZE________________ YEAR OF MAX. POPULATION________

	Males	Females	Young	Total
1981 Posthunt Estimates				
1982 Prehunt Projection				
1982 Harvest Objectives				
1982 Posthunt Objectives				
1988 Posthunt Objectives				

HARVEST OBJECTIVE BREAKDOWN BY GMU

GMU	1982 RECOMMENDATIONS		1982 HARVEST OBJECTIVES				
			RIFLE		ARCHERY & MUZZLELOADER		TOTAL
	LICENSE TYPE	TOTAL LICENSES	Male	Female & Young	Male	Female & Young	

COMMENTS AND RECOMMENDATIONS:________________________________

APPENDIX III

1982 DAU MANAGEMENT DATA

SPECIES____

DAU____

1981 POST HUNT POPULATION DATA:

	Males	Females	Young	Total	Type of Survey or Analysis	GMU's Surveyed
♂/100 ♀/θ		100				
Total Population						
Non-hunting Mortality	%	%	%			

1981 HARVEST DATA

	1981 RECOMMENDATIONS		1981 HARVEST				
			RIFLE		ARCHERY & MUZZLELOADER		
GMU	LICENSE TYPE	TOTAL LICENSES	Male	Female & Young	Male	Female & Young	TOTAL

COMMENTS AND RECOMMENDATIONS:____

ELK STATUS AND MANAGEMENT IN IDAHO

J.L. THIESSEN, Idaho Department of Fish and Game, Boise, Idaho

Elk are Idaho's premium big game species. They are found over about 50% of Idaho (41,250 square miles) with summer densities, in areas open to hunting, varying from about 0.4 to 3.0 per square mile. Elk habitat is located generally north of the Snake River Plains.

Wildfires in the early 1900's created extensive seral brushfields in northern and central Idaho which provided abundant forage for elk. Improved fire suppression techniques since about 1940 have resulted in less forage being created. Also, plant succession has reduced the amount of elk forage on existing brushfields. Maintaining large numbers of elk in northern and central Idaho is dependent upon good forage production being maintained by prescribed burning or other techniques.

South of the Salmon River, fire has not played the same role, particularly at lower elevations. Elk are more dependent on natural openings for forage and such areas are usually in adequate supply. Maintaining large numbers of elk in southern Idaho is dependent upon providing adequate cover and security areas adjacent to forage areas.

Through the early 1970's, the Department allowed general either-sex elk hunting over much of Idaho. This philosophy seemed appropriate in the 1950's and early 1960's when hunter numbers were relatively low, access to many parts of the state was limited, elk populations appeared to be relatively stable, and adjacent states allowed similar seasons.

By the late 1960's, conditions had changed noticeably. Numbers of hunters and access were increasing rapidly. Data demonstrating that several herds had been reduced primarily by heavy harvest became common. Production of calves apparently decreased. Regulations were being changed slowly, to reduce harvests. Elk hunters had noticed population declines and were clamoring for increases in elk numbers.

By the mid-1970's, the Department had substantively changed its philosophy regarding elk management. The main emphasis was and is to restore elk numbers. Seasons became more restrictive and most of the state was put under antlered-only hunting.

Elk populations have increased noticeably where these restrictive seasons were applied. We believe most herds in the state are still below what the habitat can support. Therefore, restrictive seasons will continue. With hunter numbers, access, and demand for other products from elk habitat increasing, plus restrictive seasons in adjacent states, we have reached the point where general either-sex elk hunting may no longer be advisable statewide. At the least, any move in that direction should be taken very cautiously.

Long range management plans (1981-85) for elk were recently approved by the Idaho Fish and Game Commission. A long range objective of realizing over 100,000 elk in Idaho by 1985 appears obtainable without jeopardizing habitat.

A total of 78,700 elk tags were sold in Idaho in 1981. Nonresidents purchased 8,726 of the 9,500 (quota) available. Twenty-three percent of the residents and 6% of the nonresidents who purchased tags did not hunt. The average success of all residents who hunted was 10% and that of all nonresidents who hunted was 18.5%.

In 1981, antlered-only hunting was provided on an unlimited basis in 48 of 96 management units while general either-sex hunting was allowed for part of the season in 8 management units. Fifteen units were limited to controlled hunts only and 14 units had controlled hunts in addition to general seasons. Twenty-four management units were closed to all elk hunting. General seasons varied from 5 to 68 days in length. General archery seasons were available in 39 management units and general or controlled muzzleloader seasons were available in 5 units.

One of the objectives in the 5-year elk management plan is to maintain post season ratios above 15-25 bulls per 100 cows depending upon the management unit. Prior to 1976, post season bull:cow ratios were high, varying from about 30-50:100 depending upon the management unit. These ratios have been reduced in the past 6 years to about 20-40:100 because of the heavy emphasis on bull harvest. The percent of males in the harvest for the 10-year period 1972-1981 was 53, 53, 57, 62, 84, 80, 80, 83 and 78, respectively.

About 11 checking stations are operated annually in major elk producing areas to obtain data on kill location, age structure of the harvest, antler development, and other physical parameters, as well as hunter success and attitudes.

Approximately 10,000 elk are counted and 8,000 classified each winter with the aid of helicopters. Post season cow:calf ratios vary between 100:25-60 depending upon the unit with most herds having ratios in the mid 40's to mid 50's. The average ratio has improved slightly since 1975.

Harvest surveys are conducted using a telephone contact system to approximately 10% of elk tag buyers. The principal benefits of the telephone techniques are: 1) a precise number of hunters can be sampled; and 2) non-response bias is eliminated. A high percentage (50-100%) of controlled hunt permittees are contacted via the telephone. Harvest for the 10-year period 1972-1981 was 9,300, 12,400, 8,700, 9,000, 4,100, 6,400, 7,700, 6,300, 8,300 and 9,500, respectively. Over 400,000 hunter days of recreation were expended for elk in Idaho during 1981.

MICHIGAN ELK HERD

ROBERT STRONG, Michigan Department of Natural Resources, Lansing, Michigan

Elk were native to the Lower Peninsula of Michigan before the land was settled, disappearing about 1877 when man came with axe, plow, and rifle.

The first attempt to re-establish elk in the state was made in 1916 when 28 elk were imported from Jackson Hole, Wyoming. Some were released in 1918 in Alpena County and a few in Roscommon County. These attempts failed but a group of 8 elk released in the Pigeon River State Forest in 1918 survived and increased in number.

By the early 1960's, the elk population had increased to an estimated 1,000 to 3,000 animals. Their feeding effects were seen on forest reproduction and farm crops bordering the forest. Hunting seasons in 1964 and 1965 removed 477 elk. An additional 41 were taken by poachers and lost to crippling during the open season for a total removal of 518 elk. Poaching losses and changes in land use and human disturbances after the 2 seasons in the late 1960's and early 1970's further reduced the herd.

The early 1970's had seen a controversy between oil and gas developers and environmentalists over unregulated development in the forest. Court battles ensued for 10 years with a compromise reached in 1980 which allowed one oil company instead of 5 to explore and drill wells under the strict supervision of the Department of Natural Resources and a citizen group. The drilling will be accomplished with each location of wells, pipelines, and facilities located in the least environmentally sensitive areas. Elk, bear, and bobcat were the principle wildlife species mentioned throughout all the proceedings with elk-versus-oil the main thrust of most concern.

A combined aerial-ground census in 1975 showed an actual count of 159 elk and an estimated total of 200. Public concern for the elk has resulted in increased law enforcement efforts and stepped-up habitat improvement. A similar count in 1977 showed 255 actual and 300 estimated elk, while the latest count in December, 1980, showed an actual count of 437 elk and an estimated herd of 500.

Forest reproduction is suffering from elk browsing, especially sugar maple, basswood, and large-toothed aspen. Some farms on the edge of the forest have suffered damage to corn, alfalfa, and beans. The herd probably exceeds 600 elk at this time and various types of control are being considered in the management of the growing herd.

MONTANA STATUS REPORT

TERRY N. LONNER, Montana Department of Fish, Wildlife and Parks, Bozeman, Montana

Montana's human population is about 750,000 and 1 out of every 7 people in the state hunt elk. There is presently about 1 elk for every 10 people and most of the elk populations in the state are currently at a level where further increases could cause severe winter depredation problems on private lands. Although we've acquired over the years 18 big game management areas (168,702 acres deeded and 66,452 acres leased) mostly for winter range, only about 10% of all the elk use these areas.

Elk are distributed primarily in the forested areas of western and central Montana, but also occur in the Missouri River Breaks of northeastern Montana. Land ownership status where elk occur is 73% public, 2% state school land, and 25% private. Approximately 80% of the elk harvest occurs on public land, which is almost entirely national forest.

Proposals for the 1982 elk hunting season involve 127 elk hunting districts with basically 5 kinds of hunting regulations. These are: archery only (most all units during the special archery season and 1 unit during the general rifle season); either-sex hunting but mostly with short seasons for cows and calves (20 units); antlered bull hunting with the harvest of cows and calves controlled by permits or quotas (77 units); antlered bull only (11 units); and permit only (18 units).

Elk hunting starts about September 10 with a general archery season that lasts 1 month and continues with a general rifle season that begins about October 20 and ends in late November. There are 2 prescheduled late hunts by permit only starting in mid-December and ending in mid-February that take place in the upper Yellowstone and Gallatin drainages near Yellowstone National Park. Over 90% of the elk harvest, however, occurs during the general rifle hunting season. Depending on winter severity, depredation hunts also occur to control elk numbers.

Starting this year (1982) the Montana resident will pay $9.00 for an elk tag and an additional $2.00 for a conservation license. For contrast, a resident deer hunter will pay $8.00 for a deer tag. Another $6.00 must be paid to hunt elk with a long bow and arrow. Beginning this year, the nonresident elk hunter will have to pay $275.00 and this license must be purchased from the Fish, Wildlife and Parks office at the State Capitol in Helena on a first come, first served basis. This license includes 1 deer tag, an elk tag,1 black bear tag, and authorizes hunting for game birds and fishing. It also gives them the privilege to buy some special tags (grizzly bear, lion, archery stamp) and apply for others (either-sex elk, sheep, goat, moose and antelope). Application for special licenses must be made by June 15, for both resident and nonresident. In 1981 total elk license sales contributed to over half (53%) of the license fee revenue generated by all hunting during that year.

In recent years, hunting demand for elk has been continually increasing, but the elk supply has remained about the same with an average annual harvest of 12,800 since 1975. The number of elk hunters reported afield in Montana has increased from 78,000 in 1970 to 90,000 in 1980. Although survey results are not complete for 1981, total elk licenses sold were in excess of 100,000. Nonresident elk hunters reported afield increased from 9,750 in 1971 to 18,000 in 1975. In 1976, a 17,000 limit with an increased license fee was placed on nonresident elk licenses. This quota was reached last year by July 20.

Our statewide objective for 1985 is to provide 676,300 days of elk hunting annually at a hunting success rate of 15% with an average effort of 46 days per elk harvested. This means a sustained harvest goal of about 14,700 elk.

Research emphasis on elk currently involves the winding down of an elk-logging-roads study that is in the final report preparation phase. Radio telemetry is being used on a broad scale to help us better understand seasonal distribution and movement patterns within several of our management units. We are also concerned about below normal net calf recruitment in a few elk populations where spike bulls are the primary herd sires. Suspecting that a lack of mature bulls in the pre-hunting population is the reason for the problem, we initiated last fall a branch-antlered bull season in one of these areas. This is an experiment to see if allowing more bull recruitment into older age classes will help alleviate the problem.

ELK MANAGEMENT IN NEW MEXICO

GARY L. RICKMAN, New Mexico Department of Game and Fish, Silver City, New Mexico

The estimated elk population in New Mexico is 13,000. The hunt structure has been a stratified season with unlimited permits. In 1980 15,721 hunters were afield and they harvested 2,111 elk for a success rate of 13.4%.

Through research efforts in the southwestern quarter of the state, on Fort Bayard and T-Bar, we found with this type of hunting, especially in areas with easy access, that the bull:cow ratio was declining. The pregnancy rates of cows in such areas were also declining. The data from Fort Bayard, a refuge, when compared with data from T-Bar which is a high access area, indicated that there was too much pressure being placed on the bull segment of the population. There was also a high incident of illegal kills recorded during the hunt in the high access areas.

With this information at hand it was recommended that the elk hunt be changed to a limited permit system for each elk management unit. This recommendation was accepted for the 1981 season. On the T-Bar the number of hunters dropped from 934 hunters to 491, the harvest from 108 bulls plus 26 illegal kills, to 79 bulls and no illegal kills, and the hunter success rose from 11.5% to 16%. Statewide there was a decrease of 2,600 hunters afield, 614 fewer elk harvested and an increase of 1.6% in the hunter success to 15%.

Each winter as funds permit aerial surveys are flown on each of the major elk herds in the state. This is done to determine population trends and calf survival rates. This data is used to determine the number of permits to be issued in each management unit. It is felt that given the results of the 1981 hunt that the bull:cow ratio will increase and there by an increase will be seen in pregnancy rates.

At present the elk research efforts are on twin study areas, Fort Bayard, a refuge, where there is little or no pressure on the population and T-Bar where the area is highly accessable and receives outside pressure year around. By comparing data on the 2 areas we can get a feel of what affect these pressures will have on an elk herd.

There are 3 basic studies ongoing in these areas; disease, population dynamics, and eleaophorosis. All the data collected will be used in an attempt to build a management model for elk in New Mexico.

On the Fort Bayard study area the elk were experiencing a decline in pregnancy rates from 100% in 1978 to 40% in 1980. It was also noted that during the 1980 breeding season the bulls were remaining with breeding groups 2 months longer than normal indicating an extended breeding period. During that same year small spotted calves were observed in late October and early November contrary to the norm. Calves have normally lost their spots by late September. Since this is a non-hunted herd it was felt that there might be a disease causing the problem. The symptoms of a reduced pregnancy rate and a prolonged calving period are a textbook example of <u>Cambylobacter fetus</u> (vibriosis).

In the winter of 1980-81 we captured and pregnancy tested 14 elk. Blood samples were taken from each elk and the sera was shipped to Ames, Iowa for analysis. The results of these tests were negative for leptospirosis and brucellosis. The test for vibriosis showed 1 cow positive, 12 cows had probable exposure at 3 different levels, and 1 negative. The cow which tested positive was not pregnant. Eight cows at the next lower level of exposure had a 50% pregnancy rate. The 4 cows at the next lower level of exposure had a 75% pregnancy rate, and the 1 cow that tested negative was pregnant.

This was more than enough for us to continue research on C. fetus in elk on Fort Bayard and T-Bar even though there had been vibriosis test run in the past on T-Bar with negative results shown. The most recent test on T-Bar show a probable exposure at low levels.

Research on eleaophorosis has been ongoing in the Gila National Forest on the T-Bar since the 1960's. Dr. Grant Kinser of New Mexico State University has found an effective insecticide (Pyrethrin) which will kill the intermediate host. This last year ear tags impregnated with the insecticide were put on cattle released in the area. It is hoped that the long term effectiveness, 28 days, will encompass the emergence period of the vector. The results of this action has not yet been determined.

OREGON STATUS REPORT

ROBERT N. JUBBER, Oregon Department of Fish and Wildlife, Portland, Oregon

Rocky Mountain Elk

Oregon's Rocky Mountain elk population estimates for 1980 and 1981 were 14% and 5% above the management objective level, respectively. Two mild winters in a row with good calf production continued to maintain the herds at levels which required substantial harvests of antlerless elk in both 1980 and 1981. Bull ratios averaged 7 compared to 6 in 1980 and 7 in 1979. Damage complaints from June 1980 through May 1981 dropped 7% from the 1979-80 total due to a very mild, open winter (76 to 57). Current conditions have required trapping, feeding and hazing the northeast units. A summary of herd inventory data is provided in Table 1.

Hunting seasons were changed substantially for 1980 and 1981 with a split elk season adopted by the Fish and Wildlife Commission. The main goals of this strategy were to:

a. Reduce opening weekend hunting pressures statewide;
b. Maintain adequate bull escapement; and
c. Provide reasonable quality hunter experience.

Two popular elk units have continued on limited entry basis with a 3-point bag limit on the Snake River Unit maintained for the 1981 season. Hunter numbers continue to increase even though they must choose a 5-day first period or a 9-day second season. Elk tag sales for 1981 show a 3.5% increase from 1980. The 1980 estimated bull harvest was 30% above the 1979 level with 8,967 reported taken compared to 6,244.

A total of 13,800 controlled antlerless permits plus 2,025 damage controlled hunt permits were authorized in 1980, compared to 14,900 and 1,825, respectively in 1981. The 1980 permits generated a kill of 6,210 antlerless elk. Success for the 1981 bull season may compare with last year's kill and the antlerless hunts for the past season were quite successful based on field checks only. The first period bull hunt draws 65% of our Rocky Mountain elk hunters.

Roosevelt Elk

Western Oregon elk herds showed a steady increase from 1979 through 1981, with calf:cow ratios at 36:100 in 1979, 37:100 in 1980, and 33:100 in 1981. Bull:cow ratios continued to average 9:100 for the Roosevelt herd. A summary of herd inventory data is provided in Table 1.

Damage problems continue at high levels with 122 complaints received in the 1979-80 period and 113 complaints for the 1980-81 report period.

Trapping and moving animals to new areas is still feasible, but most of the compatible Roosevelt range has been successfully stocked. Damage problems have also been alleviated by emergency hunts, controlled antlerless hunts, fencing, hazing, and kill permits.

Hunting season changes were adopted for 1980 and 1981 with the split bull elk season providing a 4-day and 7-day season. The 1980 season statistics show that 60% of the hunters prefer the first period hunt in the coastal area, compared to 41% in the Cascade Mountains units.

In 1980, 2,000 controlled antlerless permits and 740 damage permits were authorized and in 1981, 1,000 controlled and 1,195 damage permits were authorized.

Two of the historically popular elk units, Tioga and Saddle Mountain, are under a 3-point bull bag limit and limited entry on a first-come, first-serve basis. All other units are spike bull bag limits and no hunter quotas.

Management objectives for Roosevelt elk have not yet been determined.

Inventory of both Rocky Mountain and Roosevelt elk is accomplished primarily by aerial census. The substantial number of controlled antlerless hunts the past 2 years has provided opportunity for collection of reproductive tracts and jawbones for fetal rate and age class determinations in the various herds.

Table 1. Herd inventory data, 1980-81

Rocky Mountain Elk

1. Population Trends

Year	Elk Observed	Miles Travelled	Elk per Mile
1981	22,365	2,273	9.8
1980	30,550	2,382	12.8
Management Objective(M.O.)			11.0

2. Herd Composition

Year	Number Classified	Calves per 100 Cows	Bulls per 100 Cows
1981	8,301	39	7
1980	9,961	42	6

M.O.'s range from 3 bulls to 20 bulls/100 cows.

Roosevelt Elk

1. Population Trends

Year	Elk Observed	Miles Travelled	Elk per Mile
1981	1,384	593	2.3
1980	1,310	638	2.1

2. Herd Composition

Year	Number Classified	Calves per 100 Cows	Bulls per 100 Cows
1981	5,607	33	9
1980	4,750	37	9

M.O.'s are 5 to 7 bulls/100 cows.

ELK STATUS AND MANAGEMENT ON UINTAH AND OURAY INDIAN RESERVATION, UTAH

KENNETH L. PARR, Ute Indian Tribe, Vernal, Utah

The U.S. Fish and Wildlife Service (FWS), Bureau of Indian Affairs (BIA), and Tribal Fish and Wildlife personnel have gathered and analyzed all survey data from 1972 to 1981. During the latter part of 1981 the Ute Tribe employed their own biologist to continue with the wildlife surveys. The Ute Tribe Fish and Wildlife Department enforces a strict fish and game code on the reservation.

Study Area

The Uintah and Ouray Indian Reservation of the northern Ute Tribe is located in the Uintah Basin of northeast Utah. The reservation consists of 3 areas; the Hillcreek Unit, which is an isolated southern extension of the reservation, the Avintiguin Unit, and the North Unit. The total land mass of the reservation is 1,006,903 acres.

The land status within the reservation's exterior boundaries is checkerboarded comprised of tribal, state, and private lands. Land status surrounding the reservation consists of Forest Service, Bureau of Land Management (BLM), and private ownership.

Vegetation types found in this area include conifer, aspen, meadow (summer range), sagebrush-grass, sagebrush-mountain brush-grass, mountain brush-juniper, pinyon/juniper, pinyon/juniper-sagebrush, pinyon/juniper-grass, pinyon/juniper/sagebrush-grass, and agricultural land (winter range) (Utah Division of Wildlife Resources 1966).

Elk Management and Status

Management Problems. Elk management on the Uintah and Ouray Reservation is a difficult task due to the interspersion of landownership. There is oil and gas exploration both on and off the reservation, and the tribe leases wells on what is now considered critical winter habitat. These energy developments increase employment, local human populations, recreation use, secondary roads, and also increases poaching of big game on the reservation. The Ute Tribe has increased the Fish and Wildlife Department staff from 5 to 9 to counter the increased poaching, and better manage the area.

Livestock are an important part of the area's economy, however the reservation allotments are not presently filled to capacity. Present livestock numbers on the reservation limit competition, however if allotments are filled to capacity forage competition and range deterioration may occur, since wildlife AUM have not been figured into the allotments.

Elk Harvest. Elk hunting on the reservation is presently limited to tribal members. The season is approximately 1 month (September 15 to October 25) and closely corresponds to the state season. Tribal members can take either sex using rifle or archery equipment.

During the 1981 elk hunt 349 tags were issued to tribal members to hunt anywhere on the reservation. There were 156 hunter report card returns indicating the harvest of 49 bulls and 15 cows. The hunt success was 41%.The low number of tribal members hunting does not adversely effect the elk population on the reservation at the present time.

Population Status. Population (trend) monitoring of elk (and deer) consists of an aerial survey. This survey was initiated by the FWS in 1972 and has continued through 1982 with the Ute Tribe and the BIA now responsible for this important survey. This survey is conducted in each unit of the reservation, classifying animals by age and sex. The FWS and Ute Fish and Wildlife Department established 31 browse utilization and pellet group transects as another tool to monitor elk (and deer) populations. These surveys show that elk are evenly distributed over 2 areas, the North Unit and the Hillcreek Unit.

The bull:cow ratio for Hillcreek is 1:4(Table 1) indicating the herd could sustain a greater bull harvest than is presently occurring. The cow:calf ratio indicates good production, however the aerial classification flights of 1981 and 1982 were very late, and the large herds (200+) that we encountered precluded accurate classifications other than bulls and unclassified. The increases in elk numbers (Fig. 1) may be attributed to several factors. These include minimal hunting pressure and harvest. Present minimal livestock useage has reduced competition for forage. In addition, migration of elk from the Bookcliffs resource area to the east may also be occurring. Elk collared and transplanted to the resource area by the Utah Division of Wildlife Resources have been observed during the winter months on the Hillcreek Unit.

The 8 year average of the bull:cow ratio on the North Unit is 1:5 (Table 2), cow:calf is 44:100; however, even with the 1982 data, there appears to be good herd composition and production. Total numbers fluctuate on this unit, with elk wintering at higher elevations off the reservation during mild winters (Fig. 2). The high number of elk in 1980 and 1982 correspond to cold winters and deep snows which concentrate elk on critical winter habitat located on reservation lands.

Since these animals do not recognize political boundaries, and management of herds is not 1 agency's responsibility, a "Biological Unit Management Plan" is being developed. This is a coordinated effort initiated by the U.S. Forest Service, and includes state, tribal, BIA, and BLM agencies. The basic objectives of the management plan are:

1. To coordinate efforts (state, tribal, federal) to manage elk (and deer) and their habitats.
2. Identify limiting factors (e.g., winter range, calving grounds) that will control size and distribution of herds.
3. To determine what information is needed to monitor or evaluate the change in population and habitat conditions.
4. To identify opportunities to improve habitat conditions (e.g., prescribe burns on Forest Service, tribal, and BLM lands).

These objectives if implemented will benefit the wildlife resources in the Uintah Basin to a greater extent.

Future Management. Future elk management on the Uintah and Ouray Reservation will consist of:

1. Pursuing the Biological Unit Management Plan as a coordinated effort between concerned agencies for the North Unit.
2. Continuing with browse utilization/pellet group transects and aerial surveys to monitor elk populations for the Hillcreek and North Units.
3. Developing a range unit plan between the BIA field office and Tribal Fish and Game Department including range studies on the North and Hillcreek Units.

The reservation surrounding areas are managed for multiple use. Coordination between agencies to manage elk and other wildlife is necessary to effectively manage these migrating animals.

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Table 1. 1973-1982 Summary of Elk Aerial Survey Data-Hillcreek Unit, Uintah & Ouray Reservation, Utah

Year	Calves	Cows	Bulls	Unclassified	Total Sample	Calves/ 100 Cows	Calves/ 100 Adults	Bulls/ 100 Cows
1973	56	143	3	0	202	30	38	2
1974	59	139	24	1	223	42	36	7
1975	1	14	9	264	288	7	4	64
1976	99	139	48	98	384	71	53	35
1977	24	48	32	232	336	50	30	67
1978	0	122	7	0	129	0	0	7
1979	37	69	8	0	114	54	48	12
1980	172	275	62	10	519	63	51	23
1981			65	937	1002			
1982	23	192	82	855	1152	12	8	43
9 Year Average	52	127	31	162	372	41	33	24

Table 2. 1973-1982 Summary of Elk Aerial Survey Data-North Unit, Uintah & Ouray Reservation, Utah

Year	Calves	Cows	Bulls	Unclassified	Total Sample	Calves/ 100 Cows	Calves/ 100 Adults	Bulls/ 100 Cows
1973	63	144	36	0	243	44	35	25
1974	19	48	12	0	124	40	32	30
1975	22	39	8	11	80	56	47	21
1976	22	61	22	0	105	36	27	36
1977	No Elk were counted							
1978	31	72	9	0	112	43	38	13
1970	110	217	27	0	354	51	45	12
1980	161	250	45	0	456	64	55	18
1981	Animals not classified			201	201			
1982	111	630	43	0	784	18	16	7
8 Year Average	67	182	25	2	282	44	37	20

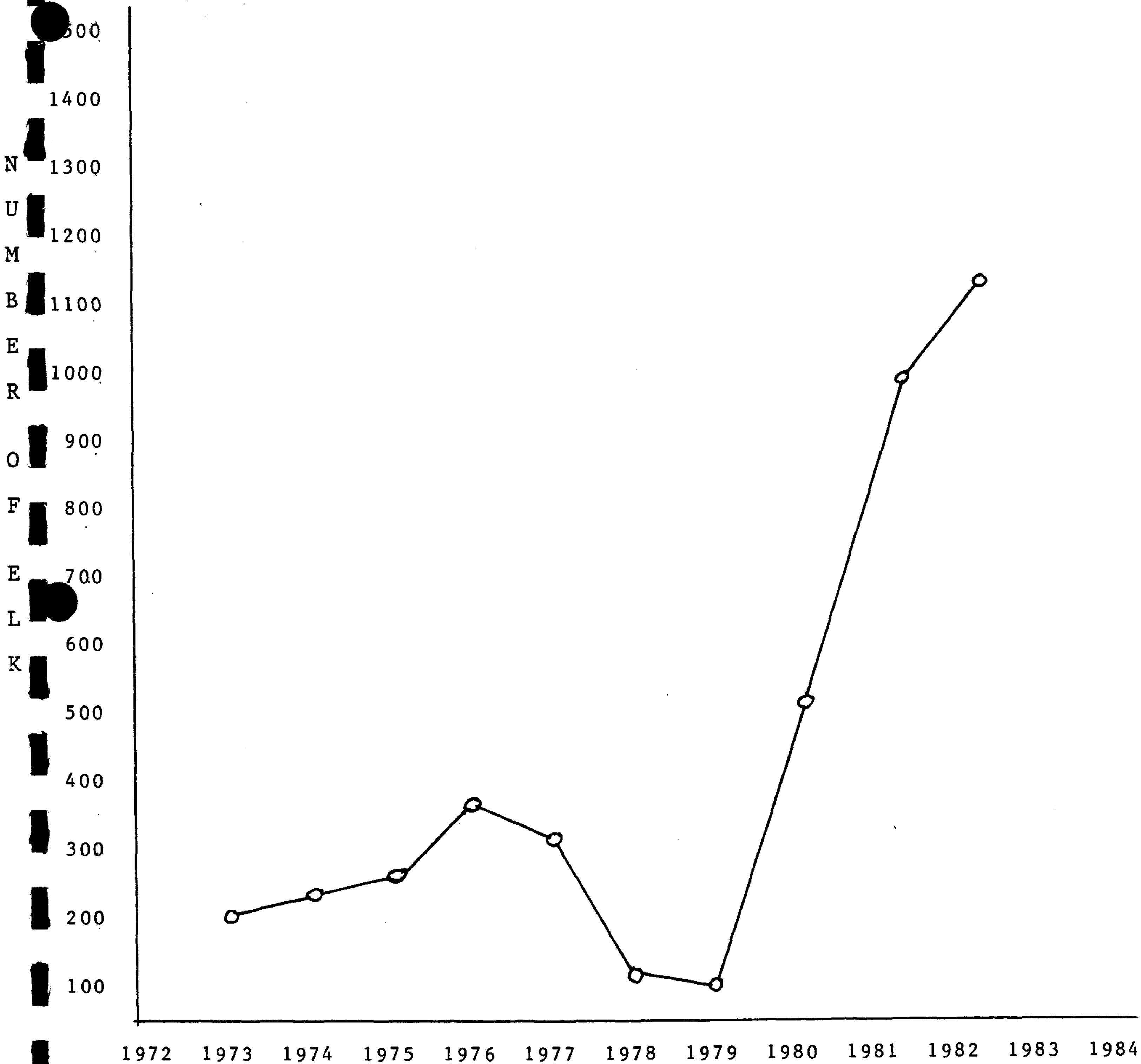

Figure 1. Elk aerial survey results 1972-1982 Hillcreek Unit, Uintah and Ouray Indian Reservation, Utah

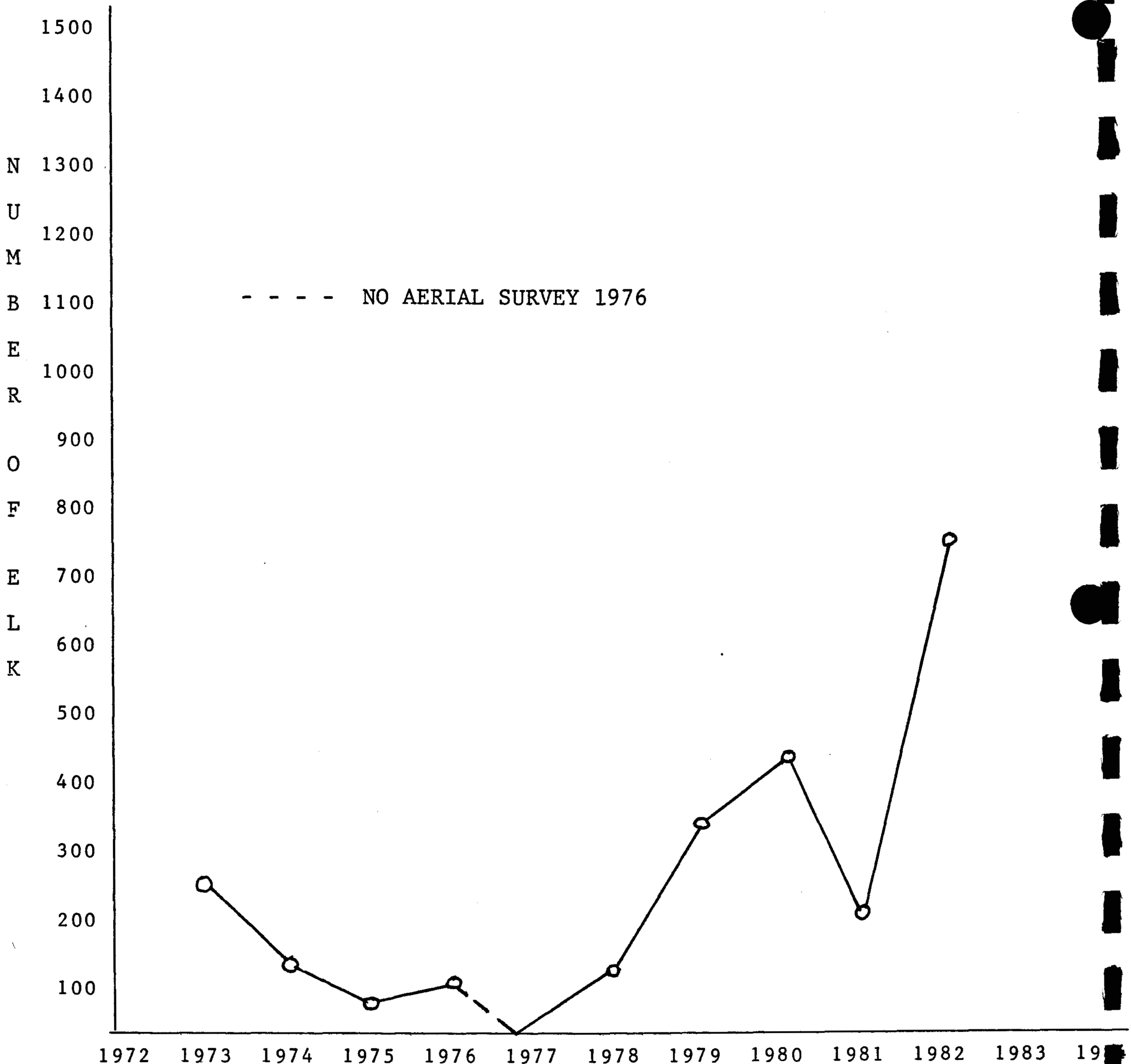

Figure 2. Elk aerial survey results, 1973-1982 North Unit, Uintah and Ouray Indian Reservation, Utah

ELK STATUS IN UTAH

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Present Status

The present elk population in Utah is estimated to be between 18-19,000 head and increasing on most management units. Currently there are 25 elk management units. Elk have been moving into areas where they have not been since they were extirpated near the end of the 1800's. However, 2 recently reestablished areas now have sufficient elk to initiate hunting seasons with a limited number of permits.

Preseason composition counts for the 1976-1980 period indicate a statewide average of 21 bulls per 100 cows and 50 calves per 100 cows. Although bulls are being harvested intensively under the open-area-bull hunting regime, productivity has not changed significantly.

Harvest

Seventeen of the 25 management units are hunted under the open-area bull regulation, where an unlimited number of bull permits are sold and a hunter may hunt on any of the 17 units. The remainder of the units have a limited number of bull permits valid only for the specified unit for which a person has to draw a permit.

The general season has opened on the closest Wednesday to the first of October for the past 7 years. In recent years, the mid-week opening date has done little to distribute hunting pressure.

Open-area-bull permit sales increased sharply from 17,652 in 1976 to 37,645 in 1979 due largely to a more liberal application procedure which allowed hunters to buy an open-area permit if not successful in drawing a restricted area permit. This 113% increase in permit sales occured even with a 7-9% hunter success rate. It was evident that elk hunting was gaining popularity and for many, it was a family outing at a pleasant time of the year. In 1980, the Board of Big Game Control increased the fee for an open-area-bull permit from $15 to $30 for residents. This was the first elk permit fee increase in almost 30 years. The net result was a drop in permit sales to 17,569, a few below the 1976 level of sales. There was also a shorter sales period for open-area bull permits in 1980, which somewhat masked the effect of the fee increase. Many people claimed they were not aware of the shorter application period. However, in 1981, sales only increased to 19,747 even with adequate publicity of the shorter sales period.

A limited number of antlerless or hunters' choice permits are authorized in combination with the open-area bull season for management units where antlerless removal is desired. Sales of restricted-area-elk permits have averaged 1,955 permits the past 5 years.

An archery elk season is also held each year concurrent with the archery deer season which is 17 days in length and ends on Labor Day.

Nonresidents are restricted to the purchase of archery or general season open-area bull permits. Even though there is not a limit, nonresident sales have been under 300 per year probably because of the high cost ($220). Harvest information for the period 1977-81 is provided below:

	1977	1978	1979	1980	*1981
Open bull permits sold	28,692	32,142	37,645	17,569	19,747
Hunter afield	27,166	30,783	34,654	16,694	18,562
Bulls harvested	2,285	2,923	2,313	1,824	2,444
Percent success	8	9	7	11	13
Restricted permit sales	1,872	2,020	2,020	1,980	1,885
Hunters afield	1,742	1,985	1,962	1,921	---
Elk harvested (bulls, cows and calves)	787	1,088	935	767	958
Archery permit sales	784	918	1,526	1,072	1,237
Hunters afield	665	866	1,453	1,006	---
Elk harvested	51	82	97	96	95
Percent success	8	9	7	10	---
Total harvest	3,123	4,093	3,345	2,687	3,497
Percent success	11	12	9	14	16

*Preliminary estimate

Research

Demographic and productivity studies are being continued on the Cache Elk Herd at the Hardware Ranch. A graduate student from Utah State University is completing a study on the reproductive performances of elk seeking refuge on the ranch during the hunting season as compared to elk not using the ranch. His findings will be submitted to the Journal of Wildlife Management for publication.

Transplants

Since the last elk workshop, Utah has transplanted an additional 50 head onto the Bookcliffs Unit and about 50 head onto the Indian Peak area. We have a signed agreement with the U.S. Forest Service for a 100-head transplant into Currant Creek Basin. This agreement has to go through the state clearing house before it is final.

There are still large historical elk areas in south central Utah that have only a few elk but have the potential to support sizeable herds. Transplants will be continued wherever agreements can be obtained in order to establish elk in all available habitat.

WYOMING STATUS REPORT

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There are 37 elk herds in Wyoming. These herds occupy 27,600 square miles of habitat (28% of the state), of which 3,318 square miles (12% of occupied habitat) is classified as critical. There are an estimated 71,000 wintering elk in these herds. Elk numbers are stable or increasing in all herds, and elk are expanding their range into habitat not occupied in recent time. An increase in elk numbers and year round use in the Red Desert is the most prominent example of this range expansion. Wyoming elk numbers can be maintained if the present habitat is maintained. Statewide management objectives have recently been updated. Existing management objectives call for a wintering population of 65,200 and hunting seasons which provide 282,300 recreation days and a harvest of 19,300 elk by 67,400 hunters. The revised objectives are 68,500 wintering elk, 298,500 recreation days and 16,400 elk harvested by 58,900 hunters. Harvest, recreation days, and total hunters have averaged 17,200, 345,853 and 68,000 respectively for the past 5 years.

Problems

While prospects appear bright for elk in Wyoming, there are substantial problems facing elk. The major problems are:

a. Timber management. Forage:cover ratios are less than optimum on some summer elk ranges on national forests. However, the U.S.Forest Service(USFS) has demonstrated a willingness to cooperate in the management of forest resources. The biggest problem associated with timber management is the increased number of roads. Road construction for timber harvest has opened up significant portions of heretofore roadless areas. Roading has reduced available habitat and also changed management strategies for these forests. Previously, hunter density had been controlled by limited access. In the absence of adequate road management, hunter density objectives must either be altered or the number of hunters controlled by permit.

b. Energy development. Energy development and its associated impacts are the most serious problems facing the management of all wildlife including elk. These impacts include more roads, surface mines, drill pads, power lines, and even whole new towns. The most immediate threat to elk is the development of oil and gas along the Overthrust Belt in western Wyoming. This development will eventually effect the habitat of 13,300 elk. The greatest long-term threat to elk in the state is an increasing human population and the resources necessary to support these people. The entire winter range for elk summering on the east side of the Bighorn Mountains is being threatened by home developments for the growing communities of Buffalo and Sheridan, Wyoming. The Department has attempted to identify critical elk habitat throughout the state. We are trying to influence reclamation so that impacts are for as short of a period as possible.

c. Damage. While elk damage agricultural products in some parts of Wyoming, elk damage is not as serious a problem as with deer and antelope. We are trying to maintain elk numbers so that damage is not excessive. Where damage does occur, landowners are compensated through Wyoming's Damage Compensation Law.

d. Grazing. In general, forage condition on elk ranges is adequate. However, it is anticipated that competition with domestic livestock will increase as forage is lost through energy development. This problem will be most serious in the Wyoming Range in western Wyoming and the Sierra Madre Range in south-central Wyoming. Future decisions regarding forage allocations on federal land may also have a dramatic effect on elk populations depending on these ranges.

d. Disease. Brucellosis is present in many of the elk herds in northwestern Wyoming. All herds where brucellosis has been isolated are supported artificially on winter feedgrounds. The major problem associated with brucellosis is its effect on the reproductive rate of infected elk. Post hunt calf:cow ratios in infected herds average approximately 33:100; this ratio in non-infected herds averages 47:100.

Management

The management for Wyoming elk varies from herd to herd. Season length varies from 15 days to approximately 3 months. Harvest restrictions include permit-only hunting, open bull hunting with permits required for cows and calves, and open hunting for any elk. Harvest statistics are determined through a mailed survey. Several attempts have been made to improve the quality of this survey through bias detection. Checks of the survey's biases suggest that less than 3% of the respondents report the wrong sex and age of harvest. However, it has been determined that the non-reporting bias has a significant effect on harvest estimates. Non-respondents apparently have a lower hunting rate than respondents. Also, non-respondents that did hunt were found to be less successful. These 2 sources of bias inflated harvest estimates by 12%. Harvest estimates are currently being corrected for this bias.

Research

Research on elk herds has been very limited in recent years. An elk-logging study completed in 1980 in the Gros Ventre elk herd measured the impacts of logging and associated roading on elk in the Bridger-Teton National Forest. This study was a cooperative project involving the Wyoming Game and Fish Department and the Bridger-Teton National Forest.

A study to determine movements, distribution, and herd integrity of the Cody elk herd is presently being completed. This study is being conducted for the Game and Fish Department by the University of Wyoming. A study to identify the importance of the Atlantic Rim to the Baggs elk herd has just begun. Atlantic Rim is the site of a proposed coal mine. This study is being conducted by Loren Ward, Rocky Mountain Forest and Range Experiment Station, and is a cooperative effort including the U.S. Forest Service, Wyoming Game and Fish Department, Bureau of Land Management, and Rocky Mountain Energy.

TECHNICAL SESSION

THE BIOPOLITICS AND MANAGEMENT OF CALIFORNIA TULE ELK 1982

BANKY CURTIS, California Department of Fish and Game, Sacramento, CA

Abstract: The current management program for Tule elk is examined. California Tule elk populations are estimated to have exceeded 500,000 before the advent of white man. Loss of habitat and conflicts with man reduced the population to less than 100 in the late 1800's. Protection and transplants stimulated recovery. By 1949 hunts had to be held to help control agricultural damage. As hunts continued, opposition developed and increased until 1971 when state legislation prohibited hunts until the California population exceeds 2,000. Populations in the Owens Valley and other areas exceeded range capacities forcing the development of new techniques to capture and transport penned and free roaming elk. Ten new elk herds have been begun since 1971 and the public sector continues to play a significant part in the management of this species. About $100,000 is spent for Tule elk management annually. The influence of special interest conservation groups will continue to grow rapidly and will soon become a major factor in managing many wildlife species.

EARLY HISTORY

The Tule elk (*Cervus elaphus nannodes*) is native to California and once roamed the large central valleys and the adjoining foothills in vast numbers. Reports from early explorers and estimates of range areas and grazing capacities suggest that early population levels were somewhere near 500,000.

These early herds ranged from the mountains in Kern County in the south to Cow Creek in Shasta County in the north. The eastern and western boundaries were the Sierra Madres and the Pacific Ocean, respectively (McCullough 1969).

Early predation was quite limited consisting of occasional elk being taken by grizzly bear, black bear or Indians and elk calves being taken by coyote or bobcats during the calving season. Population levels were probably determined by habitat conditions especially in the arid southern portion of their range.

THE DECLINE

The decline of the Tule elk began with the advent of white man. Exotic plants introduced with the Spanish Mission expanded rapidly in the extensive perennial bunch grass that provided much of the early Tule elk range. Competition with livestock from these missions also reduced the forage available for elk.

Heavy hunting by fur traders, the market hunting that developed to provide meat for the 49'ers and the direct conflict with early farmers and ranchers caused the early populations to crash.

In 1852 the California Legislature established a 6-month closed season on Tule elk in 12 counties. This regulation apparently had little impact as in 1860 Tule elk could be found only in the marshes of Tulare and Buena Vista Lakes.

In 1873 the California Legislature again attempted to help by giving the Tule elk complete protection. By this time there was considerable doubt if there were any elk left at all (Curtis et al. 1977). A deputy warden sighted a single pair of elk on the Miller and Lux Cattle Ranch in 1875. While there is some controversy as to whether or not all Tule elk are descendants from this pair, there is little doubt that very few Tule elk existed in 1875 (Tule Elk Interagency Task Force 1979).

THE RECOVERY BEGINS

Henry Miller of the Miller and Lux Cattle Ranch grew interested in the animals and provided protection. By 1905 the population was estimated at 145 and elk were causing considerable damage to grain, alfalfa, and corn crops (Merriam 1921).

Several transplants were attempted by Miller in order to reduce depredation and to establish new herd areas. Trapping success was limited and the mortality rate was high but elk were released in new areas. In 1914 the California Academy of Sciences became involved and by 1916, 146 elk had been distributed to 19 different locations.

Most of the early transplants failed and by 1960 only 3 Tule elk herds were in existence, the Tupman Reserve (near the original site on the Miller and Lux Ranch) containing about 32 head, the Owens Valley herd containing about 300 head and the Cache Creek herd northwest of Sacramento containing about 80 head.

EARLY MANAGEMENT 1950-1970

The Tupman Reserve consists of a 600-700 acre fenced enclosure where the elk are sustained in an artificial feeding situation. Management in the 1950's and 60's consisted of culling animals whenever the herd exceeded 32.

The Cache Creek herd is free roaming and situated on a large private ranch. Population levels are controlled by the rancher and poachers.

The Owens Valley herd however, presents a more complex problem. The herd begun in 1933 and 1934 expanded rapidly. In 1943, 143 elk were counted in an aerial census.

As the Owens Valley population grew so did the conflicts with agriculture. Elk damaged fences and crops of corn and alfalfa. In 1949 the first Tule elk hunt since 1863 was authorized. In 1952 the California Department of Fish and Game agreed to maintain the population between 125 and 275 animals by authorizing hunting permits in a public drawing. The dispute continued. The ranchers wanted to get rid of the elk and the proponents of the elk wanted to oust the ranchers. In 1961 the California Fish and Game Commission agreed to keep the Owens Valley herd below 300 animals. This level was acceptable to the ranchers and was the policy of the commission for several years.

In 1968 the Committee for the Preservation of the Tule Elk was organized and opposition to the policy grew. The Committee for the Preservation of Tule Elk opposed the hunting of Tule elk and proposed making much of the Owens Valley a Tule elk refuge.

A hunt was proposed in 1969 and a major battle developed. The commission finally approved the hunt but the Tule elk committee generated a media campaign that created much public opposition to the hunts.

THE LEGISLATIVE ERA

In 1971 the Fish and Game Commission based on the recommendation of Dr. Dale R. McCullough and his Owens Valley Tule elk study agreed to establish 490 as the maximum level for the Owens Valley elk population. The new policy called for 290 elk in the bottomland herds and 200 in the upland herds.

In 1971 the state legislature again became involved and enacted legislation that removed the authority for the Fish and Game Commission to hold a public hunt until the statewide Tule elk population exceeded 2,000 or the legislature determined that suitable areas to accommodate such a population could not be found. It also provided that the Owens Valley Tule elk population should not exceed the established carrying capacity of 490 (see Appendix I for complete text).

The Committee for the Preservation of Tule Elk then turned its attention to Congress in hopes of establishing a Tule elk refuge in the Owens Valley.

In 1972 the Department of Fish and Game, the Bureau of Land Management, the Inyo National Forest, and the Los Angeles Department of Water Power began a study of the Tule elk in the Owens Valley in order to develop a management plan.

In 1976 Congress after much discussion and deliberation decided against the Tule elk refuge and instead passed a resolution supporting California's legislative goal of 2,000, establishing the Interagency Tule Elk Task Force and directing federal agencies to cooperate with the state in restoring the Tule elk (see Appendix II for complete text).

THE DECISION

In 1977 the long anticipated moment arrived and the annual aerial census tallied 582 elk, 92 above the established capacity. The Department of Fish and Game faced a difficult decision. State law prohibited them from allowing the Owens Valley population to exceed 490 and the Commission could not authorize a hunt. The department had made several transplants from penned herds but no successful attempts had been made to capture a large number of Tule elk in the Owens Valley.

A frantic search for suitable transplant sites ensued but none were found. The decision was made. Uniformed Fish and Game personnel would eliminate the excess animals.

The reaction was dramatic. The Committee for the Preservation of Tule Elk mobilized and letters of protests were received from all over the United States. Pressure opposing this action was also exerted through members of Congress, the California Governor's Office, and the State Legislature.

Finally, offers of possible relocation sites began to come forth. Many were totally unreasonable but the more possible ones were evaluated and places to release the elk were found.

Once the necessary environmental documents had been completed the only remaining problem was capturing 92 free roaming Tule elk.

THE RELOCATIONS

A few elk had been captured by immobilizing them from a helicopter with a tranquilizing gun but it had never been done in any large scale operation.

A team of experts was assembled and the Tule elk relocation project was begun. The first expedition was accompanied by numerous members of the media including network television representatives. Workers used M-99 as an immobilizing agent and a sling under the helicopter to transport the animals to a base station. At the base station animals were treated with antibiotics, aged, weighed, and loaded into horse trailers. In addition, numerous blood, hair, and fecal samples were taken and some were fitted with telemetry collars. The capture process proved successful but expensive.

In the 1977-78 winter, 79 Tule elk were captured and relocated; 4 died during the capture operation and 9 died in the Owens Valley from other causes. The cost of capturing the animals was established at about $1,000 per animal. This cost included travel expenses, mileage, helicopter rental, drugs and medical supplies, and radio telemetry equipment.

In August 1978, the aerial census of 514 indicated the population was again in excess of the established capacity.

Using the same technique, 51 animals were captured and relocated. Technical advances in the sling and training of more personnel increased the efficiency of the operation and the cost dropped to about $800 per animal.

In 1979, 42 Tule elk were removed from Tupman Tule Elk Reserve State Park. A corral trap was constructed around the feed troughs and the animals were loaded through a loading chute without drugs.

In August of 1980, during the aerial census, 533 elk were counted. By now release sites were more available and acceptance of relocating the Tule elk was more widespread. There were however, some problems. The costs of helicopter contracts, gasoline, and manpower had made the projected costs extremely high and the animals capturd one at a time did not have adequate social bonds to hold the herd together at the release sites. Animals often split up and wandered off.

A new technique using the helicopter to herd the elk into a corral trap was developed. The first trap yielded 19 animals and the second 76. Additional elk had to be darted from the helicopter to balance sex ratios but the cost dropped from $750-1,000 per animal to about $300 per animal. The cows and calves were not immobilized but sampling was done in a darkened "squeeze chute".

In the 1980 project, 101 elk were captured and relocated with no mortalities. Subsequent monitoring has indicated a much greater tendency for the animals to remain in herd units (Curtis 1980).

This corral trap was again used in 1981 with the same success. Table 1 summarizes the Tule elk relocations since 1977.

The released elk have not been without problems. The stress of capture and change of habitats have been difficult for these new herds. Some unforseen problems have also arisen. The Point Reyes herd reacted to a copper deficiency and later to an outbreak of "Johnne's Disease". The Fort Hunter Liggett herd has been plagued by poaching, the Camp Roberts herd has had bulls attack and become entangled in parachutes, a portion of the Mt. Hamilton herd has begun causing extensive agricultural damage, and the Jawbone Canyon herd has all but disappeared.

Table 1. Tule elk relocations 1977-1981

Area	Date Released	Number Relocated	Source
Concord Naval Weapons Station	Jan. 1977	7	Tupman
Grizzly Island	Jan. 1977	8	Tupman
Concord N.W.S.	Nov. 1977	31	Owens Valley
Mt. Hamilton	Jan. 1978	16	Owens Valley
Lake Pillsbury	Feb. 1978	13	Owens Valley
Jawbone Canyon	Feb. 1978	17	Owens Valley
Point Reyes	Mar. 1978	10	San Luis NWR
Lake Pillsbury	Oct. 1978	25	Owens Valley
Mt. Hamilton	Oct. 1978	26	Owens Valley
Hunter Liggett	Dec. 1978	22	Tupmen
Camp Roberts	Dec. 1978	21	Tupman
Laytonville	Nov. 1979	10	San Luis NWR
Laytonville	Dec. 1979	5	San Luis NWR
Mt. Hamilton	Nov. 1980	21	Owens Valley
Lake Pillsbury	Nov. 1980	22	Owens Valley
Hunter Liggett	Dec. 1981	26	Owens Valley
Tupman	Dec. 1981	2	Owens Valley
Mt. Hamilton	Dec. 1981	2	Owens Valley
Point Reyes	Dec. 1981	3	Owens Valley

The following summarizes the current situation and estimates carrying capacities for each of the Tule elk herds in California (Bureau of Land Management 1981; J. Boggs pers.comm.):

Herd	Current Number	Maximum Allowable Population
Owens Valley	443	490
Cache Creek	120	200[a]
Tupman	63	32
San Luis NWR	34	40
Concord NWS	32	45
Grizzly Island	47	100
Mt. Hamilton	47	150[b]
Lake Pillsbury	70	150[b]
Point Reyes	20	300
Jawbone Canyon	6	---[c]
Camp Roberts	18	100
Hunter Liggett	29	375[b]
Laytonville	17	---[c]
California Zoos	15	15
	961	1982

[a] Dependent on major land purchase
[b] Estimate only - actual capacity to be determined by further study
[c] Insufficient data available

THE FUTURE

The future of Tule Elk Management is still in question but one point is clear. Public and political views will be a major factor in determining the nature of that program.

The pattern has been well established in California. If the public is not satisfied with the management program pressure is exerted upon the Legislature until the authority for the management of that species is removed from the State Fish and Game Commission. Similar situations have already occurred with mountain lion and bighorn sheep (Weaver pers.comm.).

Wildlife managers that work with politically sensitive species need to be aware of the views and desires of the public or they may be without a management program.

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APPENDIX I

STATE FISH AND GAME CODE SECTIONS PERTAINING TO TULE ELK

332. The commission may determine and fix the area or areas, the seasons and hours, the bag and possession limit, and the number of elk that may be taken under such rules and regulations as the commission may prescribe from time to time. The commission may not authorize the taking of tule elk until the total statewide population of such mammals exceeds 2,000 or it is hereafter determined by the Legislature, pursuant to the reports required by Section 3951, that suitable areas cannot be found in California to accommodate such a population in a healthy condition. Only a resident of the State of California over the age of 16 years and possessing a valid hunting license may obtain a license for the taking of elk.

The fee for the license may be determined by the commission but not to exceed fifty dollars ($50). The fees shall be deposited in the Fish and Game Preservation Fund and shall be expended in addition to money budgeted for salaries of the department, for the expense of enforcing the provisions of this section and the processing of the applications (Amended by Stats. 1971, Ch. 1250).

3951. The commission may authorize the taking of tule elk pursuant to Section 332. The department shall relocate tule elk in areas suitable to them in the State of California and shall cooperate to the maximum extent possible with federal and local agencies and private property owners in relocating tule elk in suitable areas under their jurisdiction or ownership.

The number of tule elk in the Owens Valley, presently the major habitat of such mammals, shall not be permitted to increase beyond 490, or any greater number hereafter determined by the department to be the Owens Valley's holding capacity in accordance with game management principles. However, tule elk from the Owens Valley may be relocated to other suitable areas within the state at any time to meet the department's responsibility under this section.

Department personnel may cull sick or inferior tule elk, but only when this is done for the protection, enhancement, and healthy increase of the species. Any such animal or animals so destroyed, shall be the subject of a written report to the Fish and Game Commission at its meeting immediately following such action, detailing the reasons therefore.

The Director of Fish and Game shall submit a report describing progress made in relocating tule elk, as herein set forth, to the Governor for transmittal to the Legislature no later than the fifth legislative day of the 1974 Regular Session of the Legislature and every two years thereafter. Such report shall also include not not be limited to:

(1) The population status of tule elk in California;
(2) Age and sex information;
(3) Condition of their ranges; and
(4) Other pertinent information.

(Added by Stats. 1971, Ch. 1250).

APPENDIX II

Public Law 94-389

Providing for Federal participation in preserving the tule elk population in California

Whereas, although tule elk once roamed the central valleys of California in vast numbers, the species became nearly extinct during the latter part of the last century as a result of its native habitat being developed for agricultural purposes and urban growth; and

Whereas, although around 1870 the tule elk population reached a low of approximately thirty animals, through the dedicated efforts of various citizen groups and individual cattlemen, the population has slowly recovered to a total of approximately six hundred animals, the majority of which may be found in free-roaming herds in the Owens Valley, at Cache Creek in Colusa County, California, a small number which are captive in the Tupman Refuge in Kern County, California; and

Whereas, in 1971, the California Legislature, recognizing the threat to the tule elk as a species, amended section 332 and enacted section 3951 of the Fish and Game Code which provide for the encouragement of a statewide population of tule elk of not less than two thousand, if suitable areas can be found in California to accommodate such population in a healthy environment, and further fixed the population of the tule elk in the Owens Valley at four hundred and ninety animals, or such greater number as might thereafter be determined by the California Department of Fish and Game, in accordance with game management principles, to be the Owens Valley holding capacity; and

Whereas the tule elk is considered by the Department of the Interior to be a rare, though not endangered, species by reason of the steps taken by the State of California; and

Whereas the protection and maintenance of California's tule elk in a free and wild state is of educational, scientific, and esthetic value to the people of the United States; and

Whereas there are Federal lands in the State of California (including but not limited to, the San Luis National Wildlife Refuge, the Point Reyes National Seashore, various national forests and national parks, and Bureau of Land Management lands located in central California, as well as lands under the jurisdiction of the Secretary of Defense such as Camp Pendleton, Camp Roberts, and Camp Hunter Liggett) which, together with adjacent lands in public and private ownership, offer a potential for increasing the tule elk population in California to the two thousand level envisioned by the California Legislature: Now, therefore, be it

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, that it is the sense of Congress that the restoration and conservation of a tule elk population in California of at least two thousand except that the number of tule elk in the Owens River Watershed area shall at no time exceed four hundred and ninety or such greater number which is determined by the State of California to be the maximum holding capacity of such area, is an appropriate national goal.

SEC. 2. The Secretary of the Interior, the Secretary of Agriculture, and the Secretary of Defense shall cooperate with the State of California in available for the preservation and grazing of tule elk in such manner and to such extent as may be consistent with Federal law.

SEC. 3. The Secretary of the Interior shall submit, on or before the first of March of each year, a report to the Congress as to the estimated size and condition of the various tule elk herds in California and the nature and condition of their respective habitats. The Secretary shall include in such report his determination as to whether or not the preservation of the tule elk herd at its then-existing level is, or may be, endangered or threatened by actual or proposed changes in land use or land management practices on lands owned by any Federal, State, or local agency, together with his recommendations as to what Federal actions, if any, should be taken in order to preserve the tule elk herds at the then-existing level or such other level as may be determined from time to time by the State of California.

SEC. 4. The Secretary of the Interior, in coordination with all Federal, State, and other officers having jurisdiction over lands on which tule elk herds are located or lands which would provide suitable tule elk habitat, shall develop a plan for tule elk restoration and conservation, including habitat management which shall be integrated with the comparable plans of State and local authorities in California. The Secretary's annual report to Congress shall describe the development and implementation of such plan.

HABITAT UTILIZATION AND ACCLIMATION OF INTRODUCED TULE ELK (*Cervus elaphus nannodes*) IN THE CENTRAL DIABLO RANGE OF CALIFORNIA

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Abstract: The Tule elk (*Cervus elaphus nannodes*) once occupied much of the grasslands of California. The pressures of the early settlers in the 1800's soon reduced Tule elk numbers to near extinction. Tule elk were given full protection in 1873 and the population numbered 28 by 1895.

In 1971, the California State Legislature enacted legislation which prohibited the public hunting of Tule elk until their numbers reached 2,000 or until the legislature determined that suitable areas could no longer be found to accommodate the elk in a healthy condition. With the elk numbers increasing, the California Department of Fish and Game continues to relocate surplus elk from one of the original relocation sites in Owens Valley to other areas of the state. There are presently 13 herds of Tule elk in California consisting of approximately 1,000 animals.

The Mt. Hamilton region is the site of our current research with introduced Tule elk. The study area includes both public and private lands in the Diablo Range east of San Jose, California. Our work began on March 3, 1981 and will continue until September 1, 1982. This research is funded by the California Department of Fish and Game.

The objective of this research is to study the acclimation of introduced Tule elk to their new environment by ascertaining critical factors in their habitat which promote or limit their survival. In order to do this, we are determining home range size, daily and seasonal activity patterns and critcal areas utilized by the elk for calving, rutting, summer and winter ranges. Information on natality and mortality is a prime concern. We are also examining daily and seasonal habitat utilization patterns as related to weather, topography, cover, forage, and the presence and activity of other mammal species.

There have been 4 introductions of Tule elk into the Mt. Hamilton region, all with elk originating from Owens Valley. The first introduction in January, 1978 consisted of 16 elk. The second occurred in November, 1978 with 26 elk. The third introduction was in November 1980 with 21 elk and a fourth introduction occurred in December, 1981 with 2 elk.

Of the original 42 Tule elk released in 1978, a total of 38 have separated into 4 herds throughout the Diablo Range spreading north, south, and northeast of the original release site. One group of 9 elk are located near San Antonio Reservoir in Alameda County. A second group of 10 elk are located in Isabel Valley on a privately-owned ranch. A third group of 10 elk are located near Pacheco Pass at the south boundary of Santa Clara County. A fourth herd of 9 elk has been reported in Livermore which has not been verified.

Data for this study is based largely upon elk introduced to this area in November, 1980 and December, 1981. Eleven of these elk were fitted with radio telemetry collars before release and 7 are collared at present. To date, these animals have remained in the same general area near the original release site, Horse Valley, in the central part of the range.

The elk are monitored using radio telemetry equipment 2 to 3 times per week on the ground and 1 time per week from the air. Elk locations are plotted on topographic maps. Latitude, longitude, elevation, temperature, relative humidity, and wind speed and direction are recorded for each ground location. Other data collected include identification of water sources, plants utilized, trails travelled, and counts of pellet groups and tracks.

Twenty-four hour observations have shown that the elk are active both during the day and at night. Elk activity includes feeding, resting, moving, standing, and rutting behavior. Over a 24 hour period, feeding is the primary activity with resting second and moving third. The rut was in progress during the months of August through November. The elk are most active at dawn and dusk and are least active in mid-afternoon when they may spend several hours bedded down.

Preliminary results indicate that the elk are utilizing 5 main plant communities: valley grassland, chaparral, foothill oak-woodland, valley oakwoodland, and oak savannah. The greatest percentage of elk activity has been recorded in the oak-woodlands. The elk seem to prefer bedding in oak groves where they spend several hours per day.

Most of the feeding activity has been in oak-woodlands where the elk have fed upon grass, browse such as oak leaves and pine needles, herbaceous forbs, and acorns. Digger Pine (Pinus sabiniana) is found in the foothill oak-woodland plant community. The percentage of any one plant species taken depends on the season, with grass most heavily utilized in spring and early summer and browse become more important in the fall and early winter. Early rain this fall has increased elk utilization of grass and herbaceous forbs to some extent.

Elk tend to travel along well utilized trails in moving from one plant community to another. These movements are usually in close proximity to water especially in late summer and early fall when this resource is in short supply.

A preliminary annual home range map for March through February, 1982 shows a home range size of about 22.4 km^2 (14 mi^2) for the herd as a whole, although some individuals have wandered outside this area. During this period, 2 collared female elk died and 1 young female and 1 immature spike disappeared from the herd. One collared bull died in November, 1980 shortly after release.

One calf survived the calving season. The calf was born during the first part of June in an area of foothill oak-woodland bordering on chaparral. It is possible that other calves were born but did not survive the calving season. Several cows left the herd and went into steep canyons and protected drainages, which is characteristic of calving behavior, but returned to the herd in June without calves.

The study area contains other large mammal species including black-tailed deer (Odocoileus hemionus columbianus), wild pig (Sus scrofa), mountain lion (Felis concolor), and domestic cattle (Bos sp.). The presence of cattle and of human activity cause the elk to move out of an area, but the elk do not appear to move in response to deer or pig.

Seasonal movements, thus far, indicate that cows divided into small groups in early spring and were located in oak-woodlands with steep terrain. These small groups reformed into a large herd in June or July and remained together until late November which marks the end of the rut. The summer was spent in open valleys with gentle rolling hillsides in valley grassland and oak-woodlands. At the end of the rut, the bulls left the herd and the cows travelled into steep canyons and creek drainages with generally heavy cover but have been observed on grassy plateaus since November.

We will continue to monitor this herd and will ultimately put forth suggestions for habitat improvement to insure their long-term welfare. The information obtained from this study will aid the Department of Fish and Game in establishing criteria for future elk location sites and will become the basis for an elk management plan for the Mt. Hamilton region.

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solely for wildlife purposes. Therefore, it becomes important to coordinate timber management practices that manipulate tree cover so that wildlife habitat goals are realized as well.

THE STUDY PROBLEM

Elk habitat on the Lakeside Ranger District was believed to be dramatically altered by a host of timber, rangeland, and recreational uses. In the summer of 1980 the District contracted with the University of Arizona to study conflicts created between human uses and elk requirements for habitat. The study was supported by a modest grant and designed to take place over a 14-month period (June 1980 - August 1981). The constraints of limited time and manpower required the study team to lay the groundwork that might eventually continue at some future time. It was the intention of the study team to develop, through acceptable research procedures, an initial effort that was relevant, tangible, and useable by the Lakeside Ranger District planning team. The basic assumption of the study was that good elk habitat management depends on how well we know the relationship of elk to their habitat and how well we can manipulate habitat to achieve elk habitat goals.

STUDY OBJECTIVES

A special strategy was needed to create a process for coordinating human uses with elk habitat maintenance activities. The strategy was expressed as 3 study objectives. The study's first objective was to conceptualize the landscape as a composition of physical units. These physical units are believed to provide elk with the requirements for survival. These units are interpreted from an aerial photo inventory of the study site. A second objective was to identify those physical elements that help facilitate the ongoing use and management of the landscape for recreational, rangeland, and forestry related values. The third objective was to produce management guidelines that serve to protect and mitigate negatively impacting uses within elk habitat.

SURVEYING THE STUDY AREA

The physical site features were perceived to be 1 of 2 kinds. There was the natural cover (vegetation, water, soil, etc.) and the manmade or man-influenced features. All survey work was conducted in a 2-phase process. Stereopaired aerial photographs (scale 4" = 1 mile) were used in phase one to delineate all specified surface cover types. In phase two, ground-truthing and ocular tests were conducted on a 15% sample to determine interpreter accuracy.

All information surveyed from aerial photos was than transferred to U.S.Geological Survey(USGS) base maps (scale 1:25,000 or 1:48,000). These base maps used a one square mile reference unit. These units were referenced using conventional township and range designations.

Five features relating to human uses to habitat condition were systematically mapped.

Circulation routes are found throughout the entire site. The 6 classes were separated using 2 criteria. A roadway was classified on the basis of building material (asphalt, cinder material, earth) and types of vehicular use (car, truck, four-wheel drive). Primary and secondary roads were asphalted. Light-duty roads and unimproved roads were made of cinder material. Jeep trails and pack trails were made of compacted earth.

COORDINATING LAND MANAGEMENT ACTIVITIES FOR ELK HABITAT MAINTENANCE ON THE SITGREAVES NATIONAL FOREST

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Abstract: In the summer of 1980 the Lakeside Ranger District contracted with the University of Arizona to study the conflicts created between human uses and elk habitat needs. A study area of 140 square miles was delineated. This area has all the normal kinds of human use activities found throughout the larger Lakeside District. It contains a diverse forest and rangeland ecosystem.

The project was designed to delineate elk habitat within the study area. Elk utilization of habitat and elk movements were then monitored for a 14-month period. The information developed from this effort was then used to formulate a rotation plan and management guidelines. A computer program and master mapping system were created in order to monitor habitat changes within harvest areas and across the study site.

INTRODUCTION

The Sitgreaves National Forest is located in the White Mountains along the Mogollon Rim in the east-central portion of Arizona. Rainfall, elevation, topography, and vegetation combine together to form one of the most attractive year-round environments to be found anywhere in the Southwest United States. Current trends in physical development indicate this area will continue to provide recreational and vacation opportunities and a new second-home market during the next decade. This increased use of land in traditional ways by greater numbers of people has brought land management on the Sitgreaves National Forest into a new level of operation.

The traditional land management procedures applied to the timber, rangeland, wildlife, and recreational resources are now made more complicated by increased presence of conflicting and overlapping use demands. This condition has traditionally been dealt with by employing the concept of multiple use. Multiple use is a concept of land management in which a number of products are deliberately produced from the same land base. Multiple use, however, requires the establishment of management priorities if it is to be considered as a viable concept.

The Lakeside Ranger District is required to produce land management plans that coordinate reliable information and management procedures in a way so as to mitigate or resolve these conflicts. This task can only be accomplished by employing the strategy of priority management. Timber management is the dominant land use activity on the Lakeside Ranger District, Sitgreaves National Forest. The rangeland resource is established as a second priority. Wildlife and recreational concerns are considered important but subordinant to timber and rangeland resources.

The basic assumption about wildlife habitat management in forests that are managed under the policy of multiple use is that it must be carried out in coordination with timber management (Thomas 1979). This is especially true when financial resources are directed towards the direct support of timber and rangeland activities. Wildlife habitat management in forests requires the manipulation of tree cover (Trippensee 1948). This is usually too expensive

Physical structures were classified into 2 categories. Residential structures were composed of 5 types. They were separated by type of use and size of structure. Miscellaneous structures were 1 of 8 types. Windmills, lookout towers, corrals, radio towers, excavation pits (2), utility lines and bench marks were included under this classification system.

Fence lines delineate rangeland allotments, inholdings and a various assortment of other property lines. Fence lines are believed to control cattle and influence elk movement.

Grazing allotment lines are physical-political boundaries representing management jurisdictions.

Recreational areas are sites known to be repeatedly used by recreationists for a variety of purposes. These sites were also mapped onto USGS maps.

The natural cover types were surveyed in a similar manner. Natural cover was classified as 1 of 3 types. There was forest cover, rangeland meadow cover, and water. Forest cover was mapped as evergreen plants (E), deciduous plants (D), or shrubs (S). Equal mixtures of E and D were designated as (M).

These plant cover types (E, D, M) were interpreted to have one of four height classes. Class 1 was 5-20 feet. Class 2 was 20-60 feet. Class 3 was greater than 60 feet. Class 4 was a mixture of any of the former 3 class heights.

Plant cover types were interpreted to have 1 of 3 canopy covers. Type A was 10%-30% canopy closure. Type B was 30%-80% canopy closure. Type C was a 80% canopy closure.

The rangeland meadows were either RG1 or RG2. RG1 are grasslands of 80% cover with trees and shrubs making up less than 20% cover. RG2 are grasslands of 80% cover with the remaining area in open bare ground.

Water was mapped as either tanks (T), springs (S) or earthen impoundments (W). Drainageways, whether wet or dry, were mapped separately under a stream order system.

The delineation and documentation of human elements and natural cover types formed a baseline inventory. Inventories are made more useful for management planning when they can be compiled, retrieved and updated easily. HABSCAN (Habitat Scan) was developed exclusively for this purpose. The program is designed to search out single pieces of information (i.e., stream channel) within any given square mile area. It can also compile information on a category basis (i.e., all roads within any given area). Finally, it can comprehensively search out all information inventoried for any given area.

Together the human features and the natural cover features can be combined to form the basis of a new conceptualization for the land manager. Forest stands, rangelands, and human use elements can now be set up for assessment as various kinds of elk habitat. The study team searched the literature in order to define elk habitat components.

HABITAT REQUIREMENTS DEFINED

Optimum habitat for elk is defined as the amount and arrangement of cover, water, and food that result in the maximum possible proper use of the maximum possible area by the animal (Thomas et al. 1979). Cover components for elk are defined as thermal cover (winter and summer) and hiding cover. Food for elk is either forage areas or browse material. Water must be freestanding and potable for elk.

Elk must maintain a nearly constant body temperature. Heat loss is accelerated when the elk's body temperature is greater than the ambient temperature. Heat is absorbed by the animal when the ambient temperature is greater than its body temperature. Elk can increase or decrease heat production by adjusting its physical activity and its metabolic rate (Moen 1973). Elk can also position themselves with respect to vegetative cover so as to achieve a thermal-neutral zone (Black et al. 1976). Summer thermal cover shields solar radiation from the elk thereby allowing for heat loss from the animal (Edgerton and McConnell 1976). Winter thermal cover retains ambient temperatures allowing for minimal heat losses from elk (Beall 1974, McEwan and Whitehead 1970). Hiding cover is defined as vegetative cover capable of hiding 90% of a standing elk from the view of a human at a distance equal to or less than 61 m (200 ft) (Thomas et al. 1979).

Forage openings include all natural and man-made openings in forest stands that do not qualify as cover. Forage openings are comprised of grasses and forbes that provide elk with protein. Browse materials are composed of deciduous shrubs and tree seedlings. The optimum mix of forage to cover types varies from region to region. Thomas et al. (1979) found an optimum mix to be 60% forage, 40% cover.

Potable water is believed to be important to elk especially in the Southwest coniferous forests. Studies in Montana by Marcum (1975, 1976) indicate that elk make disproportionately heavier use of areas within 1050 meters of water. Mackie (1970) estimates optimum habitat to contain potable water within 0.8 km (0.5 miles) of any point.

VEGETATIVE COVER AS ELK HABITAT

The study area was now delineated as a composition of physical units. These physical units represent various kinds of vegetative cover that are perceived by the forester to be the timber resource. Vegetative cover is perceived by the wildlife manager to be the habitat resource. It is important in terms of future land management that the habitat and forest resource be conceptualized as one entity. Therefore, it was important to identify those stand conditions within land types as specific elk habitat components.

The physical units now had to be designated as potential habitat for elk utilization. Cover components were interpreted from the inventory maps to be 1 of 3 kinds of thermal cover. Hiding cover per se was not mapped. Good thermal cover is any vegetative canopy exceeding 80% canopy cover. Fair thermal cover ranged from greater than 30% to less than 80% canopy cover. Poor thermal cover is composed of less than 30% canopy cover.

Water was directly interpreted from the baseline inventory. No translation was needed. Food components were interpreted from the inventory maps to be either forage or browse types. Forage openings were defined as rangeland meadows (RG1 or RG2). Browse areas were mapped as deciduous (D), shrub (S), or mixed (M) plant cover, 5-20 feet high Class 1 (D1,S1,M1).

A separate research was carried out to document elk sightings within representative portions of the site. This field work involved over 700 man-hours of time on site. This was the primary means of corroborating elk utilization with habitat components (Delguidice and Rodiek 1982). The data generated over the 14-month period was not considered to be indicative of long-term elk utilization patterns. An extended monitoring period could produce data reflecting the true relationship between elk habitat and elk use. This knowledge can lead to the creation of management guidelines designed to maintain elk habitat under a multiple use system. A preliminary analysis was conducted using available information.

COORDINATING LAND MANAGEMENT ACTIVITIES

Two products are needed to coordinate land management activities with elk habitat maintenance. First, a hypothetical 120-year rotation plan was designed for the study area (Table 1). Actual plans should be coordinated with Lakeside District personnel. The purpose of this plan was to demonstrate how timber management practices can be staged within the total study area. Each successive plan can then be coordinated with all others so as to maintain habitat over time within given areas. A set of management guidelines were then coordinated with this rotation plan. These guidelines concentrated on habitat component treatments, debris and downed woody material, riparian zones, and roadways on site (Appendix I).

The HABSCAN computer program can update and monitor actual changes. Changes to habitat can be assessed within harvest zones and in relocation to the status of habitat through the study site. This provides the land manager the capability of comparing any habitat change to the overall habitat condition on the forest.

CONCLUSIONS

The Sitgreaves National Forest is managed under the concept of multiple use. This means the simultaneous provision of wood, water, recreation, and wildlife as required by the Multiple Use Sustained Yield Act (U.S. Laws, Statutes, etc., P.L. 86-517, 1960). Priorities for management place wildlife in a subordinate position relative to timber and livestock values. In terms of the Sitgreaves National Forest, the options for wildlife can be realized through a coordinated effort where habitat and the forest resources become one and the same entity. Fundamental to this effort is the identification of habitat components essential to selected wildlife species. Therefore, wildlife and their relationship to habitat within the managed forest must be clearly demonstrated within land type and stand condition. Management tools must be developed to comprehensively assess the status of habitat and the changes in habitat due to forest management practices. These tools must be cost-effective and available to the land manager and field forester.

The forest and rangeland ecosystems of the Sitgreaves National Forest and the growing complex of land use demands placed on them is representative of many forest lands. Land management of these sites must be given the highest priorities in terms of financial support and professional procedures. These lands represent one of the last remaining opportunities for managing our future welfare. We must make every attempt to manage these lands in the best possible manner.

Table 1. Hypothetical Rotation Schedule

Stage	Condition Prior to Action	Action Taken	Components Present After Action Taken	Time Period (years)
1	Mature harvestable stand	Clear cut	Forage	0-10
2	Dense seedlings 0-7′ tall, hiding cover	25% thinned at 20 years	Hiding cover maintained for 30 years (10-40)	10-40
3	Thinned saplings and poles 40′ tall, thermal cover	Natural tree growth crowns fill-in, stand consists of even-aged poles	Thermal cover	40-50
4	Even-aged poles >40′ tall	Commercial thinning 30% of stand	Forage and small saw timber	50-80
5	Class B canopy (70%), thermal cover 14-20" DBH	Maintain mature canopy trees	Thermal cover	80-90
6	>14" DBH mature, thermal cover	30% thinning, some thermal removed	Forage areas in openings	90-100
7	Thermal restored 18-22" DBH	Maintained or harvested	Thermal or forage	100-200

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APPENDIX I

HABITAT GUIDELINES FOR COORDINATING TIMBER MANAGEMENT WITH ELK HABITAT ON THE LAKESIDE RANGER DISTRICT, SITGREAVES NATIONAL FOREST

GUIDELINES FOR ELK HABITAT MANAGEMENT

Assumptions

1. Forage, water and cover are the primary habitat factors that limit elk populations.

2. The type, amount and interspersion of forage, water and cover can be planned for so as to provide elk with predictable habitat requirements.

3. Habitat requirements for elk are of paramount importance in long range silvicultural planning and in the more immediate range--timber harvest planning.

4. Log slash and downed woody material influence elk use and elk movement within a given area.

5. Elk habitat is critical on winter range and summer range. Competitive uses reduce available habitat to elk by rendering it as either unuseable or unavailable.

6. Forage and cover requirements should be considered in both silvicultural and timber harvest planning.

7. Habitat suitability for elk can be evaluated by the ratio of cover areas to forage areas within the harvest area and immediately adjacent to it on all sides.

8. The ratio of cover to forage areas for silvicultural planning must take into account the condition of the stands by type for the entire areas throughout the time frame of planning to be meaningful for elk herds.

9. Roads left open to vehicular access impact elk utilization of any given area.

Guidelines

Optimum elk habitat is the amount and arrangement of cover and forage areas that results in the maximum proper use of the maximum possible area by the animal. This occurs when the greatest possible area is used and the vegetation is utilized to the maximum without deterioration.

1. The ratio of approximately 50% in cover to 50% in forage areas of proper size and arrangement approaches optimum habitat. (Sitgreaves Forest Study Area)

2. Elk require water in the arid Southwest. Optimum habitat on the study area includes potable water within 1.0 miles of any given point (estimates from study site).

3. Optimum hiding cover for elk is defined as vegetation capable of hiding a standing adult elk from the view of a person at a distance greater than 150 feet (1 sight distance).

4. Hiding cover patches should not be separated by open spaces exceeding 5 sight distances.

5. Thermal cover is defined as vegetative canopy and associated stem and branch structure which modifies the ambient air temperature for elk located within that cover patch.

   Poor thermal cover = < 30% canopy closure

   Fair thermal cover = 30% - 80% canopy closure

   Good thermal cover = > 80% canopy closure

6. Optimum size of good thermal cover patches for elk on the study area were estimated to be 10-20 acres in size within a larger site of 30-60 acres in size. These sites also contain forage, water and poor to fair thermal cover patches.

   In other words, any given study site should be made up of:

   1/3 = Good thermal cover min. size 10 acres
   1/3 = Forage + (potable water avail.)
   1/3 = Poor + Fair thermal cover min. size 10 acres

7. Forage enhancement should be encouraged through timber management practices in open areas, along rut roads and under forest canopy.

8. Calving areas should be identified and kept free of timber harvesting, grazing and recreational uses for a reasonable period of time prior to calving season and after calving season ends.

9. Cattle enclosures should be developed around water impoundments so that at least 50% of the shoreline (high water mark) and aquatic vegetation is left for wildlife use.

10. Logging roads and all roads other than primary and secondary roads should be rendered closed to vehicular traffic. These determinations can only be made after considering the roads' locations within various portions of elk habitat.

11. Logging cuts should always leave hiding cover strips around their perimeters so that harvest areas are integrated into surrounding forest areas.

DEBRIS AND DOWNED WOODY MATERIAL GUIDELINES FOR TREATMENT ON ELK RANGE

Dead and downed woody material may be described as unsalvaged mortality. The utilization of this material is an important objective of good timber management. It is also considered as a form of hiding cover for elk utilizing newly cut areas within the forest. This material must be considered as a fire hazard. Guidelines set forth here are designed to render downed woody material (logs, branches, stems, stumps, bark and limb piled, root clumps) as positive elements in habitat utilized by elk.

Assumptions

1. Downed woody material can prevent elk from traveling through a given area. Obstacles to travel should be considered as unnecessary elements within the managed forest.

2. Downed woody material should not constitute hazardous fuelwood conditions.

3. Debris and downed woody material can prevent forage and seedling regeneration on the forest floor.

4. Some debris can actually favor elk use over specific human uses. This situation must be assessed against other desired uses.

Guidelines

1. Natural downed material should not constitute a fire hazard nor a regeneration problem nor a travel obstacle to elk.

2. Timber harvest debris should be limited to slash piles of specific dimensions. These piles are created to collect and dispose of excess woody material (usually burning).

   Type 1. 15 yards in diameter (45 feet)
   Less than 8ft. high
   Underlaid with temperature resistant material (sand gravel base)

   Type 2. 5 yards in diameter (15 feet)
   Less than 8ft. high
   Underlaid with temperature-resistant material

3. Slash piles should be located so that burning and treatment after burning (forage enhancement) can be readily implemented.

4. Access to water should be maintained.

5. Woody debris created by timber management should never be placed in or along the wetland/riparian zone.

6. Slash pile placement should be strategically selected by harvest and planning personnel.

RIPARIAN ZONE TREATMENTS GUIDELINES FOR TREATMENT ON ELK RANGE

Riparian zones can be identified by the presence of vegetation that require free or unbound water or conditions that are more moist than normal. Wetlands and hydric vegetation were for a significant portion of time during the year. Together these two interrelated zones provide elk with water and forage resources.

Guidelines for treating these zones are designed to increase productive values (forage) and decrease destructive uses within these zones.

1. Road construction which traverses or runs within these zones must be given special consideration. Soil, vegetation, water quality and temperature variables should be identified prior to disturbance.

2. Any unavoidable disturbances should be mitigated so as to return these zones to original structure and function after disturbance has been completed.

3. Access to water should be carefully selected. Livestock and elk should be provided with separate access points to common water sources.

4. Forage enhancement schemes should be planned for in and around free flowing water courses. Grazing rotation schemes could easily compliment this activity.

5. Barbless top wire fences should be used around water impoundments.

6. Seeps and springs should be fenced so that no large animal can disturb the surface flow from the underground source.

7. The ratio of water to forage areas should be maintained and over time, increased for both livestock and wildlife.

8. Forest hiding cover should be maintained and developed around water impoundments.

9. Forage enhancement should be designed for portions of the most promising water impoundments.

10. Develop separate water sources for recreational uses. Avoid human activity concentrations around water impoundments whenever possible.

A HABITAT ANALYSIS OF SPRING-SUMMER ELK RANGE ON THE APACHE-SITGREAVES NATIONAL FOREST, ARIZONA

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Abstract: A 99-km^2 area in the southeastern portion of the Apache-Sitgreaves National Forest, Arizona, was identified as spring-summer elk range. Elk use occurred predominantly above 2310 m, in the southcentral portion of the site. Calving activity occurred between late May and the end of July. Solitary adult females and calves were observed with increased frequency above 2280 m. Elk use of these upper elevational zones, during those periods of increased human-related activity, indicated the importance of the area to elk.

The area is dissected by rut roads, fence lines, and utility lanes. Forests comprise 92% of the study area. Dense timber stands accounted for almost half of these forests, and existed in greatest proportion in the upper elevation where highest elk use was documented. Elk were observed feeding in open meadows significantly ($P \leq .005$) more during early spring than late spring-summer. Elk use of forests increased from 50.88% during early spring to 82.06% during late spring-summer.

ACKNOWLEDGMENTS

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INTRODUCTION

A comprehensive habitat analysis is an important step in the ecological study of wildlife species (Andrewartha and Birch 1954). This analysis should include investigations into the physiography, climate, soil, vegetation, and other components of the habitat mosaic bearing some influence on the animals' use of the area.

Most free-ranging elk (*Cervus elaphus*) are associated with forested land (Lyon 1971, Pedersen et al. 1980, Ward 1980), and analyses of elk habitats are increasing in direct response to increased human presence and impact upon these forested lands (Morgantini and Hudson 1979). Recently, elk research has been involved with the analysis of habitat from a new perspective, the elk's utilization of the existing habitat components (Lyon 1980, Pedersen et al. 1980).

This study originated from an extensive elk habitat - human impact study in east-central Arizona. The purpose of this study is to (1) identify and describe spring-summer elk habitat, including an examination of man-influenced alterations of the site through construction; (2) examine elk use habitat types; (3) provide information concerning calving activities; and (4) lay the groundwork for future, more detailed examination of elk requirements-habitat relationships. The study concentrates on the period from March to October, 1981, although data were collected from May, 1980, through October, 1981.

STUDY AREA

The study area lies within the southeast corner of the Apache-Sitgreaves National Forest (ASNF) of east-central Arizona, 34° N, 109° W (Fig.1). The area encompasses approximately 99 km^2.

Topography and Soils

The area is characterized by rolling terrain, with elevations ranging from 2219 m in the northwest to 2704 m in the southeastern portions of the site. Mountain peaks greater than 2432 m are interspersed throughout the study area.

The soils are comprised principally of the Gordo series, formed from more recent extrusions of lava and basaltic ejecta than the surrounding areas. These soils have more litter and a thicker A horizon than the semiarid soils at the lower elevations outside the study area boundaries. These differences are probably caused by differences in plant production. Higher precipitation and a lower rate of decomposition of organic matter because of lower temperatures, are the primary factors influencing the plant production (Anonymous 1981).

Climate

The site exists in an upper climatic zone described as subhumid. This area receives a mean annual precipitation of 50.8 - 101.6 cm, a mean annual temperature of 1.67° - 71.78°C and a frost-free period ranging from 80-130 days (Anonymous 1981). Average monthly temperatures during the study conformed closely with normal temperatures (Fig. 2). Precipitation, however, was noticeably lower than normal from October, 1980, to mid-January, 1981, and substantially higher from February to mid-March, 1981 (U. S. Weather Bureau 1980 and 1981) (Fig. 3).

Vegetation

Lowe (1964) characterizes this area as belonging to the Transition and Canadian Life Zones. The Transition Zone is equivalent to the ponderosa pine (*Pinus ponderosa*) forest. Pure stands occur most commonly between 2128 m and 2432 m. The lower limit of the ponderosa pine forest is the lower elevational limit of the entire coniferous forest formation within Arizona. Plant-available soil moisture is the most direct factor affecting this lower ecological limit. Gambel oak (*Quercus gambeli*) is the tree most commonly associated with the pines. Trembling aspen (*Populus tremuloides*) may be scattered or exist in large stands on old burns, usually above 2280 m. Pinyon, juniper, and big sagebrush (*Artemisia tridentata*) may be associated with the pine in the lower portion of the study area, between 2128 m and 2280 m. Douglas fir (*Pseudotsuga menziesii*) is occasional to frequent above 2128 m. These ponderosa pine stands are also rich in shrubs and forage cover in many areas.

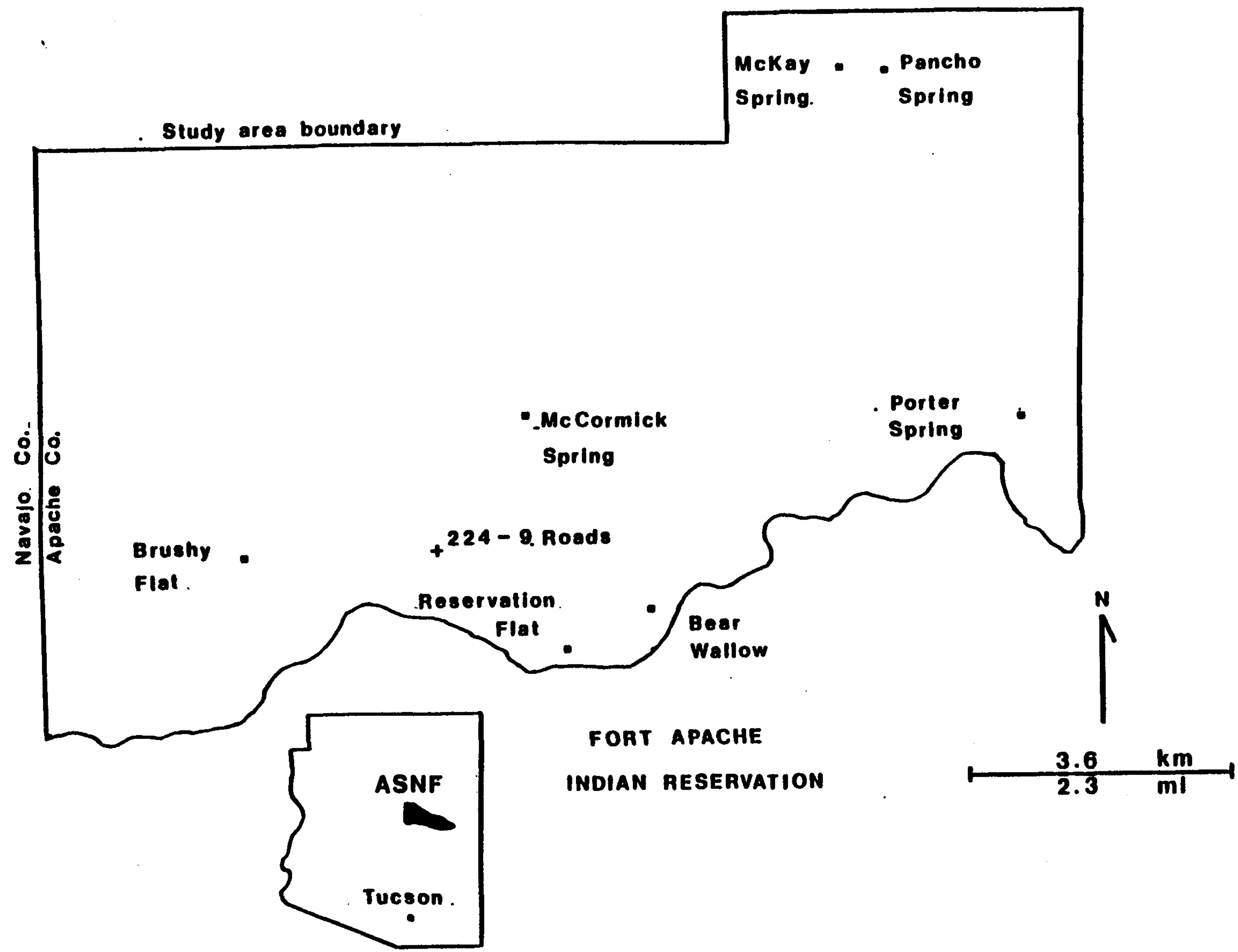

Fig. 1. The Apache-Sitgreaves National Forest (ASNF) study area, in the White Mountains, Arizona.

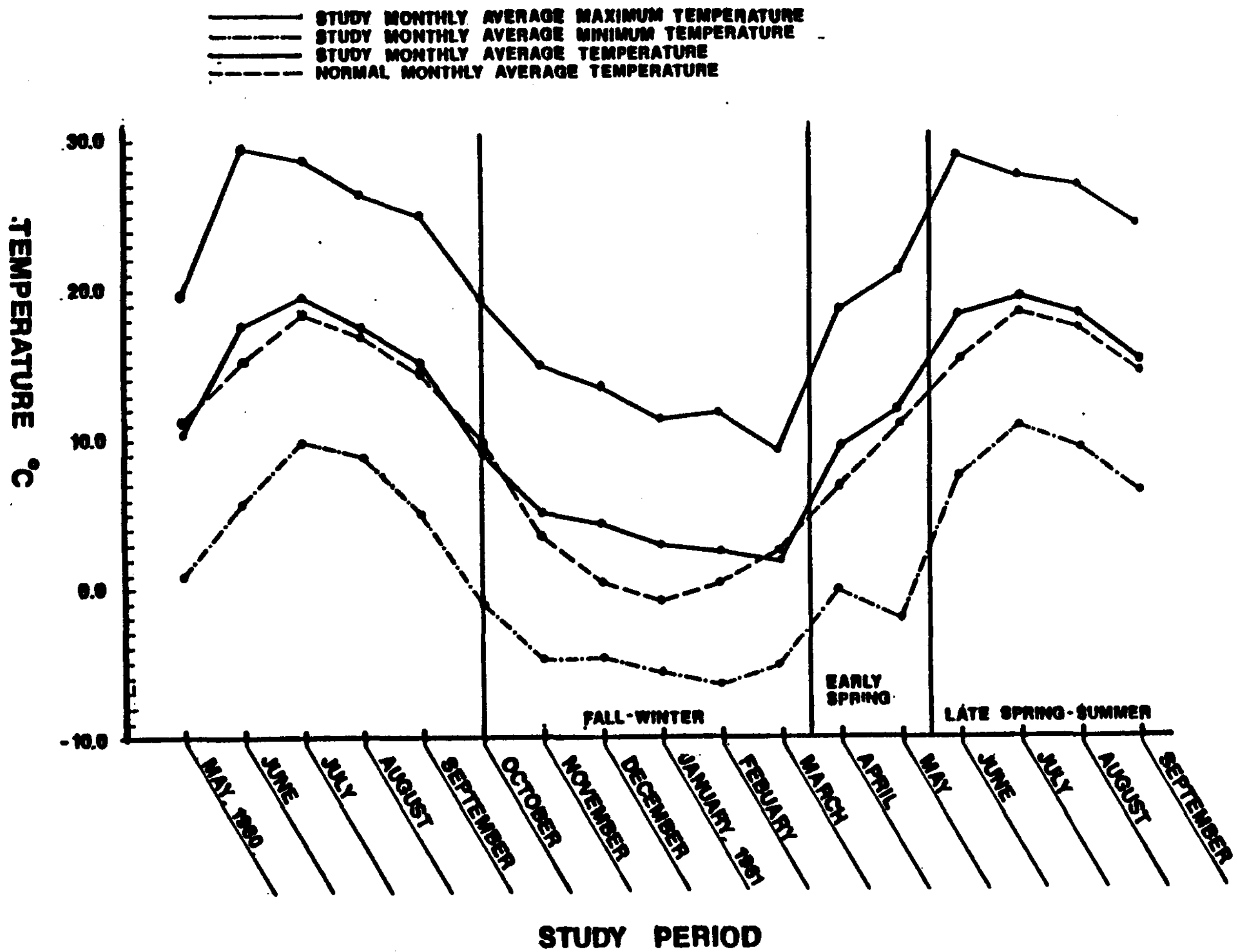

Fig. 2. Comparison of normal monthly average temperatures (based on 40 years of data) to monthly average temperatures during the study (U. S. Weather Bureau 1980 and 1981)

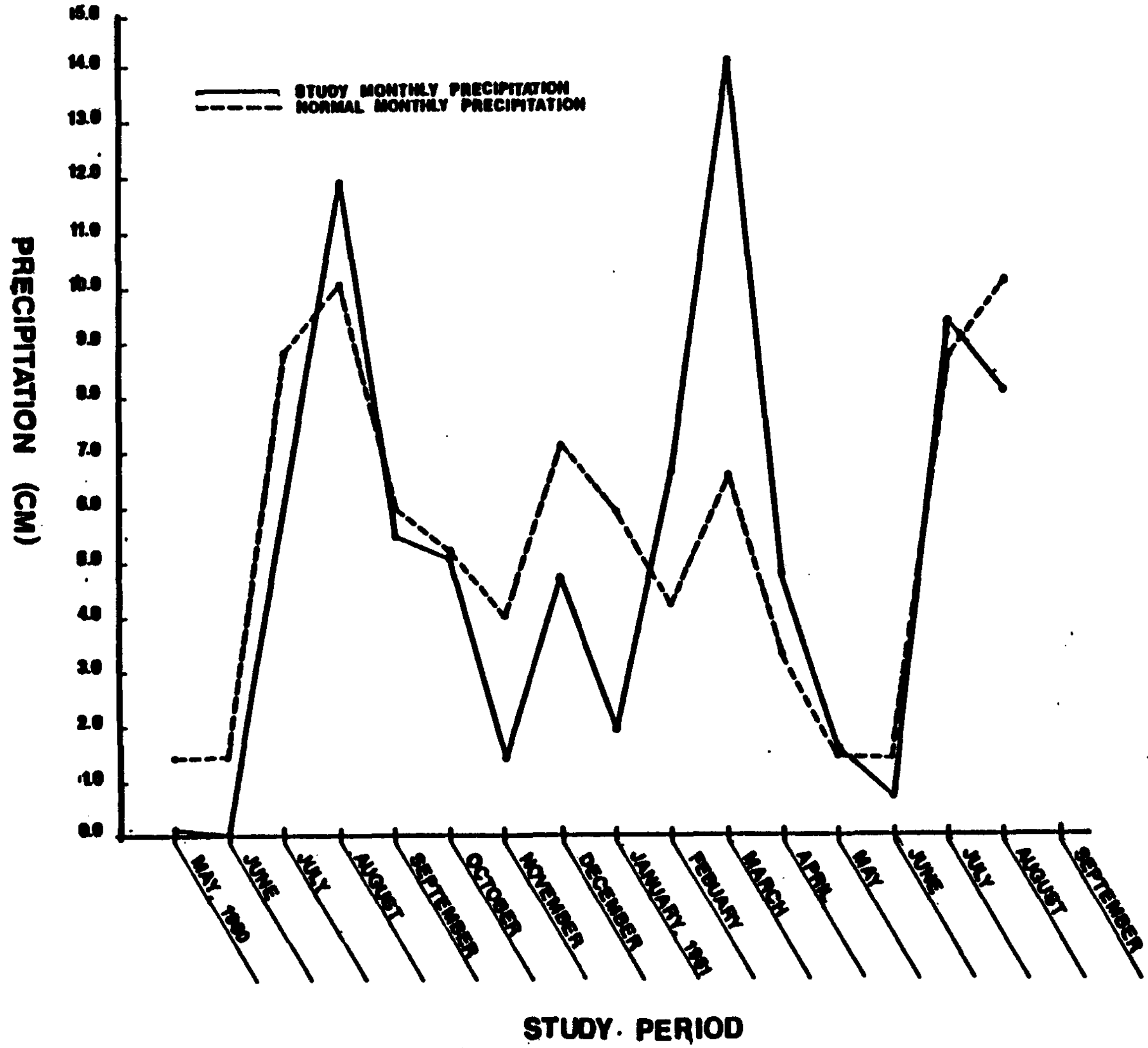

Fig. 3. Comparison of normal monthly precipitation (based on 40 years of data) to monthly precipitation during the study (U. S. Weather Bureau 1980 and 1981)

The Canadian Zone is identified by fir forests consisting of mixed species. Douglas fir and white fir (Abies concolor) are the principle tree species, although Englemann spruce (Picea engelmanni) and blue spruce (Picea glauca) are also scattered throughout these forests. Ponderosa pines are often present, though confined more to ridges and southerly exposures. The ponderosa pine also exist along the edge of the fir forest where the two forests merge in the continuum (Lowe 1964). The fir forests on site occur on rugged terrain. Gambel oak, trembling aspen, and New Mexican locust (Robinia neomexicana) are browse species associated with the Canadian Zone.

Timber and Range Management

Sustained and merchantible timber production is the primary management objective of the U.S. Forest Service. Areas are entered once every 20 years for sawtimber harvests and intermediate cuts (Burbridge and Neff 1976). The forests are basically managed for even-aged stands. Aesthetic and wildlife considerations have resulted in uneven-aged management along heavily utilized roads, however. Clearcutting, selective cutting, and controlled burns are traditional practices utilized within the ASNF.

The site is comprised of entire and portions of 7 grazing allotments. Cattle grazing within the allotments is permitted from June 1 through October 30, primarily under a deferred rest and complete rest rotation system (R.J. Peterson, USFS, pers. comm.). At least one pasture in an allotment is rested a year.

Wildlife

The area exists within Wildlife Management Units 1 and 3B (Arizona Game and Fish Dept. 1980). Arizona classifies 10 species of animals as big game. Seven of these species inhabit the study area including; mule deer (Odocoileus hemionus), black bear (Ursus americanus), and Merriam's turkey (Meliagris gallopavo). Pronghorn antelope (Antilocapra americana), mountain lion (Felis concolor) and Coues white-tailed deer (Odocoileus virginianus couesi) are also occasionally observed.

METHODS AND MATERIALS

Three seasons were recognized based upon noteable differences in monthly average temperatures. These were; early spring (March 15-May 15), late spring-summer (May 15-October 1), and fall-winter (October 1-March 15) (Fig. 2). Fall-winter weather data are included to provide a complete concept of temperature and moisture conditions during the entire period of data collection. Weather data were obtained from the U. S. Weather Bureau's station at McNary, located 4.83 km off the study area at an elevation of 2219 m.

Habitat Inventory

An elk habitat-oriented classification system (Table 1) was utilized for an air photo-interpretation of the study area. The purpose of this classification system and photo-interpretation was to delineate and inventory cover types (vegetation), forage openings and other naturally-occurring and man-made habitat components (Carneggie and Holm 1977, Anderson et al. 1980, Pedersen et al. 1980). U. S. Forest Service natural color photographs (1:15840 scale) were utilized for the interpretation.

Table 1. Elk habitat-oriented classification system for air photo-interpretation of study area in the Apache-Sitgreaves National Forest, Arizona.

Forest stand

Vegetative type	Canopy closure (5)
D . . . Deciduous	A . . . 10 - 30 %
E . . . Evergreen	B . . . 30 - 80 %
M . . . Mix	C . . . > 80 %
S . . . Shrubs	

Height (ft)

1 . . . 5 - 20

2 . . . 20 - 60

3 . . . > 60

4 . . . Mixed (any two)

Forage Openings

Fo <10% canopy closure

Drainageways

DW

Water Sources

S . . . Spring

T . . . Tank

L . . . Lake

W . . . Other water impoundment

Man-made

Points . . . structures

Lines . . . roads, fence lines, utility lanes

Areas . . . recreational areas

Interpretors using mirror stereoscopes ocularly estimated forest canopy closure classes with 90% confidence. Estimations were verified by dot grids. Stand height was also interpreted by ocular estimation. Six trips (18 days) to the field for ground-truthing photo-interpreted data, included checking stand heights with a height finder. Estimates of height class proved to be accurate.

Identification and location of natural and man-made habitat components were field checked. U.S. Geological Survey (USGS) and U.S. Forest Service (USFS) maps provided supplemental data in regard to man-made physical features and structures.

Photo-interpreted data was transferred from photo-overlays to USGS 1:24000 scale base maps, utilizing a zoom-transferscope. There was some loss in accuracy of photo-interpreted data where adjacent overlays were patched together in the transfer process. Cover type information was stratified by differential shading of the 3 canopy closure classes, regardless of height and vegetative type. Total areas of cover types and forage openings were individually planimetered and logged as part of the inventory. Areas of recreation sites and linear measurements of fence lines, utility lanes, and logging (rut) roads (3 types) were inventoried and logged by 2.59 km^2 section. The base maps were reduced to 1:48000 scale and composite maps of the site were prepared.

Elk Observations

Observation of elk groups and documentation of fresh pellets, tracks and bedsites were utilized to determine use of an area by elk. The principal observational technique involved tracking on foot and horseback. Early morning and evening road counts (Davis and Winstead 1980) were driven during June and August, however. This technique permitted more systematic observation of the study area and a more valid examination of elk distribution. The study area was divided into three 30 km^2 segments for purposes of the road counts. These segments differed with respect to their stand canopy closure, mosaics, and range of elevations.

Group composition, activity exhibited, and habitat type utilized (Franklin and Lieb 1979, Waldrip and Shaw 1979, Pedersen et al. 1980) were recorded on field information sheets for each elk group observed by the author. Supplemental elk observations were reported by Forest Service personnel. Locations of all elk observations were plotted on a map of the study area within 16.2 ha accuracy.

Changes in group composition and knowledge of the social biology of elk (Murie 1951, Boyd 1978, Franklin and Lieb 1979, Waldrip and Shaw 1979) were used to examine the occurrence and location of calving activities. Adult cows, often accompanied by their yearling female offspring, have been reported leaving cow groups during the early summer months to calve (Boyd 1978, Franklin and Lieb 1979, Waldrip and Shaw 1979). These researchers and others have also found yearling and subadult males simultaneously leaving cow groups to form bull groups. This further reduced mean size of cow groups observed during the calving season. Periods of absentism of calving females and some young males ranged from 1-6 weeks (Franklin and Lieb 1979). Calving activities during this study are defined as parturition and initial rearing of calves. Observations of solitary adult female elk, an adult female accompanied by a yearling, and calves were used as indicators of calving activities. Murie (1951) found that cow elk remain within a few hundred meters of their newborn calf. Based upon this premise, a "predator call" was directed towards solitary females upon observation, in an attempt to elicit defensive behavior. This type of response was interpreted to be indicative of a calf in the immediate vicinity.

Five habitat types were recognized during this study. Forest stands possessing canopy closures of the classes defined in the habitat classification system (Table 1), comprised the 3 forest types. Forest openings with areas greater than 0.60 ha (micro-openings) were the other 2 habitat types. The habitat types utilized and activities exhibited by elk upon observation, were entered on key-punch cards at the University of Arizona.

Vegetational Measurement

The point-centered quarter vegetation sampling method (Cottam and Curtis 1956, Dix 1964) was utilized to measure the relative frequencies and densities of the 2 or 3 dominant plant species on 6 openings and as a general inventory of the other species present.

Adjacent hiding cover was measured on 4 sides of the openings. The technique involved measuring 61 m into the adjacent forest stand and ocularly estimating if vegetation would hide 90% of a standing adult elk (Thomas et al. 1979). Vegetation possessing this capability at 61 m or less was characterized as optimum hiding cover. Vegetation not possessing this capability was described as less than optimum.

Data Analysis

Elk distribution measured by road counts was plotted by number of elk observed per kilometer of route driven. Data were analyzed per 2-week periods in each of the 3 designated areas to reduce bias due to weather and elk activity changes (Davis and Winstead 1980).

The determination of a critical-use elk area was based predominantly upon the frequency and timing (calving season) of observed elk use. Documentation of fresh physical evidence was also an important consideration. A 3-way contingency table of habitat type utilization data was tested by chi-square to detect differences in elk use for feeding and traveling, by season. Data from the 3 forest types and micro-openings were combined and tested against data from open meadows. Data from the 3 forest types were tested to detect differences in their use by season and activity. Two-way contingency tables of data were also tested to detect differential elk use of open meadows and forests for a specific activity by season.

RESULTS

Areas Frequently Used by Elk

Critical-Use Elk Areas. The study area, particularly its upper elevational zones of spruce-fir and ponderosa pine, was persistently utilized spring-summer habitat by elk. Reynolds (1966a, 1966b) and Patton (1969) have made similar observations of elk use of such ecosystems in various parts of Arizona and New Mexico.

Figure 4 illustrates the locations of 114 observations of elk groups recorded by season. The observations map (Fig. 4) clearly shows the heavy use elk made of the elevational zones above 2310 m in the south-central and

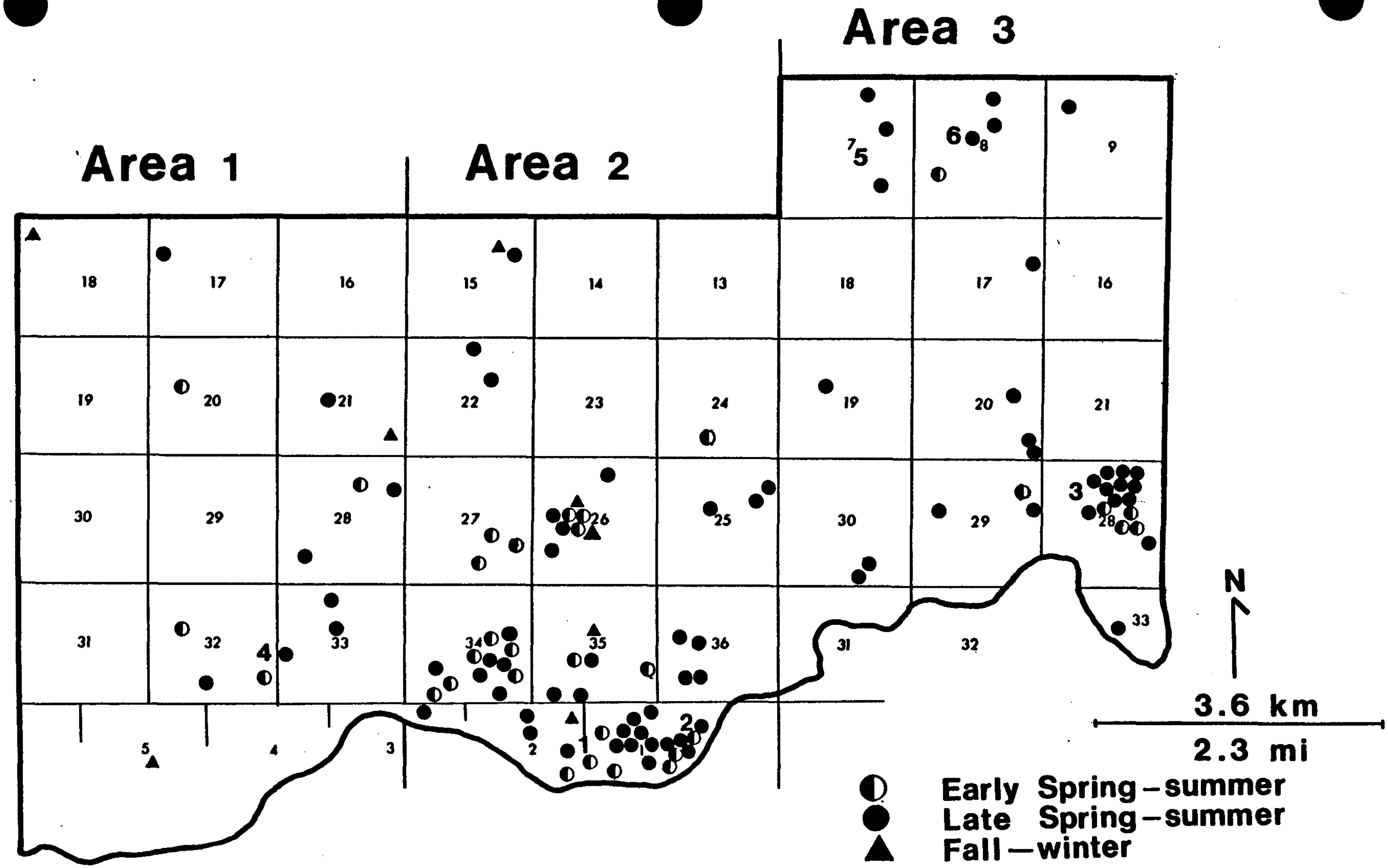

Fig. 4. Seasonal locations of elk observations recorded during the study (1980-1981) on the Apache-Sitgreaves National Forest, Arizona. Areas 1, 2, and 3 were the three areas designated for the road counts. (Within study area boundaries: 1, Reservation Flat; 2, Bear Wallow; 3, Porter Spring; 4, Brushy Flat; 5, McKay Spring; 6, Pancho Spring)

southeastern portions of the study area. One-hundred six of the observations were recorded during early spring and late spring-summer (Fig. 4).

Elk were observed as early as April 10, actively utilizing habitat within the Reservation Flat-McCormick Spring (Fig. 1) area (Table 2). This area is at an elevation of 2396 m. Elk use was occurring less than 2 weeks after snow accumulation of 60.96 cm. There were 11 additional observations of elk reported by Forest Service personnel in the Reservation Flat-McCormick Spring area. These observations provided supportive evidence of the importance of this area to elk. The Brushy Flat (Fig. 1) area (100 m lower than Reservation Flat) was also receiving elk use by early April (Table 2). There were only 8 observations of elk, including those reported by the Forest Service. Documentation of fresh physical evidence, however, suggested that regular use was made of this area by elk. The Porter Spring (Fig. 1) area (160 m higher than Reservation Flat) was inaccessible until late April. Frequent elk use was observed by May 2, however, and elk were sighted in the area until the end of September (Table 2).

Table 2. Monthly range and frequency of elk observations within high use areas of the Apache-Sitgreaves National Forest study area, Arizona

Area of elk use	No. days area observed	No. elk observations
Reservation Flat-McCormick Spring	40	49
Porter Spring	25	20
Brushy Flat	25	5

Road count results illustrated high elk use in Areas 2 and 3 (Table 3). The observations supported our contention that the upper elevational zones were important spring-summer habitat for elk. Elevations range from less than 2250 m to 2341 m in Area 1; 2310 m to 2493 m in Area 2; and 2371 m to 2645 m in Area 3. Elk were observed in Area 1 during early and late June, although not as frequently as in Areas 2 and 3 (Table 3). Though road counts during early and late August resulted in fewer elk being observed, the results did support the general observation of more frequent elk use in the higher elevations of Areas 2 and 3 (Table 3).

Table 3. Elk distribution as measured by road counts during four designated time periods in the Apache-Sitgreaves National Forest study area, Arizona[1]

Time Period	No. elk per kilometer		
	Area I	Area II	Area III
Early June (1st - 15th)	0.13	0.57	0.61
Late June (16th - 30th)	0.25	1.00	0.27
Early August (1st - 15th)	0.00	0.67	0.14
Late August (16th - 31st)	0.00	0.19	0.20

[1]The 3 areas utilized for the road counts are illustrated in Figs. 4 and 6.

Calving Activities and Calving Areas

Observations provided a means for relating areas within elk habitat to elk calving activities. The data showed that size and composition changes in cow elk groups that coincided with specific periods of their biological calendar, conformed closely with socio-biological findings in the literature (Boyd 1978, Franklin and Lieb 1979).

The mean size of cow groups from November 7 to May 1 was 10. Mean size continued to decrease from May 1 to August 20 (Table 4). Franklin and Lieb (1979) and Waldrip and Shaw (1979) documented similar decreases in group size in northern California and Oklahoma, respectively. The depressed group size was primarily due to the increased observation of solitary adult females (Table 4). These cow elk were often accompanied by a yearling female. The first solitary female was observed on April 25 in the Reservation Flat area. May 28 to June 26, however, was the period of most frequent observation of such indicators of calving activities (Table 4). Observations of solitary adults accounted for 80.95% of the total number of cow groups observed. Data were not collected during July. Solitary females were still being observed during early August (Table 4). This indicated that some females may have dropped calves during July and had not yet rejoined cow groups.

Increased observation of bull groups coincided with the calving season. Only 1 bull group was observed prior to May 1. Sixteen observations of bull groups were recorded from May 2 to June 26, however. Bull groups were observed with particular frequency during June, having comprised 44 % of the total observations. The mean group size was 3, although groups of 8 were observed during May and June. The first newborn elk calf was observed on June 4 (Table 4), in a flat-lying position at Brushy Flat. By August, calves were being observed more frequently (Table 4) in the areas where solitary females had been most evident (Fig. 5). Cows and calves were banding together and calf groups were observed at this time as well. Calves would flee with

Table 4. Socio-biological indicators of elk calving activity in the Apache-Sitgreaves National Forest Study area, Arizona (1981)

	Cow elk groups				
			Observations indicative of calving[1]		
Period of biological calendar	Total observations	x group size	Total no.	Period of highest frequency No./Total observations	No. with calves
May 1-June 26	34	3.15 $\pm SE=0.60$	20	May 28-June 26 17/21	1
July 30-August 20[2]	13	3.00 $\pm SE=0.74$	6	July 30-August 15 5/8	7
August 21-October 11	5	4.20 $\pm SE=1.46$	2	______	1

[1]Observations of solitary adult females or an adult female accompanied by a yearling female, or calves.

[2]No data was collected during most of July.

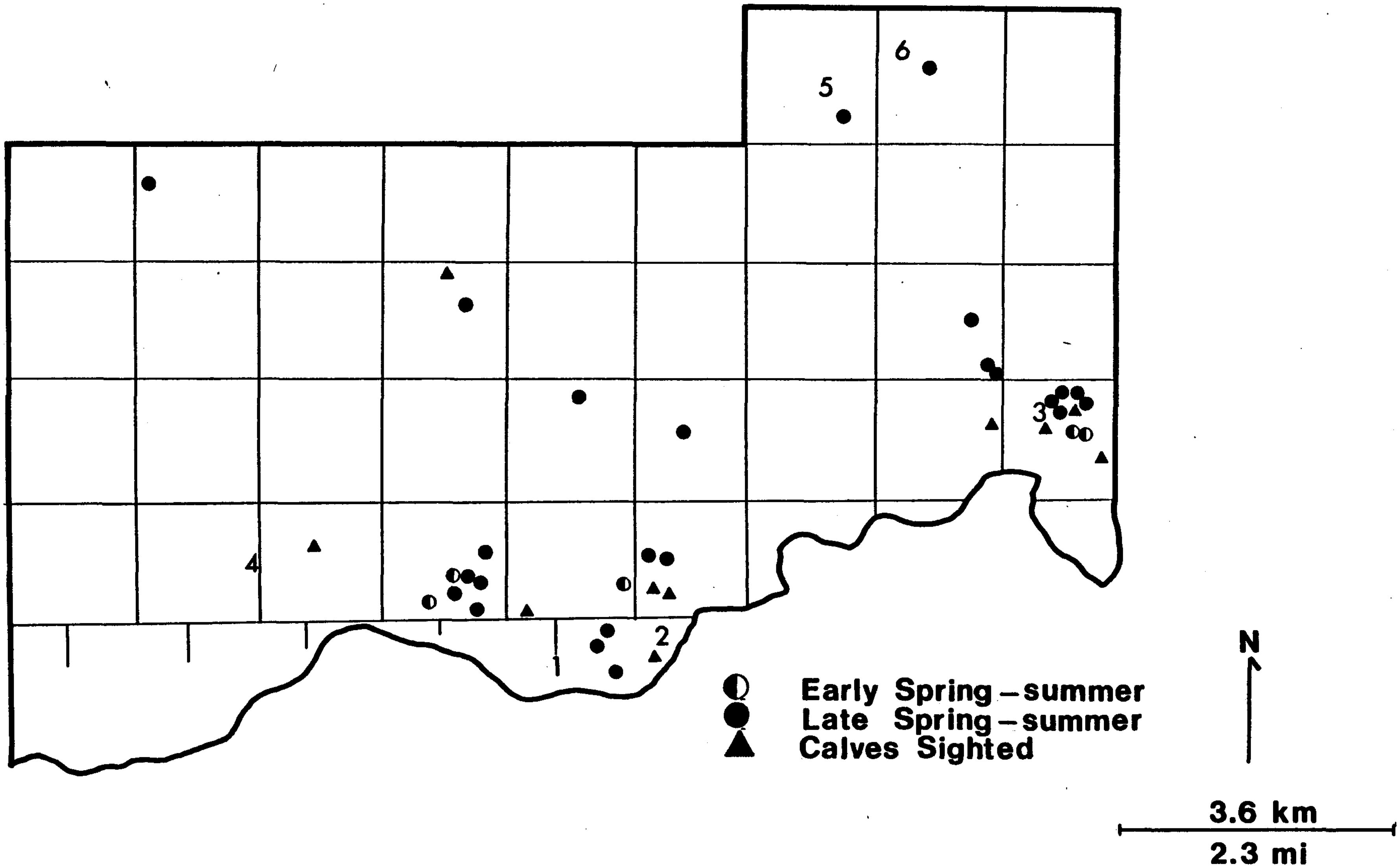

Fig. 5. Seasonal locations of elk observations (solitary adult cows, and solitary adult cows with a yearling female) indicative of calving activities, including observations of calves, in the Apache-Sitgreaves National Forest, Arizona (1980-1981). (Within the study area boundaries: 1, Reservation Flat; 2, Bear Wallow; 3, Porter Spring; 4, Brushy Flat; 5, McKay Spring; 6, Pancho Spring.)

adults when disturbed. Murie (1951) observed this type of behavior after they were 5 or 6 days of age.

Observations indicated calving activities were occurring at the Reservation Flat, Bear Wallow, and Porter Spring areas (Fig. 5). Observations indicative of calving were also made near the Brushy Flat, Pancho Spring, and McKay Spring areas (Fig. 5).

Habitat composition

Vegetative Cover. Forest stands comprised 92% of the study area (Table 5). Dense timber stands (greater than 80% canopy closure) accounted for almost half of these forests. More than one-third of the forests were comprised of intermediate stands (30-80% canopy closure). Forest stringers and patches of open canopy (10-30% closure) were interspersed throughout the intermediate and dense timber stands. Figure 6 illustrates the mosaic of forest canopy closures. This mosaic changes noticeably from west to east. With respect to the 3 areas delineated for road counts, Area 1 is comprised of a somewhat even mixture of forest stands possessing canopy closures of the 3 classes (Fig. 6). Areas 2 and 3 are dominated by intermediate and dense timber stands, respectively (Fig. 6).

Forage Openings and Drainageways. Forage openings accounted for only 7.69% of the area (Table 5). Micro-openings were not delineated by photo-interpretation, however, their existence is acknowledged and their importance illustrated in subsequent sections. Figure 7 illustrates the interspersion of forage openings, drainageways, and forests. The drainage system connects most of the individual forage openings to other openings. Many of the drainageways contained potable water for 6 weeks after snowmelt (mid-May). Most of the drainageways are flanked by undulating topography and intermediate to dense timber stands along much of their courses.

Human Impact. The study area is dissected by an intricate system of light duty and unimproved roads and jeep trails (Fig. 8). Though some areas are more remote than others, most of the site is accessible by vehicle, barring moist weather conditions that may exist during winter and early spring months. There is a mean of 3.70 km of road per 2.59 km^2 section (Table 6).

Fence lines (Fig. 8) and utility lanes additionally alter the natural condition of the site (Table 6). Fence lines are utilized for forest boundaries, delineating grazing allotments, resting pastures, protecting water impoundments, and distinguishing specific areas for recreation.

The Lakeside Ranger District recognizes 10 recreation areas (Fig. 8). Camping, hiking, recreational, and off-road vehicular uses occurred on these areas. Woodcutting and hunting were consumptive activities observed throughout the site. Human activities appeared to increase from early spring to late spring-summer.

Water Sources. There were 35 tanks, springs, seeps, or other types of water impoundments distributed throughout the study area (Fig. 9). Water levels were particularly low during June and July. Most of the impoundments and tanks, however, contained potable water throughout the early spring and late spring-summer seasons. The tanks and impoundments are man-made, usually earthen dugouts. Most points within the area are less than 1.61 km from potable water, particularly in the upper elevational zones.

Table 5. Area and percent of Apache-Sitgreaves National Forest study area attributable to canopy closure classes.

Canopy closure class (%)	Area (ha)	Percent of study area
1 - 10[1]	763.57	7.69
10 - 30	1338.78	13.49
30 - 80	3372.68	11.98
> - 80	4451.84	44.84
Total	9926.87	100.00

[1]Classified as forage openings.

Table 6. Mean distance (km) of man-made construction per 2.59 km^2 section within the Apache-Sitgreaves National Forest study area, Arizona

	Roads			Fence lines	Utility lanes
	Light duty	Unimproved	Jeep trail		
Dist. $\bar{x}$	0.45	0.52	2.72	1.13	0.08
$\pm$ SE	0.09	0.10	0.46	0.20	0.02

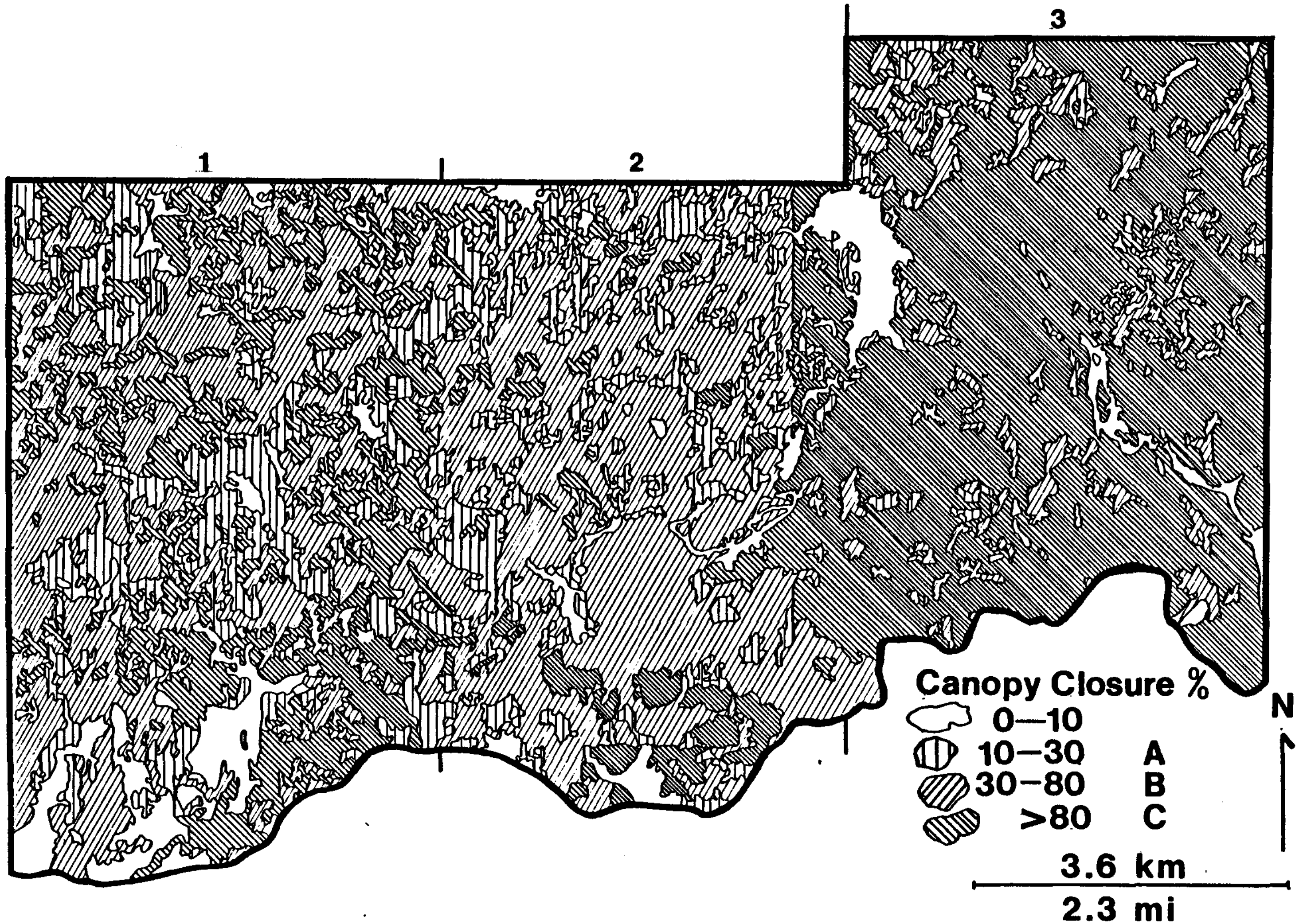

Fig. 6. Air photointerpreted map of forest stand canopy closure classes delineated in the Apache-Sitgreaves National Forest study area. Extended solid vertical lines represent boundaries of three areas designated for road counts.

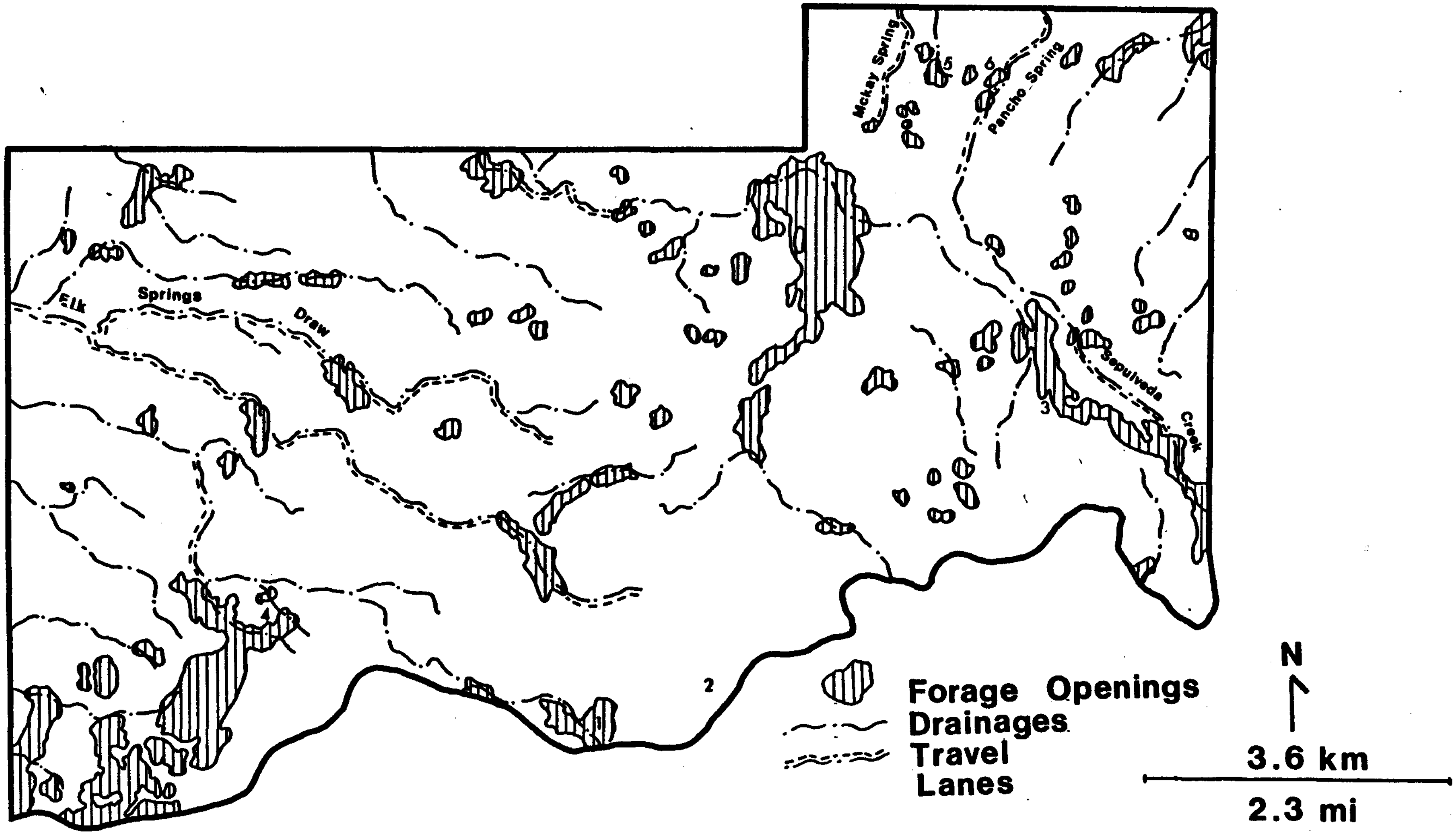

Fig. 7. Distribution of forage openings and drainageways, including those drainageways known to be utilized as travel lanes by elk in the Apache-Sitgreaves National Forest study area, Arizona.

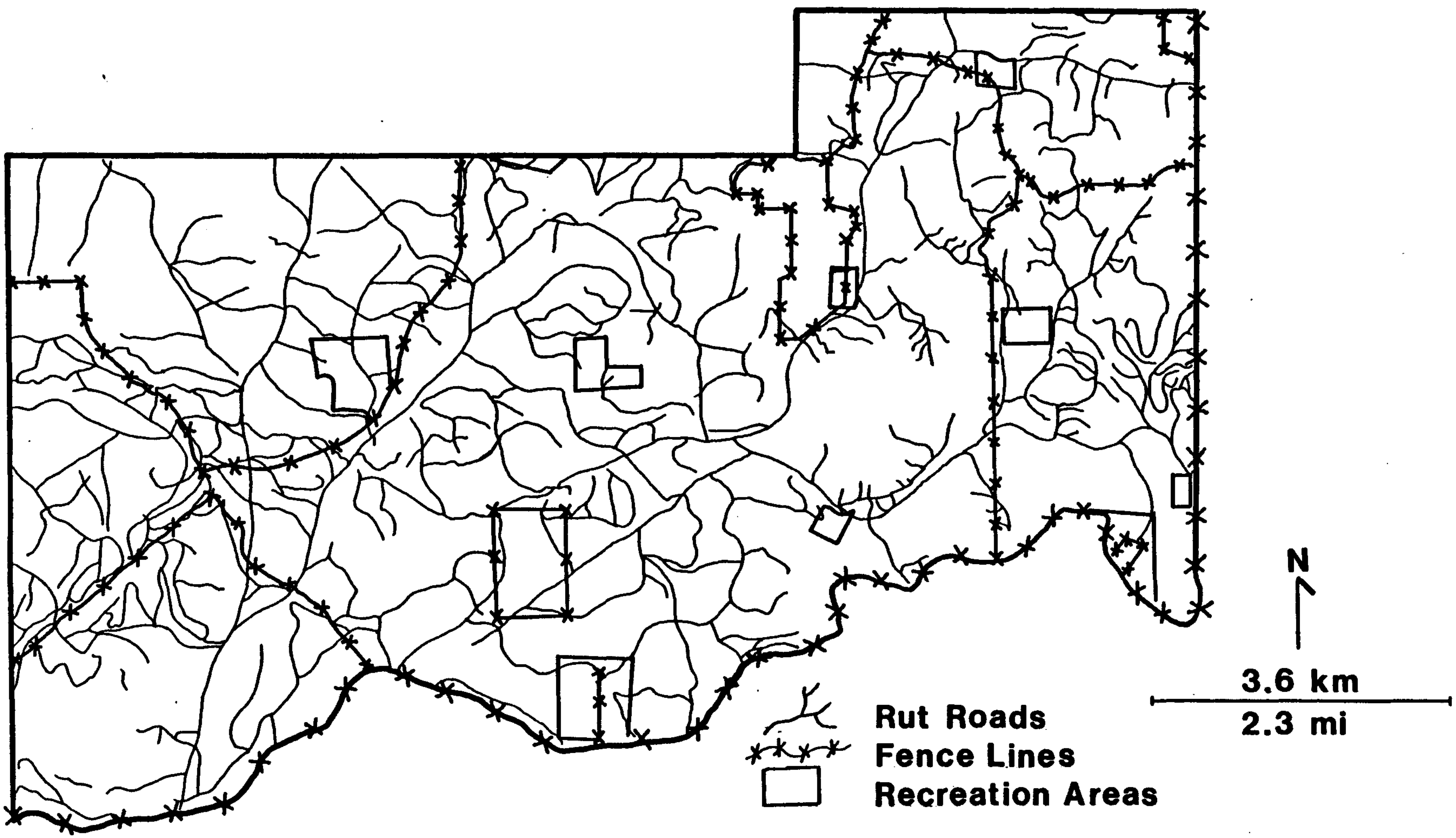

Fig. 8. Roads, fence lines and recreation areas dissecting the Apache-Sitgreaves National Forest study area, Arizona

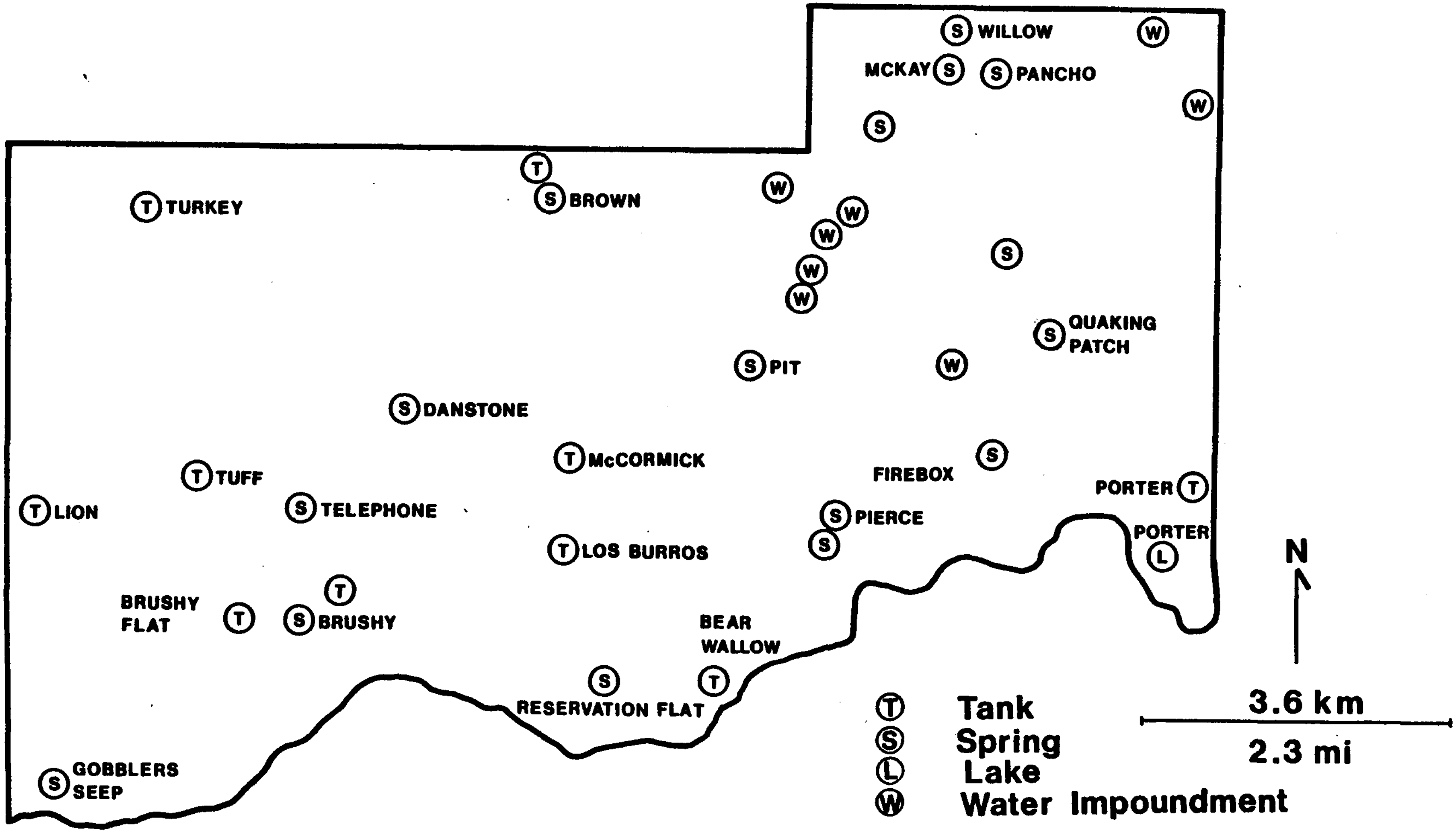

Fig. 9. Distribution of water sources within the study area in the Apache-Sitgreaves National Forest, Arizona

Analysis of Six Critical-Use Elk Areas

Six forage openings and their adjacent habitats were demonstrated to be critical-use areas for elk. Reservation Flat, Bear Wallow, and Porter Spring were areas where numerous elk observations were made. These included many believed to be indicative of calving activities. Documentation of fresh tracks and pellets, and observation of solitary females and calves during the calving season, reflected the importance of Pancho Spring, McKay Spring, and Brushy Flat to elk during the spring-summer seasons, and perhaps more importantly to calving females during the calving season.

All of these forage openings exist at elevations greater than 2280 m, Brushy Flat at the lower end of a continuum and Porter Spring at the upper end (Table 7). The slopes of the forage openings are characterized as level. Pancho Spring, Bear Wallow and McKay Spring are recognized as microopenings (Table 7). Reservation Flat, Porter Spring and Brushy Flat are open meadows with areas ranging from 6.25 ha to 26.04 ha (Table 7).

Kentucky bluegrass (Poa pratensis) was identified as the most dominant forage species on each opening, with the exception of Reservation Flat; western wheatgrass (Agropyron smithii) was dominant on this site (Table 8). Kentucky bluegrass was second in order of abundance (Table 8). The mean relative frequency and density of Kentucky bluegrass on the forage openings were 41.78% and 45.40%, respectively. The forage species measured second in order of abundance on the other 5 sites and varied from one to another. Collectively, this group of species was comprised of grasses, forbs and sedges (Table 8). A wide variety of additional species, many of high nutritional value and utilized to varying degrees by elk, were also documented.

The 6 forage openings possess optimum hiding cover as described by Thomas et al. (1979) on at least 3 sides (Table 7). The undulating topography and understory vegetation often enhanced the quality of the adjacent hiding cover.

All these forage openings were accessible by vehicle. Porter Spring and Bear Wallow were considered more remote in terms of distance from the main entranceways into the study area (Table 7). The openings at Brushy Flat, Porter Spring, and Pancho Spring are abutted by improved roads. Reservation Flat is abutted by an unimproved road and Bear Wallow by a jeep trail. The opening studied at McKay Spring is not directly abutted by a road, although an improved road exists in proximity.

Elk Utilization of Habitat Types

A chi-square contingency test of observed elk use of open meadows and forest (including micro-openings) showed a significant (chi-square= 49.22 with 2 df, $P \leq .0005$) interaction between season and habitat type used. During early spring, 49.12% of the elk observed were sighted utilizing open meadows. This use of open meadows decreased to 17.94% during late spring-summer. In fact, according to observational data, elk use of open meadows ceased by mid-June. Observed elk use of the forest increased from 50.88% during early spring to 82.06% during late spring-summer. Wing (1969) similarly found elk use of mountain meadows in Idaho rapidly decreasing after mid-June, as summer progressed.

During early spring, there were no observations of elk utilizing micro-openings. During late spring-summer, however, elk were observed using micro-openings in 21.19% of the observations recorded within the forest.

Table 7. Description of six forage openings determined to be important to elk in Apache-Sitgreave National Forest, Arizona

Forage opening location	Approximate elevation (m)	Area (ha)	Edge length (m)	Change in elevation to peaks within one mile (m)	Proximity to water source / type	Rating of adjacent hiding cover[1]	Vehicular accessibility (Easy, Remote)
Reservation Flat	2395.52	26.04	5618.42	85.12	On site/spring	Optimum	Easy
				97.28		Optimum	
				122.82		Optimum	
				91.20		Optimum	
Bear Wallow	2468.48	0.07	187.04	24.32	On site/man made dugout	Optimum	Remote
				164.16		Optimum	
				316.46		Optimum	
				55.94		Less	
Porter Spring	2556.64	6.25	1805.43	77.52	On site/spring	Optimum	Remote
				79.34		Optimum	
				147.44		Optimum	
				103.66		Optimum	
				57/76		Optimum	
Brushy Flat	2298.24	9.25	2114.70	48.64	On site/man-made dugout and spring	Optimum	Easy
				66.27		Optimum	
				170.20		Less	
				170.85		Optimum	
Pancho Spring	2327.42	0.45	418.27	216.14	On site/man-made dugout and spring	Optimum	Easy
				209.46		Optimum	
				192.13		Optimum	
				50.46		Optimum	
				39.82		Optimum	
McKay Spring	2334.72	0.59	334.46	184.83	On site/man-made dugout and trench	Optimum	Easy
				85.12		Optimum	
				133.76		Optimum	
				43.17		Optimum	

[1]Quality measurements were based upon optimum hiding cover as described by Thomas et al. (1979). Optimum is at least 90 percent of a standing adult elk is hidden by vegetation at a distance of 61 m or less.

Table 8. Dominant forage species on six important openings to elk in the Apache-Sitgreaves National Forest, Arizona

Critical-use forage opening location	Dominant forage species		Relative frequency	Relative density
	Common name	Scientific name	%	%
Reservation Flat	Western wheatgrass	*Agropyron smithii*	55.55	64.50
	Kentucky bluegrass	*Poa pratensis*	25.00	23.95
Bear Wallow	Clover species	*Trifolium* spp.	32.65	43.75
	Kentucky bluegrass	*Poa pratensis*	32.65	33.33
Porter Spring	Kentucky bluegrass	*Poa pratensis*	41.30	53.12
	Fleabane	*Erigeron* spp.	13.04	14.58
Brushy Flat	Kentucky bluegrass	*Poa pratensis*	36.36	38.54
	Spikesedge	*Eleocharis montana*	9.09	16.66
Pancho Spring	Kentucky bluegrass	*Poa pratensis*	66.67	73.43
	Clover species	*Trifolium* spp.	23.81	18.75
McKay Spring	Kentucky bluegrass	*Poa pratensis*	48.71	50.00
	Fleabane	*Erigeron* spp.	20.51	20.21
	Timothy	*Phleum pratense*	17.94	18.08

In terms of elk observed feeding, there was a significant (chi-square= 45.04 with 1 df, $P \leq .005$) interaction between season and habitat type utilized. During early spring, 76.92% of elk observed feeding were sighted in open meadows. In contrast, during late spring-summer, 74.79% of elk observed feeding were sighted within the forest. Waldrip and Shaw (1979) and Leckenby (pers.comm.) found similar elk use of forests during mid and late summer.

In reference to traveling and feeding, there was no significant difference in activity exhibited by elk within the 3 forest types. The forest types were utilized by elk for both studied activities.

DISCUSSION

Habitat Composition and Related Elk Use

Forage, vegetative cover, water, and specialized areas (travel lanes, calving areas) are the basic habitat components elk depend upon to fulfill their requirements (Thomas et al. 1979, Ward 1980). The habitat inventory has shown that these components, naturally-occurring and man-influenced existed in a variety of conditions and interspersions on site. Elk use of the 6 forage openings and surrounding habitats identified as critical-use areas, however, suggests habitats there were more adequately satisfying elk requirements. These openings differed somewhat with respect to elevation, edge length, and size (Table 7). Certain commonalities in the areas' habitat mosaics existed, however, that were indicative of a positive relationship with elk requirements and use.

Forage. The capability of openings to meet the forage requirements of elk is directly related to forage composition. The importance of the existence of a wide variety of grasses, grass-like plants (sedges) and forbs is their variability in phenology and palatability under changing temperature and moisture conditions. The dominance of Kentucky bluegrass, western wheatgrass, and a variety of other perennial grasses, forbs, and sedges was common to the 6 forage openings examined (Table 8). Many of these species were associated with the adjacent forests as well. Grasses of the genera *Poa* and *Agropyron* are thought to be the most palatable to elk, particularly during early spring greenup. Western wheatgrass possesses the additive value of being excellent winter forage when cured (U. S. Forest Service 1940, Murie 1951, Humphrey et al. 1960). Kentucky bluegrass is also noted for its resistance to heavy utilization, as well as its ability to recover under adequate temperature and moisture conditions (U. S. Forest Service 1940). Sedges are beneficial to elk in that they remain green and palatable into late summer and fall (U. S. Forest Service 1940, Murie 1951). In terms of the forage requirements of elk, Kufeld's (1973) summary of the literature revealed that grasses, grass-like plants, and browse were consumed all year, browse composition being lowest during mid-summer. Forbs were utilized primarily during mid-summer and fall (Kufeld 1973). Thus, it appears that the abundance and variety of forage species associated with the 6 critical-use elk areas, may be of significant value to elk in balancing their nutritional intake throughout the early spring and late spring-summer seasons.

Vegetative Cover. Observations of elk use of vegetative cover, strongly suggests a relationship between habitat composition and elk use that may be associated with a need for hiding cover. Elk were frequently observed utilizing adjacent timber stands and topography for hiding cover upon being disturbed. Lyon (1980) has submitted that "selection of habitat for forage production was a far less specific requirement of elk than selections for security and cover." Dense stands of ponderosa pine and mixed conifers were dominant within the areas most frequently utilized by elk, and where solitary females and calves were most evident during the calving season. The proximity of several mountains to the forage openings (Table 7) enhanced the quality of adjacent hiding cover. Changes in elevation from the openings to the peaks ranged from 24 m to 316 m (Table 7). These dense timber stands and topography enabled elk to remove themselves from visual contact with disturbances with a minimal expenditure of energy and distance of travel.

The shapes and areas of the 6 forage openings were also important with respect to adjacent hiding cover. These openings are characterized by irregular shapes, which maximizes adjacent forest edge (hiding) in relation to their areas. Feeding activities of elk are associated with forest edge (Reynolds 1966a, 1966b). This is interpreted as a need for security. Therefore, the irregular shapes of the openings are viewed as beneficial in affording elk security. It has also been reported that openings less than 486 m across are most effectively utilized by elk in Arizona (Reynolds 1966a, 1966b). There are no points in the 6 openings beyond 243 m from forest edge. This physical characteristic additionally reflects the value of these openings in relation to the security needs of elk.

Vegetative cover must also be examined in terms of its value in affording summer thermal cover. Cover used by elk to assist in maintaining homiothermy is thermal cover (Black et al. 1976). Elk were observed at Brushy Flat using the last remaining snow patches beneath closed canopies as bedsites in April. Numerous elk bedsites were also documented throughout the study within intermediate and dense timber stands adjacent to the other critical-use openings. The effectiveness of a closed canopy in creating a cooler micro-climate during the day by shielding the sun's incoming radiation has been demonstrated by Edgerton and McConnell (1976). The highest temperature during April was only 24.5°C (Fig. 2). The higher daytime metabolic rates of diurnally active animals (Moen 1973), however, may also have influenced the elk's selection of snow patches within dense stands during early April. The highest mean monthly maximum temperature (28.9°C) was recorded for June and temperatures remained high through August (Fig. 2). As these daytime temperatures approach or increase beyond elk body temperature, the thermal gradient becomes such that heat is absorbed by the body (Moen 1973). Should an elk's body absorb more heat than it is able to dissipate, a critical hyperthermic environment is created. The requirement of elk to maintain homiothermy and the potential adverse effects associated with a critical hyperthermic environment have been thoroughly documented by Moen (1973). In view of the high temperatures during late spring-summer, the dense timber stands possessed significant value as summer thermal cover. Furthermore, all of the bedsites documented on site were located on mountain slopes and mountain plateaus. This suggests that the higher elevations contribute to the cooling effect of these timber stands, possibly through increased air circulation.

Weather has been found to be the most influential factor in relation to habitat selection by elk (Beall 1974). Therefore, the availability of dense timber stands common to the 6 critical-use elk areas and their value as summer thermal cover appeared to be critical factors influencing the elk's selection of these areas.

Water. A need of potable water by elk has often been debated by researchers from one geographic region to another. During this study, highest elk use was documented in the upper elevations where sources of potable water were most available. Cows and bulls had been observed drinking during May, June, and October. Elevations at which the observations were made ranged from 2310 m to 2469 m. Lack of significant precipitation during May and June, less than 2.5 cm (Fig. 3), had created more dessicating conditions than normal and probably increased the importance of potable water on site. All of the 6 critical-use forage openings possessed at least one source of potable water (Table 7). Marcum (1975, 1976) found in Montana that elk preferred use of areas within 320 m of water. Leckenby (pers. comm.) in contrast, has observed elk drink only once in more than 2000 observations of elk groups, and questions the role of potable water as an elk habitat requirement in northeastern Oregon. Observations and documented elk tracks at water sources during this study indicated that potable water was regularly utilized probably due to weather conditions and a lack of succulent forage.

Travel Lanes. Travel lanes existed in various forms and played an important role in the manner in which elk utilized the study area. Travel lanes (corridors) are defined as "routes followed by elk along a belt or band of suitable cover or habitat" (Thomas et al. 1979). The extensive road and fence line systems (Fig. 8) received considerable use by elk for travel, particularly in the vicinity of Bear Wallow. Drainageways were also observed receiving frequent use by elk for movements within the study area (Fig. 7). Five of the 6 forage openings studied, possessed drainageways on site that led to other openings (Fig. 7). Elk were observed and tracked on site while alternately utilizing drainageways, forest stand edges, and fence lines as travel lanes during long movements.

Calving and Calving Areas. Observation data has indicated that calving activity on site began intensifying by the end of May (Table 4). I suspect that most calving occurred between this time and the end of July. Franklin and Lieb (1979) and Waldrip and Shaw (1979) also observed calving occurring during this period.

The response of solitary females to the "predator call" during the calving season varied, however, it always held their attention for a short time and elicited a forward approach. On several occasions females responded much more aggressively by approaching within 30 m, barking repeatedly, and stomping their front hooves. Two examples of maternal aggression of this extreme nature were observed at Porter Spring and Pancho Spring on May 28 and June 11, respectively. Murie (1951) observed similar behavior in Wyoming, upon approaching females with inactive (newborn) calves in the area. When the "predator call" was directed towards small groups of females suspected of being unbred, it initiated an immediate flee response. In reference to the solitary behavior of calving females and inactivity of offspring, Nelson and Mech (1981) contend that this constitutes a defense strategy against predation and minimizes feeding competition in white-tailed deer. The logic of this contention appears applicable to the similar behavior we observed in elk during the calving season. It also supports the rationale of using observations of solitary females as indicators that calving activities were occurring.

The increased observation of bull groups during May and June was also interpreted as an indication of the occurrence of calving activities. Franklin and Lieb (1979) similarly found that the first departure of young bulls from the cow groups coincided with the calving season and increased maternal aggression. Bull development (behaviorally and physiologically) was also probably a factor initiating formation of the bull groups (Leckenby, pers. comm.) during the calving season.

Observation data indicate that the upper elevational zones of spring-summer range were utilized most by calving females. These areas were characterized by the dominance of dense timber stands and existence of readily available sources of potable water. Waldrip and Shaw (1979) found that cows and calves made greater use of intermediate and dense timber stands in the Wichita Mountain Wildlife Refuge. All of the observations of cows with calves made during this study were within intermediate and dense timber stands. These observations suggest that these stands were of particular importance to cows and calves during the calving season. This importance was probably in relation to their value as hiding and thermal cover.

Studies in various geographical regions of the elk's western range have shown that calving activities occur on winter, spring-fall, and summer ranges (Murie 1951). Thomas (pers. comm.) contends that elk do not migrate to traditional calving areas every year. Thomas (pers. comm.) and other researchers submit that elk movements to areas for calving are dictated by weather, energy reserves, and the presence of habitat adequate to fulfill their requirements. Elk use of the habitat above 2280 m indicates that elk requirements may have been satisfied.

Differential Use of Habitat Types

Many reasons have been proposed to explain the seasonal pattern of habitat selection by elk described on this site. The decreasing use of open meadows and corresponding increased use of forests as spring-summer progressed, was examined in relation to the more frequent occurrence of human-related activities and drier weather conditions.

Cattle grazing began on the site just prior to the cessation of use of open meadows by elk. Elk use, however, was not displaced from the study area by the presence of cattle. Elk and mule deer had been observed on numerous occasions feeding within the forest less than 0.32 km from grazing cattle. Leckenby (pers. comm.) has documented similar observations in northeastern Oregon.

Small logging operations that began in April also appeared to have minimal effect on elk use of open meadows and the study area in general. Elk were often observed utilizing open meadows during daylight hours in the Reservation Flat-McCormick Spring area, less than 1.6 km from active logging operations. Furthermore, elk had been observed feeding in the same area where logging occurred, 15 minutes after operations had ceased for the day. Such behavior was exhibited by solitary females during the calving season as well. The apparent tolerance elk exhibited towards logging may have been due to the small scale of the operations and the proximity of refuge areas in the form of mountains, dense timber stands, and the Fort Apache Indian Reservation. Lyon (1971) documented a similar response by elk to logging operations in Montana.

It seems that if the elk's increased use of forests were a response to increased human-related activities and a need for security, their behavior would be more alert and they'd be observed traveling more than feeding. A chi-square test, however, revealed a non-significant interaction between activity and season. In fact, the proportion of elk observed feeding slightly increased from early spring to late spring-summer. Data, therefore, suggests that human-related activities had a minimal effect on the elk's use of habitat.

In terms of weather conditions, there was a progressive decrease in precipitation from April to June, 1981 (Fig. 3). This effectively changed the open meadows from mesic to xeric type sites by mid-June. Mackie (1970) and Marcum (1975) found that elk tend to use the forage in moist areas during the spring and summer seasons. Mackie (1970) submits that moisture has a positive effect on forage digestibility. The availability of more succulent, digestible forage at an earlier phenological state of development was apparent in micro-openings and under forest canopies during late spring-summer. This appeared to be an influential factor with respect to the elk's increased use of forests on this site.

As previously discussed, weather data showed that the mean monthly maximum temperature peaked during June and remained high through August. This indicates that, based upon thermal exchange principles, thermal regulation was probably an additional factor influencing the increased selection for forests by elk.

SUMMARY AND CONCLUSIONS

This study has identified and described an area in the southeastern portion of the ASNF as important spring-summer elk habitat. The site is comprised predominantly of forests (92%). Dense stands (greater than 80% canopy closure) existed in the greatest proportion, particularly in the upper elevations where the highest elk use was documented. Observation data indicate that calving females primarily used habitat above 2280 m. I submit that the value of the dense timber stands in affording summer thermal cover and hiding cover was the most influential factor in relation to elk use of the upper elevations. Though open meadows account for a small percentage of the site, their importance to elk during early spring with respect to forage value has been demonstrated. Furthermore, data suggest the importance of the interspersion of these meadows with adjacent timber stands and topography to security needs of elk. The importance of the forage cover associated with the forests and micro-openings was demonstrated, particularly in relation to elk use during the late spring-summer.

A quantitative habitat inventory has shown the area to be dissected by roads, fence lines, and recreation areas. Sources of potable water and drainageways are also interspersed throughout the site. Elk have been observed utilizing these man-made and naturally-occuring habitat components for various activities. Temperature and moisture conditions appeared to influence the seasonal pattern of habitat use described on site. The increasing occurrence of human-related activities as spring-summer progressed, however, had minimal effect on elk use of the site.

This study has provided the basis for future, more detailed examination of elk requirements-habitat relationships that need to be done in view of increasing human impact. It would be of great value to maintain a continous inventory of human impact, while monitoring elk population health and use of habitat. This would enable managers to identify the effects of human impact on elk and better integrate forest and habitat management objectives.

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DEVELOPMENT OF ELK AND DEER MANAGEMENT OBJECTIVES IN OREGON

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Abstract: The Oregon Fish and Wildlife Commission has formally adopted management objectives for Rocky Mountain elk (*Cervus elaphus nelsoni*) and mule deer (*Odocoileus hemionus hemionus*) after extensive public involvement. Management objectives include the number of wintering animals to be managed for, and the lowest acceptable post-hunt bull elk and buck deer ratio for each wildlife management unit. The rationale for bull and buck ratios differing by management unit is a presumption that hunting quality gains with a stronger representation of older males. With objectives, discussions about annual harvest rules now have a common frame of reference and land use planners have the quantified information they've been seeking.

INTRODUCTION

Management by clearly-defined objectives is no less desirable because the business is wildlife resources. In 1977, biologists of the Oregon Department of Fish and Wildlife earnestly undertook an effort to establish objectives for elk and deer on 67 statewide Wildlife Management Units. Priority was given to Rocky Mountain elk in 28 of those units in northeastern Oregon as part of a companion effort on all 47 units in eastern Oregon to establish objectives for mule deer.

After 4 years of development, critical reviews, inter-agency coordination and public involvement, the Oregon Fish and Wildlife Commission formally adopted management objectives for Rocky Mountain elk and mule deer on December 11, 1981. The objectives specify a target herd size of the time of early spring census and the lowest ratio of bulls per 100 cows and bucks per 100 does that is acceptable after hunting ends in the fall. Use of whole population numbers expanded from census improved understanding between all parties.

This report describes how management objectives were developed, some of the additional benchmark information that was produced, some of the frustrations, and plans for the future.

Thanks are due Len Mathisen, Central Region Supervisor, and Bob Stein, Assistant Director in charge of the Wildlife Division for their encouragement. Without the records, assistance and judgments of 13 Wildlife District Biologists in eastern Oregon, the effort to establish sound objectives would have failed.

PROJECT AREA

All of Oregon roughly east of the Cascades Mountain Range, which divides the state into a west one-third and east two-thirds, is managed under rules for Rocky Mountain elk. The primary elk ranges are associated with the Blue Mountains plateau of northeastern Oregon and those east slope winter ranges at the extreme north end of the Cascades (Fig. 1). Small elk bands in other parts of eastern Oregon were disregarded in this initial effort to formulate management objectives.

ELK MANAGEMENT "AREAS" and "ZONES"

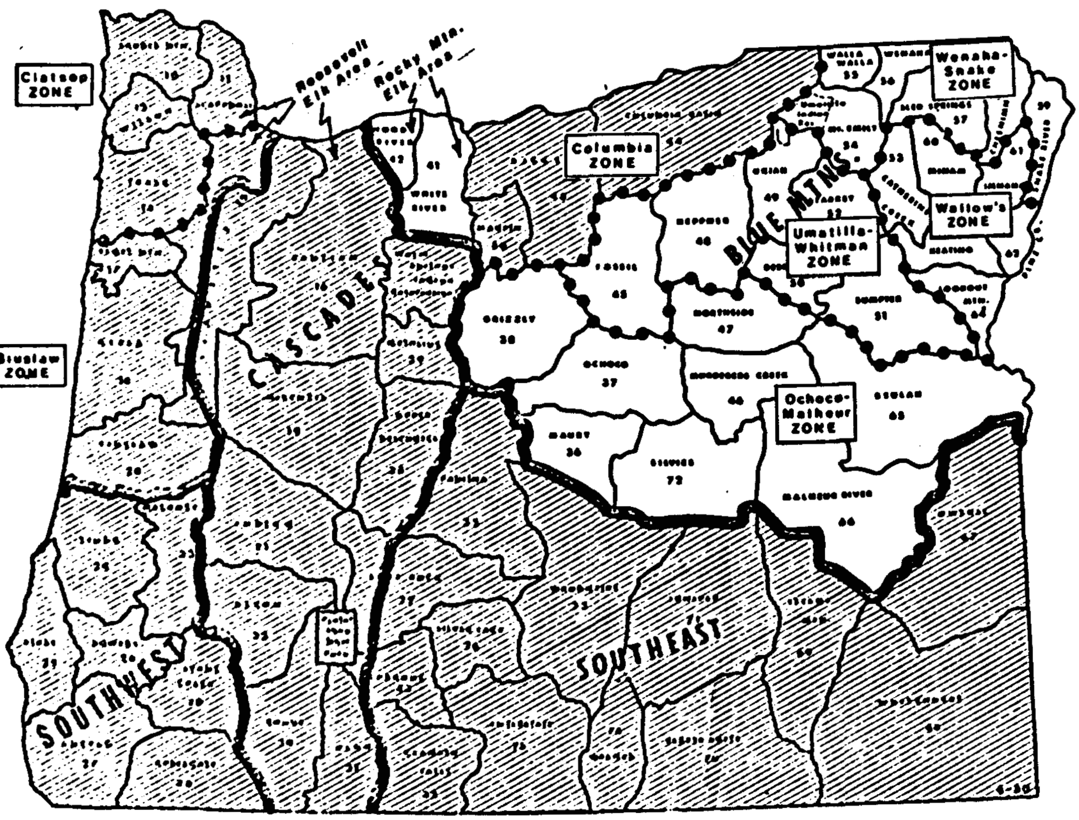

Figure 1. Eastern Oregon Wildlife Management Units including 28 key Rocky Mountain units

Herds have been managed by Wildlife Management Units since 1958. Unit management allows for special hunt rules including drawings for limited permit seasons, for special point regulations and for separate hunting dates. The development of elk objectives focused on the 28 Wildlife Management Units in northeastern Oregon that encompass an area of nearly 29,000 square miles. The companion effort for mule deer, that included all 47 eastern Oregon units, covered an area of almost 66,000 square miles.

METHODS

Range Area and Ownership

A range/ownership record was compiled for each unit that included ownership of elk and deer seasonal ranges, months of impact, and average animal density estimates (Fig. 2). Each biologist mapped his total elk and

DEER AND ELK RANGE OWNERSHIP IN SQUARE MILES

UNIT MT. EMILY

OWNERSHIP	AREA OF COUNTY/UNIT CELL: Union	Umatilla	TOTAL UNIT SQ.MI.S
WALLOWA-WHITMAN	57		57
UMATILLA		242	242
MALHEUR			
OCHOCO			
TOTAL FOREST	"	"	299
BAKER BLM			
BURNS "			
VALE "			
PRINEVILLE			
TOTAL BLM			
OTHER FEDERAL			
STATE ET AL			
COUNTY			
TOTAL			
TOTAL PUBLIC	57	242	299
TOTAL PRIVATE	176	289	465
TOTAL	233	531	764

ELK	WINTER RANGE SQ.MI.	ELK X MO'S =	ELK MO'S	ELK PER SQ.MI.	SUMMER RANGE SQ.MI.	ELK X MO'S =	ELK MO'S	ELK PER SQ.MI.	TOTAL ELK HABITAT SQ.MI.	ELK X MO'S = ELK MO'S
WALLOWA-WHITMAN	25	220 x 4	880	8.8	52	400 x 8	3200	7.7	55	4,080
UMATILLA	98	3070 x "	12,280	31.3	215	3500 x "	28,000	16.3	273	40,280
MALHEUR										
OCHOCO										
TOTAL FOREST	123	3290	13,160	26.7	267	3,900	31,200	14.6	328	44,360
BAKER BLM										
BURNS "										
VALE "										
PRINEVILLE										
TOTAL BLM										
OTHER TOTAL										
TOTAL PUBLIC	123	3290	13,160	26.7	267	3,900	31,200	14.6	328	44,360
TOTAL PRIVATE	146	2410	9,640	16.5	96	1100	8,800	11.5	232	18,440
TOTAL	269	5,700	22,800	21.2	363 *	5,000	40,000	13.7	560	62,800

DEER	WINTER RANGE SQ.MI.	DEER X MO'S =	DEER MO'S	DEER PER SQ.MI.	SUMMER RANGE SQ.MI.	DEER X MO'S =	DEER MO'S	DEER PER SQ.MI.	TOTAL DEER HABITAT SQ.MI.	DEER X MO'S = DEER MO'S
WALLOWA-WHITMAN	25	200 x 4	800	8.0	56	400 x 8	3200	7.1	56	4,000
UMATILLA	98	2700	10,800	27.6	215	3,000	24000	14.0	273	34,800
MALHEUR										
OCHOCO										
TOTAL FOREST	123	2900	11,600	23.6	271	3400	27,200	12.5	329	38,800
BAKER BLM										
BURNS "										
VALE "										
PRINEVILLE										
TOTAL BLM										
OTHER TOTAL										
TOTAL PUBLIC	123	2900	11,600	23.6	271	3,400	27,200	12.5	329	38,800
TOTAL PRIVATE	163	2100	8,400	12.9	168	1,600	12,800	9.5	252	21,200
TOTAL	286	5000 x	20,000	17.5	439 *	5000	40,000	11.4	581	60,000

* includes some winter range.

Figure 2. Range/Ownership form for the Mt. Emily Wildlife Management Unit

deer range including the amount of winter range in each unit. A distinct line between winter and summer range was not required. Winter range was often shown as an area overlapping lower elevation summer range.

Land ownership in square miles for both winter and summer range was separated by national forest, public domain (U.S. Bureau of Land Management), other public, and private on a Range/Ownership form. The number of winter months was estimated. The population objective ultimately proposed was roughly arranged by land ownership according to past observations of animal distribution. Elk (or deer) months, which means a forage demand level, were considered in the forage allocation processes underway in federal land-use planning where tradeoffs among users are envisioned.

Population Model

Trend. Population trend counts using aircraft are made each spring in Oregon on elk and deer winter ranges. Rocky Mountain elk census routes cover 2,362 miles, and usually in recent years 10-13 elk/mile are counted. The trend count level is unique for each unit because of different intensities of census and visibility. Trend counts are conducted on mule deer herds also, but far more extensively and with a greater reliance on ground counts.

A first indication of desired winter herd level usually appeared somewhere in the trend count record covering the last decade (Fig. 3). Those faulty count years, resulting from dissimilar animal concentrations, were corrected with conviction by examining recruitment levels, the trend in related units, harvest experience, and professional intuition. Trend, so

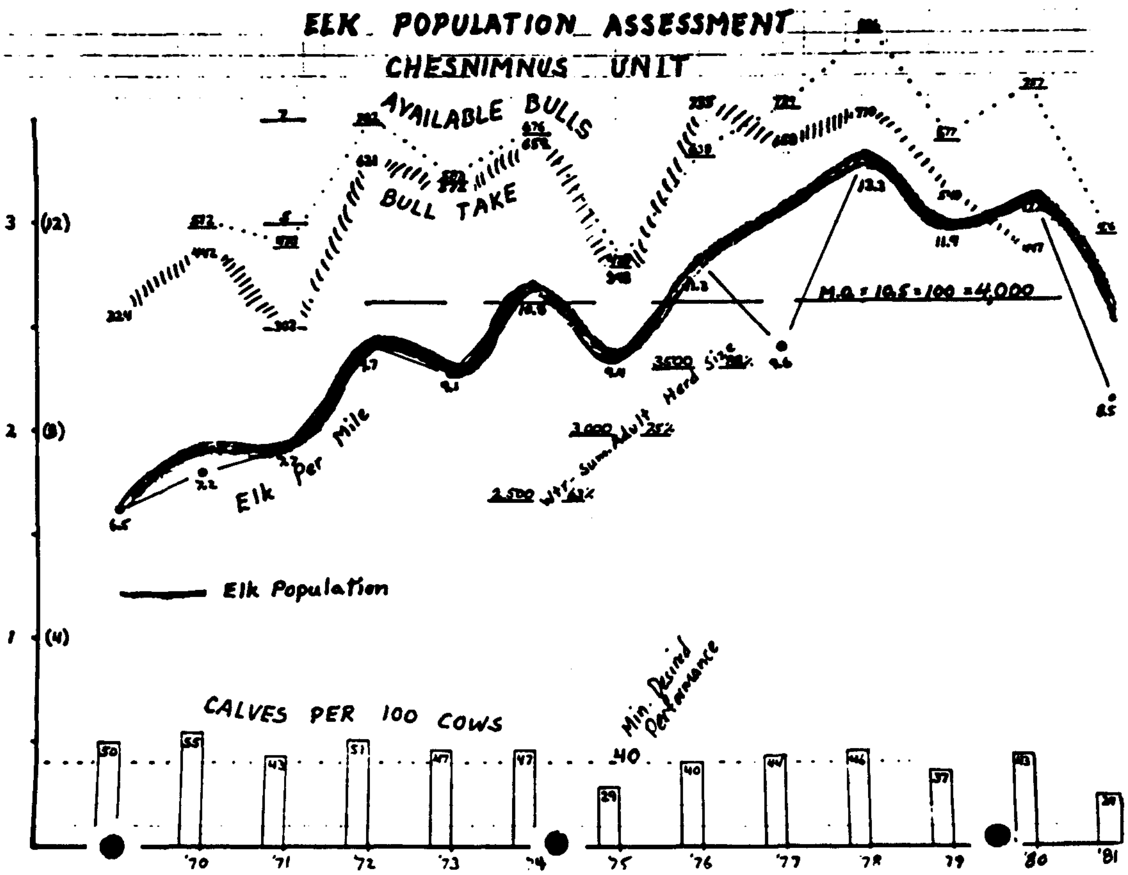

Figure 3. Elk trend count showing corrected years and correspondence with calf calf ratio and subsequent bull take, all in same calendar year

useful to the manager while failing statistical testing miserably, gave an inference of change in population numbers from one year to the next. A corrected and refined trend record provided the foundation for proposing a management objective level and developing a numerical model.

Ratios. Routine winter classification of herds into males and young per 100 adult females in Oregon produces the familiar ratios of bulls and calves per 100 cows and bucks and fawns per 100 does. The ratios for elk easily convert to a percentage, or preferably, whole number per 100 elk:

6 B:100 C:44 Cal. (equals) ÷ 150 equals	4	B
	67	C
	29	Cal.
	100	

Use of the actual field count rather than calculations based on the ratios more accurately reflects what the herd composition seems to be.

Conversion of Oregon's mule deer data requires an extra step because a fawn survival (recuitment = fawns:100 adults) count, in addition to the fall herd composition count, is taken at the end of winter. The first computation

30 F:100 Ad. (equals) ÷ 130 equals	23 F	
	77 Ad.	
	100	

When the fawn number is determined, adults (bucks and does) remain. The buck component is calculated using the fall herd composition ratio with the assumption that the buck ratio prevails over into the following spring.

12 B:100 D (equals) ÷ 112 equals .107 times 77 Ad. equals	8 B
All the rest are does	69 D
from above	23 F
	100

Conversion Principle. If a population estimate is substituted for the trend count, the bulls, cows, and calves in the over-winter herd can be calculated from the herd composition data. If the amount of change in trend each year is bio-logical, an estimate for one year in the trend record dictates how many there are for all years.

Population Estimate. Units with no seasonal exchange of animals best exemplify how an initial herd size estimate was obtained to test in a model. The model amounted to elk (or deer) per mile counts and herd composition expanded into whole numbers. The initial estimate came from general season bull and buck kill records by unit.

Using the equation that expanded the elk herd composition into percentages (whole numbers), one or more years of field data were expanded in each unit to find out approximately what percentage of bulls might be present in hunting season out of the total adult and yearling herd. Assumptions were that summer mortality did not occur and one-half of the over-winter calves were bulls. In the equation with a ratio of 6 B:100 C:44 Cal., there would be 4 bulls carried over and 14 yearling bulls (29 calves + 2) or 18% bulls in the herd. A minimum population estimate was obtained through dividing bull kill by the indicated percent bulls. The estimate was increased in relation to indicated post-hunt bull survival and consideration of other possible mortality such as Indian take. An estimate for one year only was needed to plug into the trend count record and to start the numerical model moving over time.

If the numerical model for all years, derived from a starting estimate for one year only, seemed to fail at putting out sufficient bulls for hunting season in relation to reported kill, carryover ratios and other considerations, the model was tried again using a higher starting estimate.

The form that's in use for each herd model by calendar year (Fig. 4) displays the management objective and each year's population using both index and whole numbers. It was decided 100 (100%) was to be an index representing the population management objective. The population index number for each year, which was derived through dividing the trend count by the management objective trend count level, produced an index number plus or minus the objective. Any time an estimated trend count was substituted for any year, it was put in parentheses. Each of the index numbers was representative of a whole number directly proportional to the objective. Index numbers for components were whole numbers, not a percentage.

☒ Observed ☐ Estimated UNIT: MT. EMILY Umatilla (District)

Meacham Cr. / Umatilla River (area) ELK POPULATION INDEX Wilt (Biologist)

Year	BASIC DATA: SEPT. Per 100 Cows Bulls	SEPT. Per 100 Cows Calves	FEB.-APR. Per 100 Cows Bulls	FEB.-APR. Per 100 Cows Calves	Elk Per Mile	APRIL - Number of: Total Elk	Ylgs.	Bulls	Cows	Calves Per 100 Cows	SEPTEMBER - Number of: Bulls	Cows	Calves	Total Elk
1960														
1961														
1962														
1963														
1964														
1965														
1966														
1967			3	53	15.3					45				
1968			3	45	10.9					38				
1969			2	38 (16.0)	26.9	(64)	17	1	46	40	9	55	22	86
1970			2	40	12.9	72 3600	20 1015	1 50	57	42	11 557	61 3043	26 1278	98 4871
1971			4	42	17.9	72 3600	21 1037	2 97	49	50	12 615	60	30	102
1972			6	50 (19.0)	22.1	(76) 3800	32 1220	3 144	41	49	19 754	57	28	104
1973			4	49	20.3	81 4050	26 1296	2 105	53	58	15 753	66	38	119
1974			1	58	24.7	99 4950	36 1807	1 30	62	42	19 933	80	34	133
1975			4	42 (24.0)	26.4	(96) 4800	28 1382	3 130	65	46	17 821	79 3479	36 1830	132 663
1976			1	46 (23.0)	23.6	(92) 4600	29 1440	1 32	62	51	15 752	77	39	131
	incl. 700 Union Dist.					incl. 700 Wenaha wtr. in Umatilla								
Mgt. Obj Levels	Area Sept. Pop. =					5,000	1,520	100	3380	45	860	4140	1860	6860
	Key Area Apr. Pop. =					5,700	1,733	114	3853	45	980	4720	2124	7824
			3	45	25.0	100	30	2	68	45	17	83	37	137
1977			7	51	25.2	101 5050	33 1631	4 222	64	42	20 1037	81 4013	34 1685	135 673
1978			2	42	28.6	114 5700	33 1664	2 80	79	47	18 912	96 4788	45 2250	159
1979			3	47 (28.6)	33.8	(114) 5700	36 1792	2 129	76	41	20 1025	94 4675	38 1917	153 761
1980			7	41	27.1	108 5400	30 1496	5 251	73	54	20 999	88 4401	48 2397	156
1981			7	54	28.6	114 5700	38 1909	5 255	71		24 1209	90 4491		
1982														
1983														
1984														

Figure 4. Numerical elk population model used to display census date,(left panel), expanded census for early spring (center panel), and conversion to hunting season number (right panel) without allowance for summer mortality. Gain (young in September) us additive based initially on a forecast and subsequently on the observed calf ratio in the winter following.

The population objective was meant to be the end-of-winter herd size. However, herd management through harvest of surplus was mostly on summer range, and in many units the summer adult population was different because of migratory patterns. The difference was derived from marked animal records whenever they were available. The population objective expressed for summer range was subordinate to the winter range objective. Nevertheless, all of the unit models for Oregon herds were developed in relation to the size of the summer population because the surplus destined for harvest was there. For some units with a small winter herd but sizeable summer adult population because of immigration, separate sub-models of contributing winter herds were prepared and added together to preserve the integrity of differing bull and calf ratios.

Selection of Management Objectives

Normally, for the span of years covered by the model, there were some most satisfactory times. Range information and survival data inferred there was no serious over-supply of wintering animals. The hunting season experience seemed satisfying. Problems on private lands were within a manageable level. A single level population objective was selected to avoid the handling of more numbers if a range were used.

The proposed management level for elk was strongly oriented towards private land use and the Department's ability to resolve problems. With no evidence of sustained elk over-supply or associated damage to habitat on Oregon ranges, chosen objectives for elk were considered to be below potential. The objective for deer, however, included a judgment about range capacity based on years of experience with periodic winter die-offs and damage to vegetation.

The M.O. (Management Objective) was depicted on the trend graph initially as an index to animals per mile. In the model it was number of animals. However stated, the objective and the population of any year were directly related:

$$\frac{\text{Count}}{1330} = \frac{\text{Trend Count}}{12.9} = \frac{\text{Pop. Index}}{100} = \frac{\text{Population}}{5{,}000}$$

The bull and buck ratio objective to be maintained post-season at the very least by regulating take in each unit came largely from traditional ratios. Biologists agreed that every elk unit must have at least 3 bulls:100 cows post-season for biological reasons. Some feel this may be low. The lowest acceptable level for bucks was set at 10. Quality demands were responded with bull ratios going as high as 15:100 cows in some units. Those ratios at the very least are to be sustained as demand grows and bulls become increasingly vulnerable. Buck ratios ranged to a high of 25:100 does for decision-makers to consider when weighing quality demands versus quantity.

Benchmark Numbers

With a herd model and a herd management objective, useful planning benchmarks evolved. The surplus of bulls and proportion of young to older animals was evident. Estimates of other mortality like Indian kill could be plugged in. Inferred surplus of antlerless elk was distinguishable in a standardized manner for all units. The concept of making a forecast of gain expected to be present in the hunting season for anticipating surpluses was put into practice. Oregonians agonizing about crowding were provided hunter quota proposals that considered traditional success rates, given the M.O. bull or buck supply, so that tradeoffs could be considered.

Public Involvement

Department biologists worked in-house on elk objectives, which offended some interests. Before all was in order, the program received exposure in various meetings with resource councils, largely stockgrower-oriented, and industry, largely timber-oriented. When 3 sets of reports, an elk and 2 deer reports, were completed in late 1980 to start public review, a series of informational meetings was scheduled statewide. Preceding those townhall sessions, a meeting was held at the headquarters office of 7 affected national forests along with appropriate BLM Districts to announce proposals and meet inter-agency responsibilities.

In the first quarter of 1981, 1,700 persons attended informational meetings at 24 locations throughout the state. There were 2,500 sets of public review reports given to interested persons at meetings and through mailing. The abbreviated public review report amounted to 7 pages and a comprehensive report amounting to 16 pages of information was available for special purposes.

Outspoken stockgrowers proposed lower elk numbers and some took their demands to an on-going legislative session. Some sport groups countered with higher proposals than recommended by Department biologists. The matter of how much forage would be consumed triggered an unbelievable defensive reaction from other interests when traditional equivalency ratings of 2 elk and 5 deer per cow were challenged. Nearly all respondents approved the management by objective approach and many gave support to Department proposals. Most controversy centered on a few elk units; mule deer proposals were essentially non-controversial. A decision-making date of July 1981 was postponed for 6 months to allow a special task group of range specialists from 5 agencies to ascertain if proposals were excessive for available forage. In a 4-month period, the range specialists visited with technicians and inspected some ranges, resulting in a report to the Oregon Fish and Wildlife Commission.

RESULTS

On December 11, 1981, the Oregon Fish and Wildlife Commission formally adopted 75 sets (28 elk, 47 deer units) of management objectives. The proposed population level was changed in 6 elk units in response to local stockgrower and other demands. The net effect of changes amounted to a target level for elk only 3% lower than originally proposed, a vote of confidence by the Commission in the judgments of Department biologists. No mule deer units were changed.

DISCUSSION

Since the 1940s in Oregon, the business of gathering census information on elk and deer and mysteriously devising bag opportunities out of an array of counts per mile, ratios of males and young, past kill experience, damage complaints, and range studies remained unchanged. The challenge came with the questions, "what are you trying to achieve," or "how many is enough?" Quantified goals were demanded for land-use planning. Unquantified and nebulous census indexes seemed unsuited for the allocation of habitat resources. In Oregon, a forward step was taken in elk and deer management, and the implication extends to other species. Unofficial management objectives were used in developing hunting regulations since 1979.

Communication, using quantified resource information between technicians and lay persons, has vastly improved understanding about resource management needs. The tradeoffs when decision-makers must weigh biological needs against expressed social demands are visible. For example, it is easy to display how antlerless elk take must be increased and how many of the sub-legel bulls show up missing when special 3-point rules are adopted in conjunction with a stable herd level objective.

A job is not done when it can be improved. Management objective responsibilities falling to the field biologist are annual updates, sub-herd models and sub-unit objectives, and involvement in coordinated resource management plans to meet objectives. At the staff level, an effort will be made to develop objectives in western Oregon for Roosevelt elk and blacktailed deer where the data base is less strong.

MULTIPLE ELK TAG SYSTEM AND ITS EFFECT ON ELK HUNTING PRESSURE AND SUCCESS IN WASHINGTON STATE

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Abstract: Elk hunting pressure was excessive in a few Washington elk areas between 1976 and 1978 when an average of 110,725 people purchased elk tags. In 1978, an all-time record 118,636 people purchased tags. Eastside areas received excessive pressure, particularly in the Colockum and Yakima areas. For 1979-1981, the Game Commission adopted a 4-area, 5-tag concept, under which hunters had free choice of which tag to purchase and could not change tags at a later date. By making some seasons more attractive than others, pressure was moved from Colockum and Yakima to the westside, and total elk tag sales have been reduced. In the Blue Mountains only a slight increase in pressure and slight decrease in harvest and success was obtained between 1976-1978 and 1979-1981. In the Colockum, everything decreased: pressure (-29%), harvest (-32%), and success (-4%), but the quality of the hunt improved. The 2-tag stratified system in Yakima resulted in a 50-50 split and a reduction in pressure (-31%). Improved were harvest (+23%) and success (+77%). Altogether, the eastside's 4-tags reduced pressure 21%, increased success 28% and obtained a similar harvest. Westside pressure increased dramatically the first year (1979), but was only 24% above that of 1976-1978 for the 1979-1981 period. Reduced were harvest (-11%) and success (-28%). The Mt. St. Helens volcanic eruption and the 1980-1981 restricted zone around the volcano influenced the reduced westside hunting pressure during the last 2 years of the 3-year comparison. Statewide slight declines have been noted in pressure (-3%), harvest (-6%), and success (-3%). While complicated, the 5-tag system was an improvement and has been favorably accepted by the public. Stratification with Early-Late overlapping bull seasons offers potential for further modification in the future to reduce opening day crowding. Were it not for the volcano, elk harvest under both systems would have been comparable, at least.

FIVE DIFFERENT ELK TAGS

Since 1931, the state's elk population has increased 6-fold from about 10,000 animals (Rief 1931) to about 16,000 (Pautzke et al. 1939) to about 60,000 by Population Trend Index (PTI) (Table 1). From 1935-1936, elk hunting pressure has increased 54-fold. The 47-year average is 1.7 hunters per elk (PTI), but in spite of large increases in numbers of hunters, it was 1.8 hunters per elk during the 1979-1981 period (see Table 1). All 1981 data used in this report are preliminary estimates. Final data for harvest (April 1, 1982) and tag sales (December 1, 1982) will not be available until later this year.

Hunting pressure problems have been particularly apparent on the eastside, which had 61% of the elk in the 1949-1951 period. While elk had increased from 13,000 to 23,000 in 1978, this area received about 59% of the hunting pressure. On the westside, the elk population increased from 8,000 (1950) to 35,000 (1978), but this area received only 41% of the hunters.

Table 1. Washington hunter/elk relationships, 3-year periods; 1935-1981; yearly averages

Years	Elk Tag Sales*	Hunter Pct. Success	Elk Pop. Trend Index*	Hunters Per Elk	PTI Percent Eastside
1935-1936	2	28	3	0.7	-
1937-1939	5	28	6	0.8	-
1940-1942	7	27	11	0.6	-
1943-1945	20	15	17	1.2	-
1946-1948	30	11	22	1.4	-
1949-1951	52	17	21	2.5	61
1952-1954	35	9	19	1.8	56
1955-1957	41	16	23	1.8	49
1958-1960	49	15	31	1.6	46
1961-1963	61	14	38	1.6	45
1964-1966	75	16	48	1.6	45
1967-1969	93	13	55	1.7	46
1970-1972	86	11	53	1.6	48
1973-1975	104	12	53	2.0	44
1976-1978	111	11	56	2.0	41
1979-1981	108	11	60	1.8	42
47 year ave.	54	16	32	1.7	48

* In thousands

To redistribute hunting pressure away from the eastside, particularly the Colockum and Yakima area, the Game Commission adopted a 4-area, 5-tag concept for 1979. Table 2 compares pressure, harvest, and success data of the 1976-1978 period (1 tag) to that of the 1979-1981 period (5 tags). Figure 1 shows how the state was divided into 4 elk areas.

Table 2. Washington elk hunters, harvest and success comparison between 1979-1981 (5 tags) and 1976-1978 (1 tag)

		One tag 1976-1978 yearly average				Five tag 1979-1981 yearly average				Percent change 1979-1981 from 1976-1978			
Prefix	Elk Tag Area	Elk Tags	Pct. of Total	Harvest	Pct. Success	Elk Tags	Pct. of Total	Harvest	Pct. Success	Elk Tags	Pct. of Total	Harvest	Pct. Success
M	Blue Mountains	17,163	15.5%	2,080	12.1%	17,602	16.3%	2,097	11.9%	+ 2.6%	+ 5.2%	+ 0.8%	- 1.7%
Subtotal	COLOCKUM - YAKIMA	47,834	43.2%	3,437	7.2%	33,510	31.0%	3,450	10.3%	-28.9%	-28.2%	- 0.4%	+43.1%
K	Colockum	14,727	13.3%	1,427	9.7%	10,518	9.7%	974	9.3%	-28.6%	-27.1%	-31.7%	- 4.1%
X-Y	Yakima	33,107	29.9%	2,010	6.1%	22,992	21.3%	2,476	10.8%	-30.6%	-28.8%	+23.2%	+77.0%
Subtotal	EASTSIDE	64,997	58.7%	5,517	8.5%	51,112	47.3%	5,547	10.9%	-21.4%	-19.4%	+ 0.5%	+28.2%
W	Westside	45,728	41.3%	6,490	14.2%	56,856	52.7%	5,778	10.2%	+24.3%	+27.6%	-11.0%	-28.2%
Total	STATEWIDE	110,725	100.0%	12,007	10.8%	107,968	100.0%	11,325	10.5%	- 2.5%	-	- 5.7%	- 2.8%

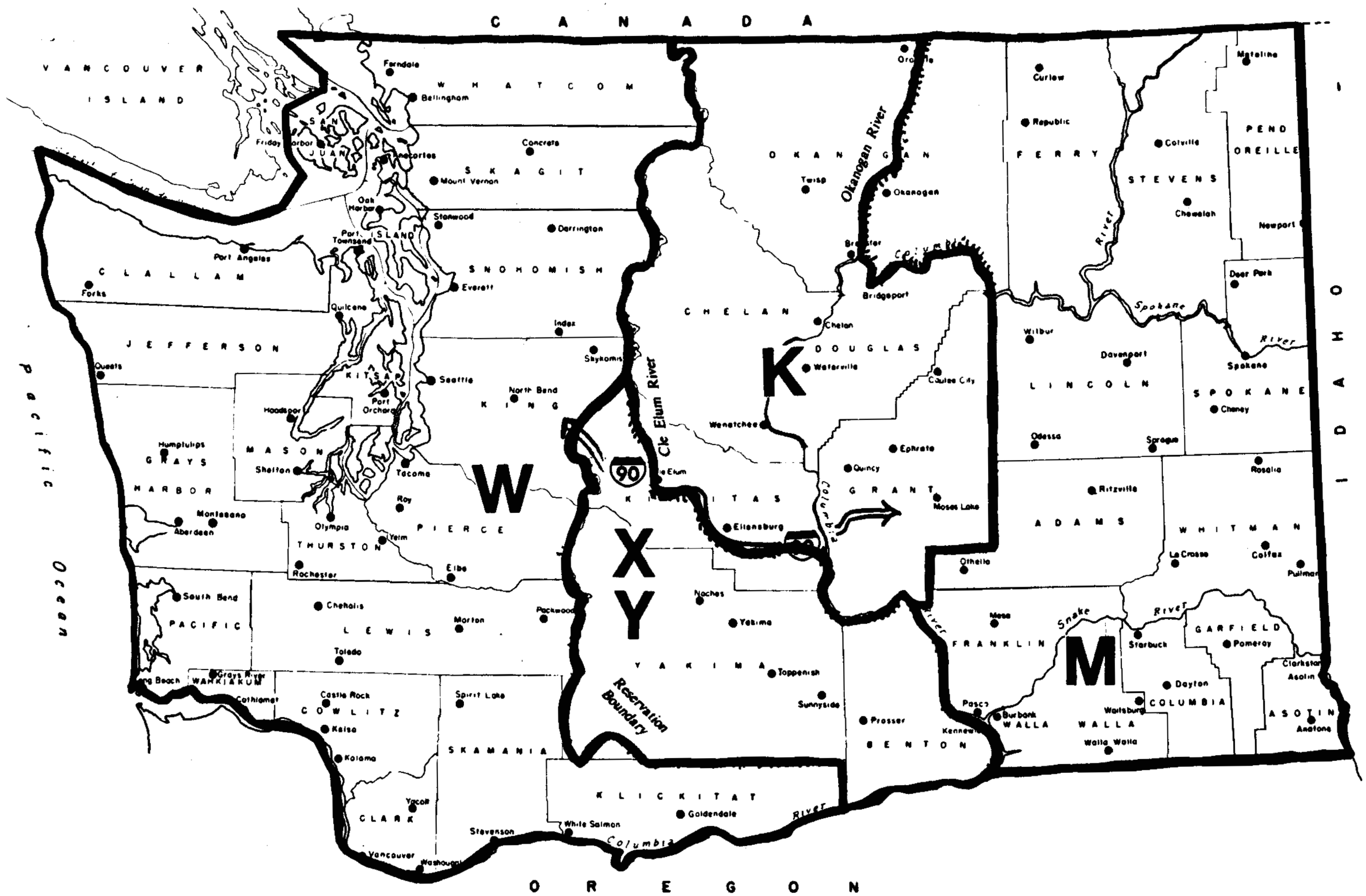


Figure 1. Washington's four elk areas.

Blue Mountains

Figure 2 shows the M elk tag (blue) which can be used in the Blue Mountains bull elk season. It has a partnership application which can be used for one of the M tag controlled either-sex elk hunt drawings. It may be used for all bow and muzzle loader hunts, which are normally before or after the general bull elk season. Table 3 shows Blue Mountains elk area information for the 1979-1981 period.

Wednesday, November 3, 1982, has been established as the opening day for this area next fall. Table 2 shows that hunter, harvest and success data is similar to the above under the 1-tag system used from 1976 through 1978. Some sentiment exists to stratify this area similar to the Yakima area experience for 1983.

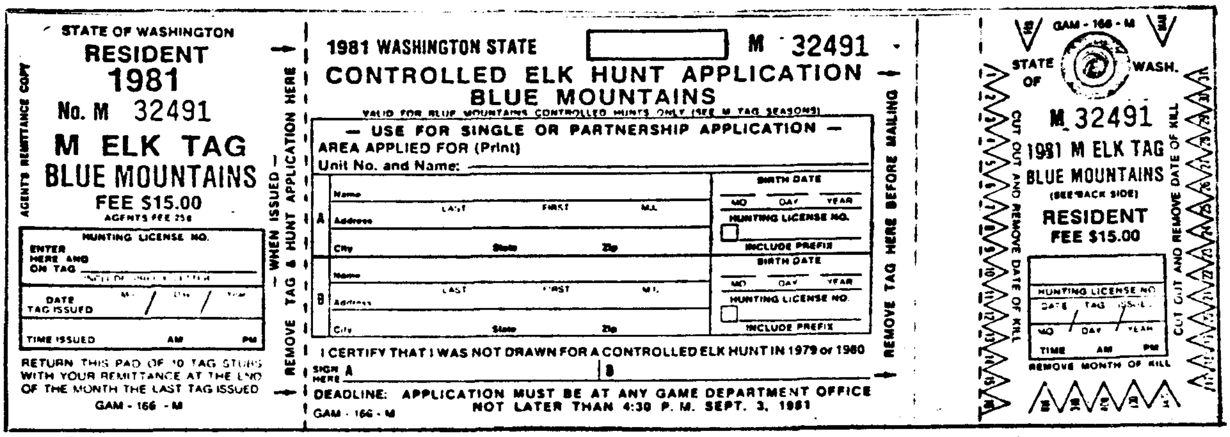

STATE OF WASHINGTON
RESIDENT
1981
No. M 32491
M ELK TAG
BLUE MOUNTAINS
FEE $15.00
HUNTING LICENSE NO.
DATE TAG ISSUED
TIME ISSUED AM PM
RETURN THIS PAD OF 10 TAG STUBS WITH YOUR REMITTANCE AT THE END OF THE MONTH THE LAST TAG ISSUED
GAM - 166 - M
AGENTS REMITTANCE COPY
REMOVE TAG & HUNT APPLICATION HERE WHEN ISSUED
1981 WASHINGTON STATE M 32491
CONTROLLED ELK HUNT APPLICATION
BLUE MOUNTAINS
— USE FOR SINGLE OR PARTNERSHIP APPLICATION —
AREA APPLIED FOR (Print)
Unit No. and Name:
A Name LAST FIRST M.I. Address City State Zip
BIRTH DATE MO DAY YEAR
HUNTING LICENSE NO.
INCLUDE PREFIX
B Name LAST FIRST M.I. Address City State Zip
BIRTH DATE MO DAY YEAR
HUNTING LICENSE NO.
INCLUDE PREFIX
I CERTIFY THAT I WAS NOT DRAWN FOR A CONTROLLED ELK HUNT IN 1979 or 1980
SIGN HERE A B
DEADLINE: APPLICATION MUST BE AT ANY GAME DEPARTMENT OFFICE NOT LATER THAN 4:30 P. M. SEPT. 3, 1981
GAM - 166 - M
REMOVE TAG HERE BEFORE MAILING
GAM - 166 - M
STATE OF WASH.
M 32491
1981 M ELK TAG
BLUE MOUNTAINS
(SEE BACK SIDE)
RESIDENT
FEE $15.00
HUNTING LICENSE NO.
DATE TAG ISSUED
MO DAY YEAR
TIME AM PM
REMOVE MONTH OF KILL
CUT OUT AND REMOVE DATE OF KILL

Figure 2. 1981 M Elk Tag.

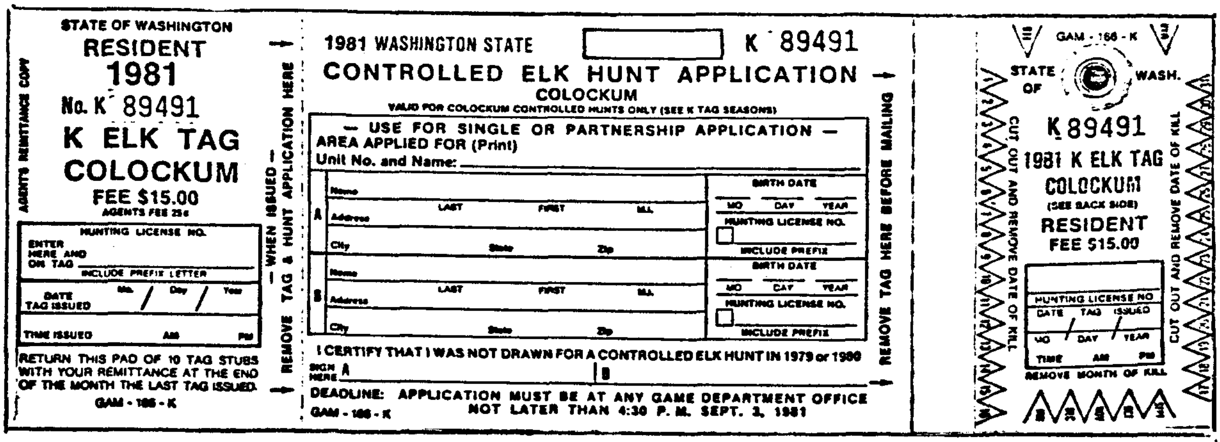
Table 3. Blue Mountains elk tag (M), 1979-1981

Year	Opening Day	November Dates	Length in Days	Elk Tags	Pct. of St. Total	Elk Harvest	Pct. Success
1979	Wed.	7-18	12	18,065	15.5	1,920	10.6
1980	Wed.	5-16	12	18,298	17.4	2.170	11.9
1981	Wed.	4-15	12	16,441	16.1	2.200	13.4
Ave.	Wed.	5-16	12	17,602	16.3	2,097	11.9

Colockum

Figure 3 shows the K elk tag (gray) which can be used for Colockum bull elk season. Its application may also be used for K tag controlled either-sex elk hunt drawings and in the same manner as the M tag for pre- and post-bull seasons hunts. Table 4 shows 1979-1981 Colockum elk tag data.

Monday, October 25, 1982, has been established as the opening date for this area next fall. Table 2 shows that pressure (-29%), harvest (-32%), and hunter success (-4%) have all been reduced under the 5-tag system. The early dates and the short 10-day season with a Monday opening have contributed to these reductions. Colockum hunters like the reduced pressure, but would like a later season. A special problem of hunter pressure moving elk across the Columbia River into the Columbia Basin irrigated farmlands has mitigated against a later season.


STATE OF WASHINGTON
RESIDENT
1981
No. K 89491
K ELK TAG
COLOCKUM
FEE $15.00
AGENTS FEE 25¢
HUNTING LICENSE NO.
ENTER HERE AND ON TAG
INCLUDE PREFIX LETTER
DATE TAG ISSUED Mo. / Day / Year
TIME ISSUED AM PM
RETURN THIS PAD OF 10 TAG STUBS WITH YOUR REMITTANCE AT THE END OF THE MONTH THE LAST TAG ISSUED.
GAM - 186 - K
AGENTS REMITTANCE COPY
REMOVE TAG & HUNT APPLICATION HERE — WHEN ISSUED —

1981 WASHINGTON STATE K 89491
CONTROLLED ELK HUNT APPLICATION
COLOCKUM
VALID FOR COLOCKUM CONTROLLED HUNTS ONLY (SEE K TAG SEASONS)
— USE FOR SINGLE OR PARTNERSHIP APPLICATION —
AREA APPLIED FOR (Print)
Unit No. and Name:
A Name LAST FIRST M.I. BIRTH DATE MO DAY YEAR
Address HUNTING LICENSE NO.
City State Zip INCLUDE PREFIX
B Name LAST FIRST M.I. BIRTH DATE MO DAY YEAR
Address HUNTING LICENSE NO.
City State Zip INCLUDE PREFIX
I CERTIFY THAT I WAS NOT DRAWN FOR A CONTROLLED ELK HUNT IN 1979 or 1980
SIGN HERE A B
DEADLINE: APPLICATION MUST BE AT ANY GAME DEPARTMENT OFFICE NOT LATER THAN 4:30 P. M. SEPT. 3, 1981
GAM - 186 - K
REMOVE TAG HERE BEFORE MAILING

GAM - 186 - K
STATE OF WASH.
K 89491
1981 K ELK TAG
COLOCKUM
(SEE BACK SIDE)
RESIDENT
FEE $15.00
HUNTING LICENSE NO
DATE TAG ISSUED MO / DAY / YEAR
TIME AM PM
REMOVE MONTH OF KILL
CUT OUT AND REMOVE DATE OF KILL

Figure 3. 1981 K Elk Tag.

Table 4. Colockum Elk Tag (K), 1979-1981

Year	Opening Day	Dates Oct.-Nov.	Length in Days	Elk Tags	Pct. of St. Total	Elk Harvest	Pct. Success
1979	Mon.	29-7	10	11,386	9.8	1,076	9.5
1980	Mon.	27-5	10	10,851	10.3	979	9.0
1981	Mon.	26-4	10	9,317	9.1	866	9.2
Ave.	Mon.	27-5	10	10,518	9.7	974	9.3

Yakima

Figure 4 shows the X elk tag (salmon) and Fig. 5 the Y elk tag (yellow) which have over-lapping bull elk seasons in the Yakima area. The Early Yakima (X) tag has a longer bulls-only season and purchasers may not apply for an either-sex controlled hunt permit.

The Late Yakima (Y) tag has a shorter bull elk season and purchasers may apply for an either-sex permit in the Yakima tag area.

The Early-Late overlapping stratification is shown in Table 6 approximating a 50-50 split over the 3 years. The drift has been toward the Early (bulls only, long season) tag. Perhaps a contributing factor has been slightly better bull escapement under the stratified seasons.

The Yakima area has benefitted the most from the 5-tag system (see Table 2). Pressure has been reduced 31% from 1976-1978. Harvest is up 23% and hunter success up 77% over the same 1976-1978 period. Data collection systems are not adequate to determine harvest and success by Early or Late tag, but in general Early tag holders take most of the bulls while Late tag holders take some bulls and all the cows and calves. It appears that the Early Yakima tag is a better deal for the hunter in spite of his not being able to apply for a permit. The stratified tag system used in Yakima has potential for use in other areas in the future. By splitting opening day hunting pressure, it makes a weekend opening day both possible and desirable.

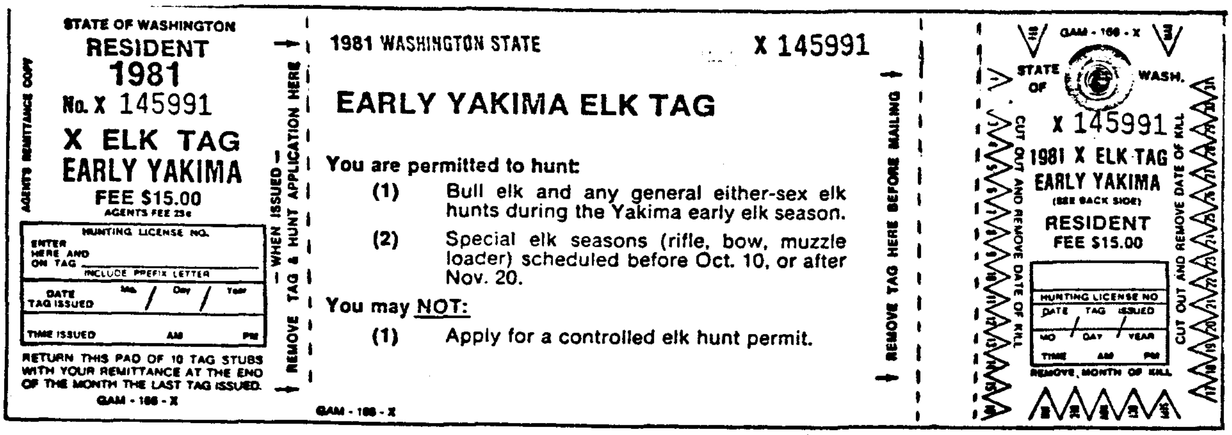

STATE OF WASHINGTON
RESIDENT
1981
No. X 145991
X ELK TAG
EARLY YAKIMA
FEE $15.00
AGENTS REMITTANCE COPY
HUNTING LICENSE NO.
DATE TAG ISSUED
TIME ISSUED
RETURN THIS PAD OF 10 TAG STUBS WITH YOUR REMITTANCE AT THE END OF THE MONTH THE LAST TAG ISSUED.
GAM - 166 - X
REMOVE TAG & HUNT APPLICATION HERE — WHEN ISSUED
1981 WASHINGTON STATE
X 145991
EARLY YAKIMA ELK TAG
You are permitted to hunt:
(1) Bull elk and any general either-sex elk hunts during the Yakima early elk season.
(2) Special elk seasons (rifle, bow, muzzle loader) scheduled before Oct. 10, or after Nov. 20.
You may NOT:
(1) Apply for a controlled elk hunt permit.
GAM - 166 - X
REMOVE TAG HERE BEFORE MAILING
STATE OF WASH.
X 145991
1981 X ELK TAG
EARLY YAKIMA
RESIDENT
FEE $15.00
CUT OUT AND REMOVE DATE OF KILL

Figure 4. 1981 X Elk Tag

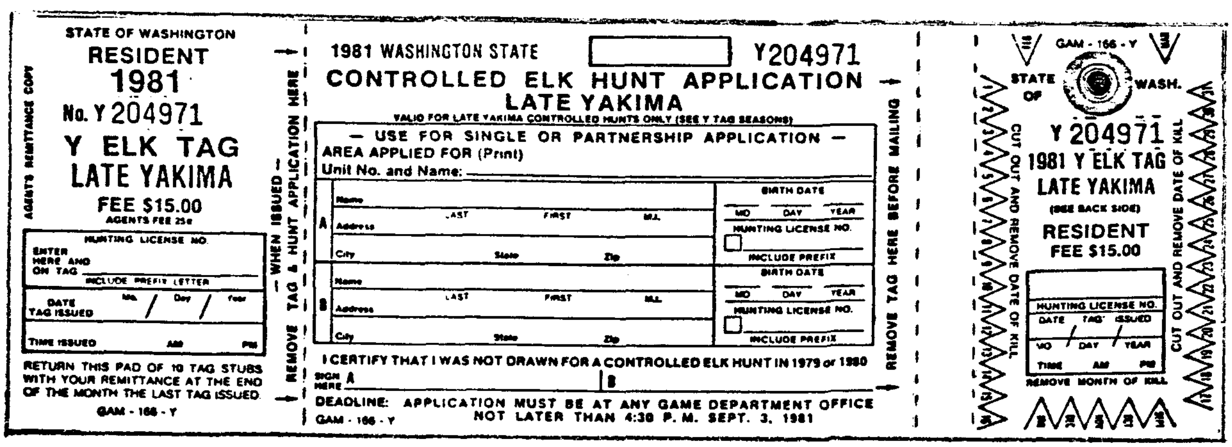

STATE OF WASHINGTON
RESIDENT
1981
No. Y 204971
Y ELK TAG
LATE YAKIMA
FEE $15.00
AGENTS REMITTANCE COPY
HUNTING LICENSE NO.
DATE TAG ISSUED
TIME ISSUED
RETURN THIS PAD OF 10 TAG STUBS WITH YOUR REMITTANCE AT THE END OF THE MONTH THE LAST TAG ISSUED.
GAM - 166 - Y
REMOVE TAG & HUNT APPLICATION HERE — WHEN ISSUED
1981 WASHINGTON STATE
Y204971
CONTROLLED ELK HUNT APPLICATION
LATE YAKIMA
— USE FOR SINGLE OR PARTNERSHIP APPLICATION —
AREA APPLIED FOR (Print)
Unit No. and Name:
Name LAST FIRST M.I.
Address
City State Zip
BIRTH DATE MO DAY YEAR
HUNTING LICENSE NO.
INCLUDE PREFIX
I CERTIFY THAT I WAS NOT DRAWN FOR A CONTROLLED ELK HUNT IN 1979 or 1980
SIGN HERE
DEADLINE: APPLICATION MUST BE AT ANY GAME DEPARTMENT OFFICE NOT LATER THAN 4:30 P.M. SEPT. 3, 1981
GAM - 166 - Y
REMOVE TAG HERE BEFORE MAILING
STATE OF WASH.
Y 204971
1981 Y ELK TAG
LATE YAKIMA
RESIDENT
FEE $15.00
CUT OUT AND REMOVE DATE OF KILL

Figure 5. 1981 Y Elk Tag

Table 5. Yakima Elk Tag (X-Y), 1979-1981

Year	Opening Days	November Dates	Length in Days	Elk Tags*	Pct. of St. Total	Elk Harvest	Pct. Success
1979	Sun.(X)	4-18	15	20,994	18.0	2,474	11.8
	Sat.(Y)	10-18	9				
1980	Sun.(X)	2-16	15	23,296	22.2	2,221	9.5
	Sat.(Y)	8-16	9				
1981	Sun.(X)	1-15	15	24,687	24.1	2,734	11.1
	Sat.(Y)	7-15	9				
Ave	Sun.(X)	2-16	15	22,992	21.3	2,476	10.8
	Sat.(Y)	8-16	9				

* X and Y tags added together

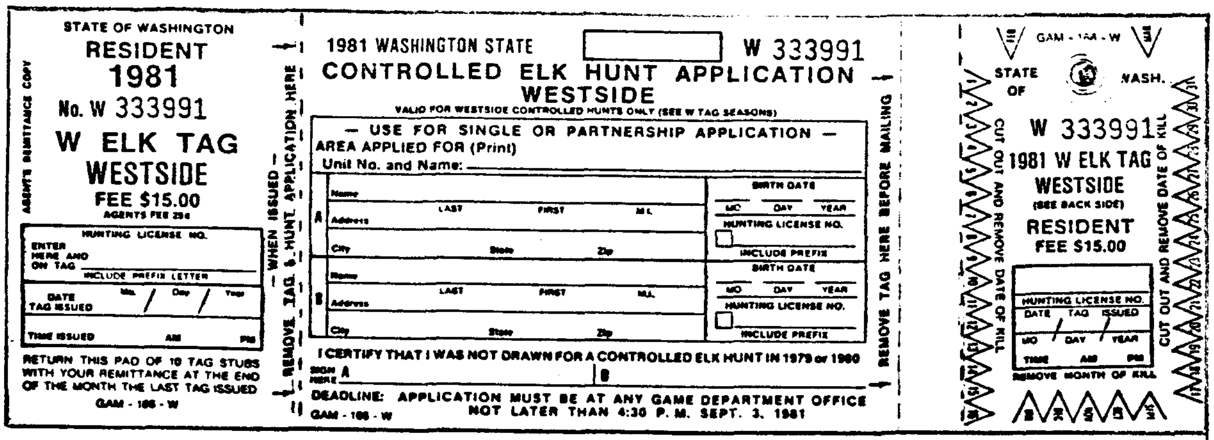
Table 6. Yakima (X-Y) Elk Tag Sales, 1979-1981

	Elk Tag Sales				
	Early Yakima (X)		Late Yakima (Y)		Yakima
Year	No.	Pct.	No.	Pct.	Total
1979	9,838	46.9	11,156	53.1	20,994
1980	11,108	47.7	12,188	52.3	23,296
1981	13,246	53.7	11,441	46.3	24,687
Ave.	11,397	49.6	11,595	50.4	22,992

Westside

Figure 6 shows the W elk tag (green) which can be used in the Westside bull elk season. It has a partnership application which can be used for one of the W tag controlled either-sex elk hunt drawings and in the same manner as the M tag for pre- and post-season hunts statewide.

Table 7 shows Westside elk area information for the recent period.


STATE OF WASHINGTON
RESIDENT
1981
No. W 333991
W ELK TAG
WESTSIDE
FEE $15.00

1981 WASHINGTON STATE W 333991
CONTROLLED ELK HUNT APPLICATION
WESTSIDE
— USE FOR SINGLE OR PARTNERSHIP APPLICATION —
AREA APPLIED FOR (Print)
Unit No. and Name:
I CERTIFY THAT I WAS NOT DRAWN FOR A CONTROLLED ELK HUNT IN 1979 or 1980
DEADLINE: APPLICATION MUST BE AT ANY GAME DEPARTMENT OFFICE NOT LATER THAN 4:30 P.M. SEPT. 3, 1981

STATE OF WASH.
W 333991
1981 W ELK TAG
WESTSIDE
RESIDENT
FEE $15.00

Figure 6. 1981 Westside Elk Tag

Table 7. Westside Elk Tag (W), 1979-1981

Year	Opening Day	Dates November	Length in Days	Elk Tags	Pct. of St. Total	Elk Harvest	Pct. Success
1979	Sun.	11-25	15	66,019	56.7	6,800	10.3
1980	Sun.	9-19	11	52,601	50.1	5,450	10.4
1981	Sat.	7-17	11	51,949	50.7	5,085	9.8
Ave.	Sun.	9-20	12	56,856	52.7	5,778	10.2

Saturday, November 6, 1982, has been established as opening day for this area next fall. Table 2 shows a 24% increase in hunting pressure over that of the 1976-1978 period. It also shows decreases of harvest (-11%) and hunter success (-28%). The increase in hunters represents Colockum and Yakima hunters of 1976-1978 switching to the more attractive dates and options of the Westside elk tag.

The harvest decline is caused by the eruption of Mt. St. Helens volcano and the resultant restricted zone around it. A portion of a major elk herd was excluded from hunting because of this. In 1979, before the eruption, the Westside harvest was 6,800 elk, exceeding the 6,490 average for 1976-1978. After the eruption, the Westside harvest was 5,450 and 5,085. The 4-year pre-eruption average of 6,568 is 1,300 above the 2-year post-eruption average of 5,268. While perhaps over simplified, this would mean that with an active volcano the Westside's elk hunting capacity was reduced 12,621 hunters taking 1,300 elk for 10.3% success (1979 rate). Since the 1980-1981 average was 13,744 hunters below the 1979 Westside total, the above projection is fairly close.

Westside hunter success, while 28% below that of 1976-1978, is more consistent with eastside areas and is comparable to the statewide average. It might even be that those who deserted eastside areas for the westside when the 5-tag system was initiated are the type of hunters who are usually unsuccessful regardless of where they hunt elk.

SUMMARY

Washington's elk hunting seasons, in spite of increasing elk populations, had become almost unworkable under a single statewide elk tag and season by 1970. A Monday opening day gave temporary respite (Parsons 1975), but by 1978 the Game Commission decided something drastic was necessary to alleviate excessive hunting pressure, particularly in the Colockum and Yakima areas (Parsons and Brown 1978). A 4-area, 5-tag system was adopted for 1979, to be kept on an experimental basis for at least 3 years (Parsons 1980). Data in this report shows that the new system: (1) improved Yakima area hunting substantially; (2) lowered heavy pressure greatly in the Colockum; (3) forced hunters to the Westside, where in concern with a volcanic eruption, lowered hunting quality but equalized hunter success; and (4) had little affect on the Blue Mountains. While it solved the major problems, it created some new ones. For the future, the stratified Yakima experience using Early (bulls only, longer season) and Late (permit applications, shorter bull season) seems to offer an excellent method for dividing opening day hunting pressure in half. Opening dates for 1982 have been established using the same 5-tag system.

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______. 1975. The Monday elk opener, an analysis of hunter preference for the opening day of elk season. Wash. Game Dept., Olympia. 17pp.

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Pautzke, C., B. Lauckhart and L. Springer. 1939. Washington elk report. Wash. Game Dept., Seattle. 23pp.

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ANALYSIS OF BULL ONLY HUNTING IN THE LOCHSA RIVER DRAINAGE, IDAHO

MICHAEL W. SCHLEGEL, Wildlife Research Biologist, Idaho Department Fish and Game, Kamiah, ID

Abstract: Various elk population parameters were analyzed to evaluate the impact of a bull only hunting strategy on the bull cohort in the Lochsa Management Unit (12) in northcentral Idaho. Between 1947 and 1972 the hunting strategy was general either sex. In 1973 and 1974 the north half of the unit was a general bull only. The south half of the unit was general either sex. Since 1975, the entire management unit has been under a general bull-only hunting strategy.

Following 7 years of general bull-only hunting, the number of harvested bulls reported at the check stations has increased, the ratio of branched antlered to yearling bulls in the harvest has remained constant (80% to 20%), the post season bull:cow ratio has remained constant (30), the post season calf:cow ratio has increased slightly (24 to 34), the number of bulls classified post season has increased, the post season ratio of branched antlered and yearling bulls has remained constant (60% to 40%), and the general population trend is upward.

A paper on this topic was presented at the Western States Fish and Game Commissioners' meeting in July, 1980. Copies are available upon request.

SOME EFFECTS OF FOREST MANAGEMENT ON ELK HUNTING OPPORTUNITY

TERRY N. LONNER, Montana Department of Fish, Wildlife and Parks, Bozeman, MT
JOHN D. CADA, Montana Department of Fish, Wildlife and Parks, Bozeman, MT

Abstract: Elk management in Montana has experienced some major directional changes since 1900. Early objectives of elk management were to introduce elk into areas with few or no elk and then protect these elk and remnant herds with very restrictive hunting regulations to allow populations to increase. This effort was successful and beginning about 1950 elk hunting regulations became progressively more liberalized until 1960 when 84% of elk hunting units had open either-sex seasons up to 2 months in length. Since 1960 elk hunting seasons have remained about the same length (35 ± 5 days), but nonpermit either-sex hunting has been declining at an accelerated rate with permit-only elk hunting on the increase. The reason for these present day restrictive elk hunting regulations appears to be more related to an ever increasing reduction of habitat security on forested land as a result of logging activities than to an increase in hunters. Elk hunters have increased from 60,000 in 1960 to 90,000 in 1980, a 50% increase, while timber removal resulted in a nearly 450% increase between these years. Assuming that elk hunters afield and elk are not going to increase substantially over the next decade (elk hunters have only increased about 15% in the last decade) the key to meeting future elk management objectives in Montana will be controlling access by road closures and/or maintenance of hiding cover quality. As a first effort in aiding resource managers to better understand the effects of timber management on elk hunting opportunity, a habitat effectiveness model is presented. Good habitat effectiveness was defined as the ability of an area to retain elk during the hunting season which would provide for a uniform harvest rate and a low bull turnover rate. This model was based upon the relationship between habitat security, elk harvest rate, effective season length, and recreational opportunity. It predicts loss or gain in hunting opportunity relative to hiding cover-open road density conditions for an area.

INTRODUCTION

Elk management in Montana has experienced some major directional changes since 1900. Early objectives of elk management were to introduce elk into areas with few or no elk and then protect these elk and remnant herds with very restrictive hunting regulations to allow populations to increase.

That effort was successful and beginning about 1950 elk hunting regulations became progressively more liberalized until 1960 when 84% of elk hunting units had open either-sex seasons up to 2 months in length (Fig. 1). These liberal seasons were necessary to achieve adequate harvests in rough, heavily-timbered country (Rognrud and Janson 1971). During the 1960's extensive logging in formerly unroaded forests resulted in a significant increase in access with substantial reductions in elk hiding cover. This, combined with an increase in hunter numbers, necessitated a return to more restrictive seasons to protect elk populations from an overharvest.

Since 1960 elk hunting seasons have remained about the same length (35 ± 5 days), but nonpermit either-sex hunting has been declining at an accelerated rate. Between 1960 and 1970 this amounted to a 28% reduction in nonpermit either-sex hunting and from 1970 to 1980 an 84% reduction. Conversely, permit-only elk hunting has increased from 3% in 1960 to 13% in 1980 (Fig. 1). The reason for these restrictive elk hunting regulations appears to be more related to an ever-increasing reduction of habitat security on forested land as a result of logging activities than to an increase in hunters. (About 80% of the total annual elk harvest, which has fluctuated moderately around an annual mean of 12,300 since 1950 [Fig. 2], has come from public land, most of which is national forest [Montana Department of Fish, Wildlife and Parks 1978]). Elk hunters have increased from 60,000 in 1960 to 90,000 in 1980, a 50% increase, while timber removal resulted in a nearly 450% increase between these years (Figs. 1 and 2).

Logging not only means at least a temporary reduction in hiding cover (trees), but a permanent establishment of logging roads. This reduction in hiding cover since 1960 will continue to be cumulative until the year 2000, since regeneration of hiding cover on logged sites will take at least 40 years. In fact, many of these sites will never again provide the hiding cover quality before cutting if managed on an even-aged rotation cycle. This is especially true for those timber stands that before cutting were in an advanced successional stage, 200+ years old and well removed from motorized traffic.

Wildlife managers have recognized that these modifications may increase harvest rates, reduce recreational opportunity, concentrate elk on limited areas or shift them to suboptimum habitats, and change the quality of hunting (Basile and Lonner 1979).

At the 1980 Elk Workshop in Cranbrook,B. C. Lonner presented a paper titled Why do we want elk, anyway? In this paper he stated that hunting is a major use of our public lands, especially those lands administered by the U.S. Forest Service(USFS) and Bureau of Land Management, and since hunting is such an ubiquitous activity on these lands, all other resource management activities can directly effect hunting regulations and opportunities. He also discussed some of the general results of the Montana Cooperative Elk-Logging Study and their management implications. He said, "The results of this effort have been generally accepted and fairly successful in application, but has this success been due to a positive biological response of the elk (i.e., better reproductive rates, better physical condition, and better natural survival rates) or due to a compensatory response of resource management agencies to further restrict the hunter to prevent an undesirable overkill of elk? For the time being, this success seems to be attributable mostly to the compensatory response of more restrictions on the hunter. In fact, much of this overall effort has resulted in recommendations or guidelines addressing the control of hunting effectiveness with road closures and hiding cover maintenance, while the initial concern was for the basic biological needs of the elk."

Generally our national forests and adjacent lands in Montana presently provide enough security (timber, topography, low road densities, and lack of development) to allow a 30-40 day general rifle season with a good opportunity for any person who buys an elk tag to kill an antlered bull throughout this season. However, there is a strong trend toward permit-only hunting for cows and calves with permit-only hunting for any elk also increasing (Fig. 2). Another concern in recent years is the increase of spike bulls in the harvest. The bull harvest in some areas of the state is 85% yearlings with many other areas trending toward this high bull turnover rate. Concurrently, where these conditions exist there is also a high harvest rate during the general rifle season with up to 70% of the antlered bull kill occurring the first week.

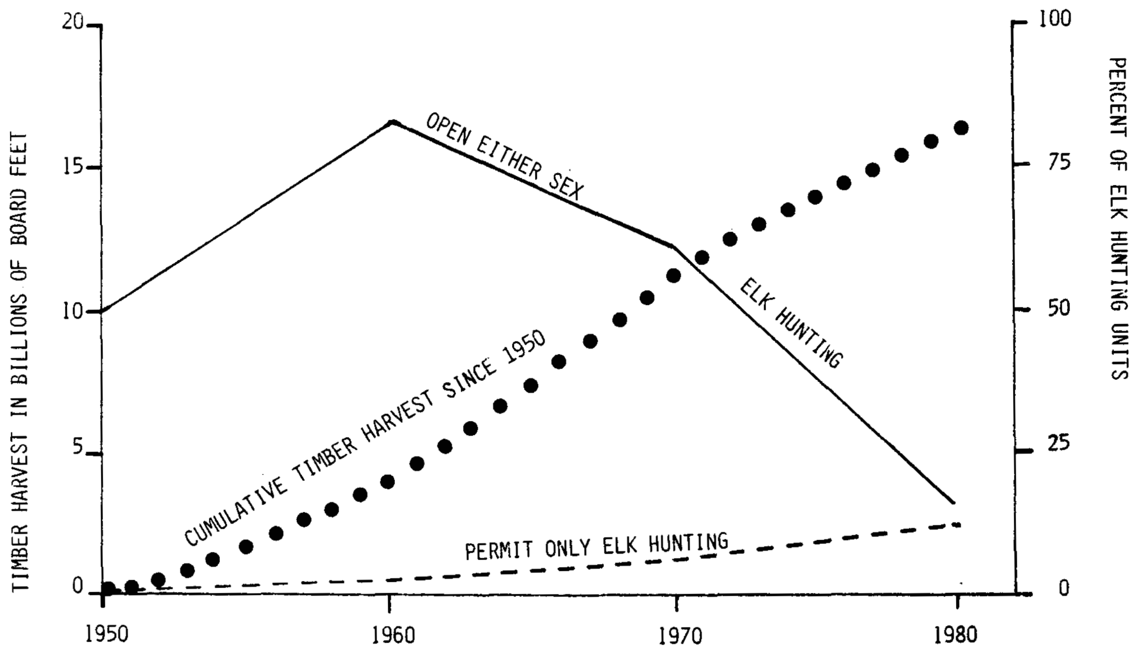

Figure 1. Trends of cumulative timber harvest from National Forest land, nonpermit either-sex elk hunting, and permit-only elk hunting, in Montana between 1950 and 1980

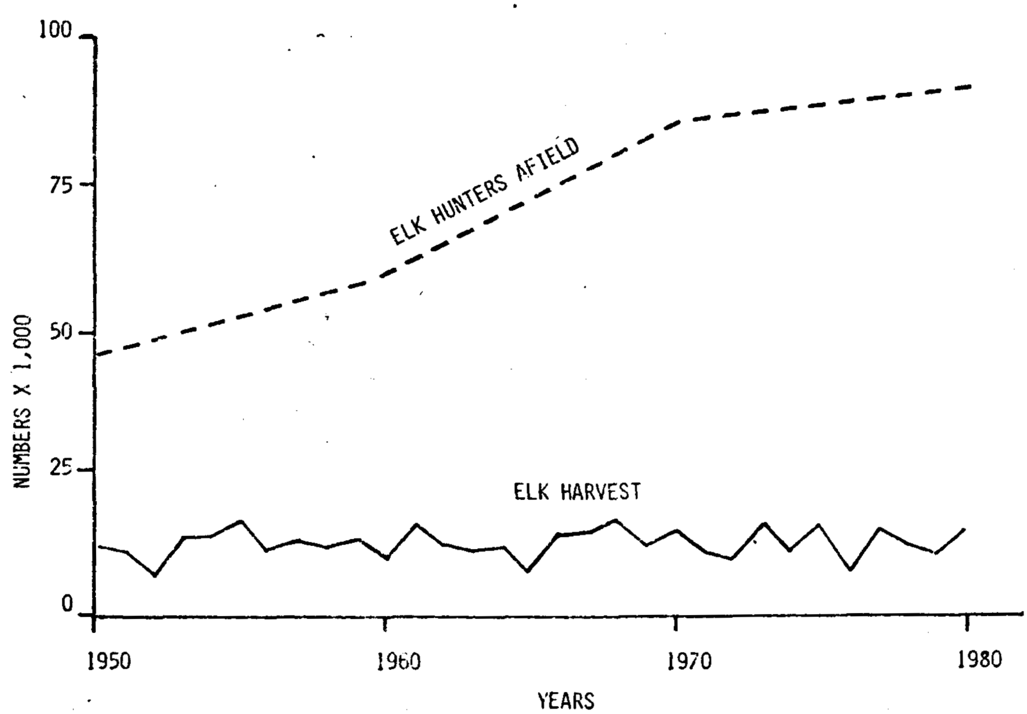

Figure 2. Trends of elk hunters afield and annual elk harvests in Montana between 1950 and 1980

The Montana Department of Fish, Wildlife and Parks' statewide objective for 1985 is to provide 676,300 days of elk hunting annually at a hunting success rate of 15% and average effort of 46 hunter days per elk harvested. This means providing the elk hunter with at least as much hunting opportunity as we now have (a 35-day general hunting season with open bull hunting and a fairly uniform harvest rate throughout the season).

Assuming that elk hunters afield are not going to increase substantially over the next decade (they have only increased about 15% in the last decade) the key to meeting this objective will be controlling access by road closures and/or maintenance of hiding cover quality.

As a first effort in aiding resource managers to better understand the effects of timber management on elk hunting opportunity, we developed a habitat effectiveness model. An explanation of this model follows.

HABITAT EFFECTIVENESS MODEL DERIVATION

Good habitat effectiveness is the ability of an area to retain elk during the hunting season, thus providing for a uniform harvest rate and a low bull turnover rate. In areas with a low habitat effectiveness a major portion of the harvest occurs in a relatively short time with a high bull turnover rate. This model was developed on the relationship between habitat security, elk harvest rate, effective season length, and recreational opportunity. Where data were not available some extrapolation and interpolation for missing data points were necessary to fully display relationships.

Habitat Security-Harvest Rate Relationship

Although habitat security can be a function of several factors, hiding cover provided by trees, and density of open roads were assumed to be the major determinants. Timber stands with at least 40% canopy cover were considered elk hiding cover. Road densities were based on all roads open to public motor vehicle use during the hunting season. Twenty-five Montana Fish, Wildlife and Parks elk hunting units were selected from areas east of the Continental Divide, therefore it is questionable how well this specific relationship would apply to areas west of the divide in Montana. Except for 4 of these units, the percent of each area that was hiding cover and road densities was determined from current forest service inventories. Nearly all of the elk harvest in these units came off of national forest land. The 4 exceptions were hunting units in the Missouri River Breaks where elk hunting is by permit only because of the low habitat security. If elk hunting in this area was unrestricted for antlered bulls, the harvest rate would be at least 85% the first week of the season (Bruce Campbell pers. comm. 1981).

Percent of the total antlered bull elk harvest during the first week of the general hunting season for each of the remaining 21 hunting units was acquired from hunter survey results determined by the Montana Department of Fish, Wildlife and Parks for the years 1979-1980. Antlered bull-only harvest information was used since elk hunting in most of Montana is unrestricted to any antlered bull.

A strong relationship was shown to exist between hiding cover, road densities, and harvest rate the first week of the general hunting season (Fig. 3). As hiding cover decreases and/or open road densities increase harvest rates the first week increase.

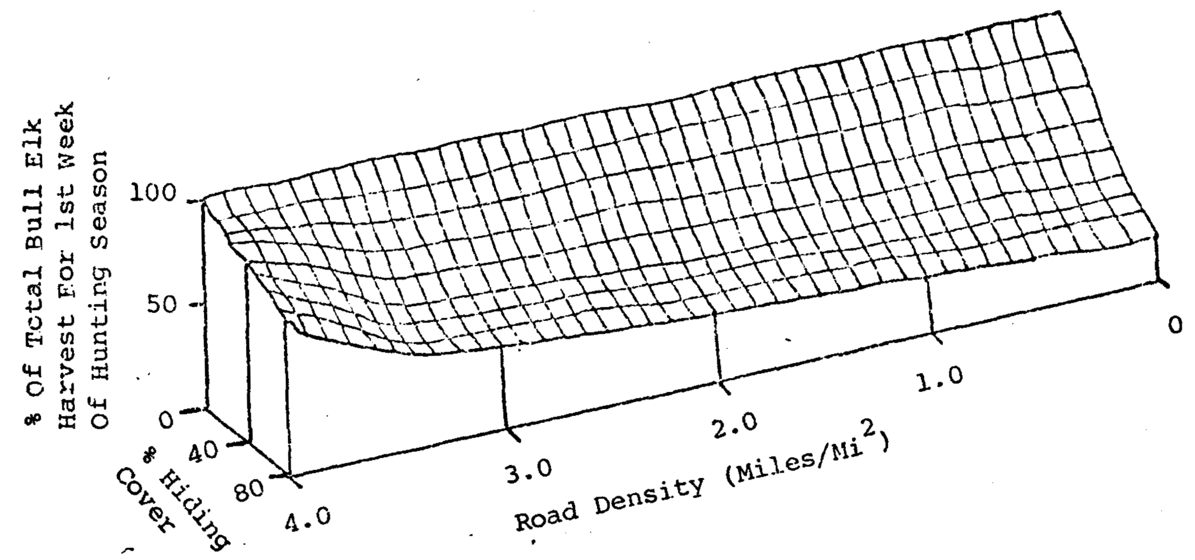

Figure 3. Relationship of percent hiding cover and open road densities to percent of the total bull elk harvest for the first week of the general hunting season for eastside forests in Montana

Harvest Rate-Effective Season Length Relationship

Since Montana has a 5-week general elk hunting season, an optimum (uniform) harvest rate would be when 20% of the harvest occurs the first week and least desirable conditions when 100% of the harvest occurs the first week. For this relationship we assumed a straight line projection between the percentage of the total season's elk harvest taken the first week and effective season length (Fig. 4). In other words, the higher the percentage of the total harvest that occurs the first week the shorter the effective season length. For example, if an area has a road density of 1 mile/mi^2 and a hiding cover percentage of 60, the model predicts a first week harvest rate (HR) of 38% (Fig. 3). This harvest rate then, results in an effective season length (ESL) of 18.4 days (Fig. 4). The equation for this calculation is:

$$\text{ESL} = \frac{700}{\text{hr}} = \frac{700}{38} = 18.4 \text{ days}$$

(Although a harvest rate of less than 20% the first week would result in an effective hunting season longer than 35 days, the graph defaults to 35 days.)

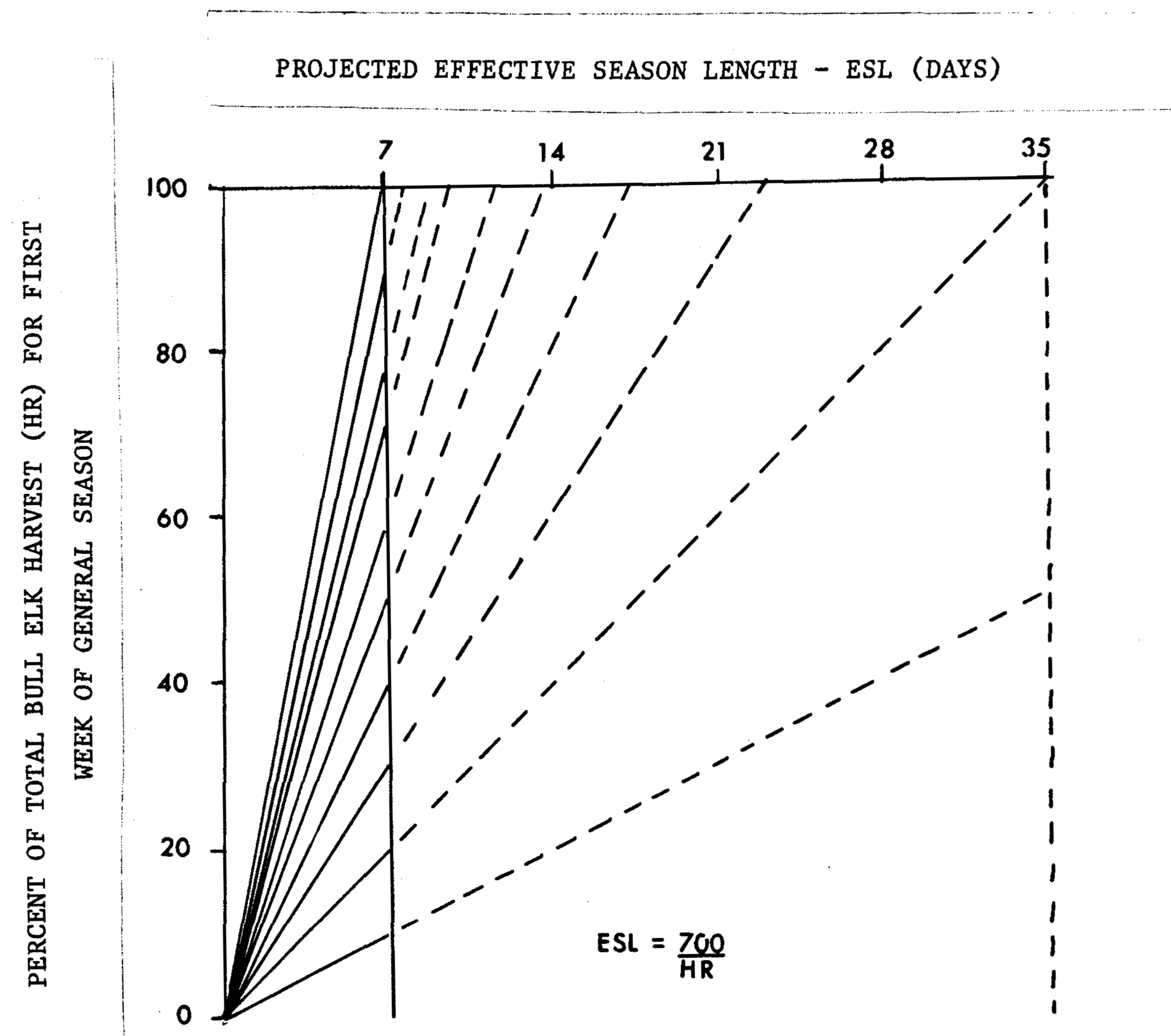

Figure 4. The relationship between harvest rate of elk for the first week of the general hunting season and effective season length

Effective Season Length - Recreational Opportunity Relationship.

Recreational opportunity is a function of season length, however hunter effort is usually not uniform throughout the season. It tends to be greatest at the beginning and toward the end of a season. Thus, the relationship between recreation days and effective season length is based upon the assumption that as the effective season length shortens, it will do so at the expense of recreation days that occur during the middle or least action portion of the season. Hunter days from check station data collected during the general elk seasons between 1973 and 1979 were ranked from most to least hunter effort per day and displayed cumulatively for prediction purposes (Fig. 5). Using the above calculated ESL of 18.4 days the habitat effectiveness (HE) calculates to be 67% of optimum. The equation for this calculation is:

$$HE = 9.56\ (ESL^{.6686}) = 9.56\ (18.4^{.6686}) = 67$$

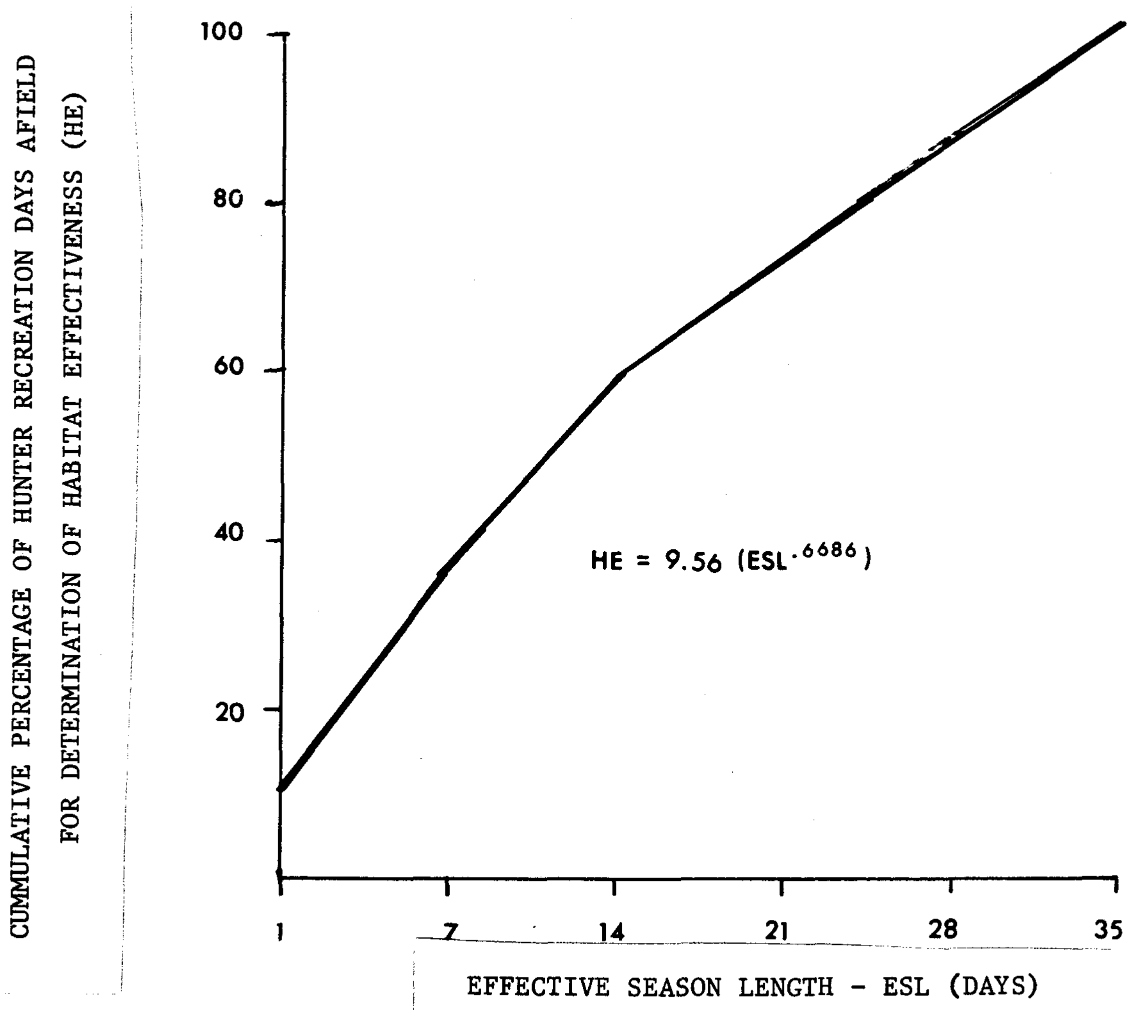

Figure 5. The relationship between cumulative percentage of hunter recreation days and effective season length for determination of habitat effectiveness in terms of elk hunting recreational opportunity

HABITAT EFFECTIVENESS MODEL

Using the harvest rate/hiding cover-road density relationship (Fig. 3) and the effective season length and habitat effectiveness graphs (Figs. 4 and 5, respectively) we summarized this process by building a predictive model showing the relationship between hiding cover, road density, and habitat effectiveness (Fig. 6). This model simplifies the exercise considerably. All one has to know is the road density and percent hiding cover for an area and look up the habitat effectiveness index from a yield table (not included in this report). Once this index is found it can serve as a reference point to compare with other indices resulting from hiding cover and/or road density changes in the area of concern. This model is most sensitive and useful when applied to relatively small areas such as a timber compartment.

Example: Using the above figures for an area with a road density of 1 mile/mi^2 and 60% hiding cover, this results in a 67% HE index. If over the next 10 years we change the road density to 2 mile/mi^2 and hiding cover amount to 50% as a result of logging, this gives us a 58% HE for a 13% reduction in HE: $100 - \frac{58}{67} = 13\%$. We can compensate some for his hiding cover removal by closing roads, which in this case would mean an open road density of zero. This exemplifies the importance of hiding cover in providing good habitat security. If no compensation is made, this 13% loss in habitat effectiveness translates into less hunting opportunity since the harvest rate will be increased with a shorter effective season length. This means it will take fewer elk hunter days to kill an elk and will also result in fewer branch antlered bulls in the harvest under open bull hunting regulations.

It also follows that as the effective season length shortens the more likely the legal season length will shorten and/or more hunting regulations will result. This all translates to less hunter opportunity with fewer hunter days needed to acheive elk harvest objectives.

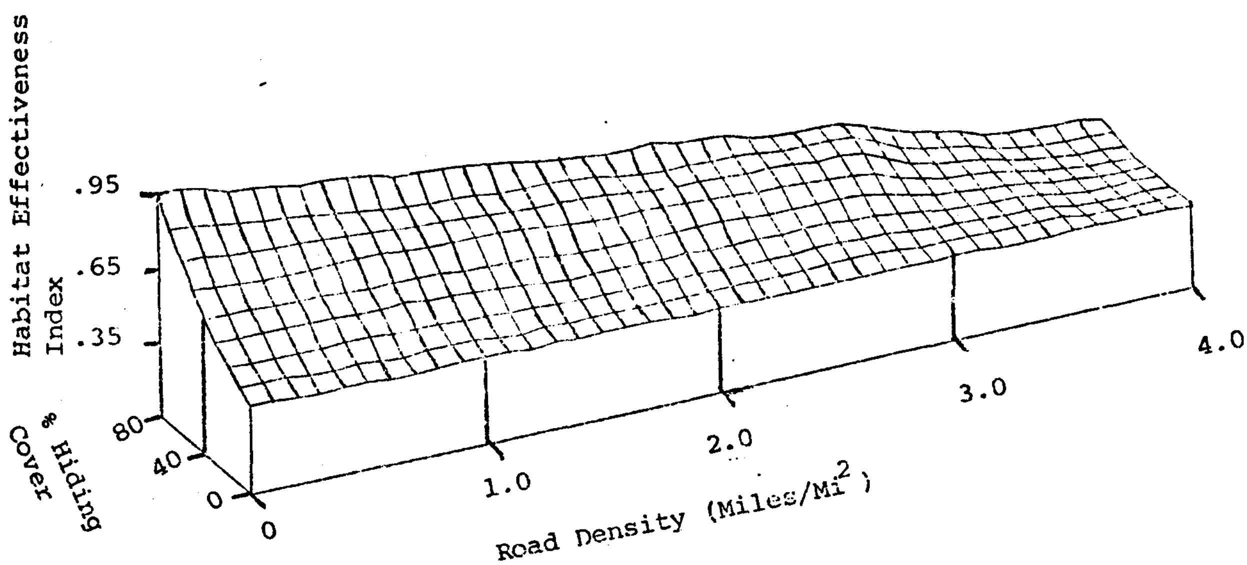

Figure 6. Relationship of percent hiding cover and open road densities to habitat effectiveness of an area in terms of elk hunting opporunity for eastside forests in Montana

DISCUSSION

Since elk habitat security is a function of space and hiding cover as influenced by human access, it is the habitat element first and most influenced by logging activities. Once an area is roaded and/or logged human access is the most manageable aspect of elk security by the land manager. However, road closures do not compensate completely for the loss of security. Roads that are built into an area and closed at its perimeter still provide at least a trailhead effect for hunters and other outdoor enthusiasts. Expected benefits of road closures can be partially negated by improved access for foot travel, horseback, motorbikes, and snow mobiles. If an area has the same hunting pressure, but less cover and easier access as a result of logging, a higher harvest is likely to occur within a shorter time period.

Unless significant changes are made in hunting season structure, detrimental biological consequences to elk populations may result from reducing habitat security by habitat alteration. A high annual bull turnover rate caused by increased hunter effectiveness could decrease net calf recruitment. Most elk hunting in Montana is unrestricted on antlered bulls with permits issued for cows and calves; therefore, antlered bull turnover rates in some areas could approach 100% allowing only male calves recruiting into the yearling or spike bull age class to be the sires of the herd. Recent findings and observations indicate this can cause conception to occur later in the fall, resulting in a later spring parturition date (Smith 1980, Prothero et al. 1979, Hines and Lemos 1979). A 3-4 week delay will prevent good calf development before winter that could predispose many calves to overwinter mortality in excess of the "evolved normal."

This process could result in low net recruitment and an eventual decline in or retarded population growth. To reverse or prevent this process it would be necessary to adjust hunting regulations so that branch antlered bulls would comprise at least 5% of the post hunt population (Smith 1980).

However, the relationships of habitat security and hunting opportunities are more apparent than those between habitat security and the basic biology of elk. Hunting recreational opportunities are good when hunting season lengths are relatively long, harvest rates are uniform, and rules and regulations few. The present 35-day general elk hunting season in Montana permits a diversity of choice with regard to time, weather conditions, hunter density, and area. A lengthy hunting season has little meaning if the majority of the harvest occurs in the first few days.

There is more to elk hunting than just killing an elk and we believe the effects of logging on hunting recreational opportunities to be as important to consider in the planning and public hearing process as those relationships between elk biology and logging. This consideration will be especially challenging to resource managers in Montana, since in the recent USFS Northern Regional Plan states, "In the future, it will be necessary to shift timber harvest to under accessed or unaccessed commercial forest land if the region's timber harvest is to be sustained" (USFS 1981).

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INTERPRETATION OF POSTHUNT SEX RATIOS IN WYOMING ELK HERDS

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Abstract: In Wyoming, wildlife managers gathering population data on elk herds typically collect posthunt sex and age ratios. Posthunt bull:cow ratios for 16 elk herds were examined using the computer simulation model, Program ONEPOP. Population models predicted higher posthunt bull:cow ratios than observed ratios for all but 3 elk herds. Prehunt and posthunt bull:cow ratios were examined for 2 herds. Simulated prehunt ratios were very similar to observed values. Underestimating bull:cow ratios can bias estimates of elk populations and male mortality.

INTRODUCTION

I once read an ad in a well-known news magazine that stated the pursuit and management of accurate information is the essence of management itself. There is little doubt regarding the value of accurate information in the wildlife management profession. A significant portion of every wildlife agency's budget is spent either directly or indirectly in the pursuit of information on the dynamics of populations to be used for making decisions on their management. Caughley (1976) went so far as to state that "wildlife management is, in fact, applied population dynamics directed at a specific sub-set of species." He also charged that the relative stagnation of the wildlife profession was a result of the lack of importance given to population dynamics in management theory and practice.

While it is arguable that many decisions regarding elk management smack of pragmatism rather than biology, the fault does not lie with management's ignorance of elk population dynamics. A great deal of elk population research throughout the west has been directed at describing the dynamics of populations and their relationship to management. In Wyoming, the Game and Fish Department spent approximately $57,600 in fiscal year 1981 in the pursuit of these data on the 37 herds managed in our state. It appears to me that an interest in the dynamics of elk populations is not a problem in most western states. Further, I do not feel that the use of pragmatism and population dynamics are mutually exclusive in managing elk herds. The problem seems to be in the determination of the type and extent of data needed and how it is ultimately to be used. Gross (1973) stated data collection problems succintly when he said, "the kinds and amounts of data may be based on an established program, or on the rationale that they are nice to have or might be needed in the future."

Since 1975, the Wyoming Game and Fish Department has attempted to improve the utility of existing data and to identify data shortfalls by use of a computer simulation model, Program ONEPOP (Gross et al. 1973). The use of this model in the management of an elk population has been described by Williams (1981). Gross et al. (1973) listed the optimum data requirements for modeling big game populations. This list included the ratio of adult males (age 1-) per 100 adult females (age 1-) posthunt. Wyoming has historically collected sex ratios of elk populations in the early winter (posthunt). This paper addresses the evaluation of these data and their significance to management using Program ONEPOP. I would like to thank the management personnel in the Wyoming Game and Fish Department for their tireless efforts in collecting the data used in this discussion.

METHODS

Pre- and posthunt ratios of bulls per 100 cows were collected by field management personnel of the Wyoming Game and Fish Department (Wyo. G&F Dept., 1977). Prehunt counts were made from the ground from mid-August to mid-September. Posthunt counts were made from the ground and air. Aerial counts were made using both fixed wing aircraft and helicopter. Posthunt counts were conducted as soon as practical after hunting seasons were concluded. Most classifications were completed by mid-February. The timing and method varied slightly between herds but methodology was consistent from year to year for individual herds.

Population modeling was accomplished using a slightly modified form of Program ONEPOP (Gross et al. 1973). These modifications are described by Strickland (1979).

RESULTS AND DISCUSSION

Models have been developed for 16 elk herds where managers are reasonably confident that the dynamics of the simulated population approximates the actual population. Field data available for these simulations included an estimate of the trend in animal numbers, total harvest, sex and age of harvest, and sex and age ratios of the population pre and/or posthunt. Table 1 presents the average ratio of bulls per 100 cows for these 16 elk herds. The observed ratios represent field data and the simulated ratios represent ratios from "best fit" models of populations. It is obvious from these data that in most simulated populations, the posthunt ratios are substantially higher than observed ratios. To evaluate these differences, it is important to first address the question of which ratio is most accurate. It is impossible to verify the correctness of either ratio. Several authors have presented data illustrating a difference in the distribution of adult bulls from cows, spikes, and calves (Peak et al. 1967, Boyd 1970, Knight 1970, Compton 1975). Most of the 16 herds listed in Table 1 occupy relatively remote mountain ranges in the summer. These ranges are characterized by dense cover and high relief. Winter ranges are usually more accessible with the lower elevational ranges commonly bordered by roads. As the elevation of winter ranges increases, their accessibility decreases and the amount of cover and relief increase. Adult bulls tend to prefer rougher portions of the winter range, a behavior that makes them much more difficult to locate than cows, calves, and young bulls. Differential distribution could bias the observed ratios; this bias would cause an underestimate of the number of adult bulls in the population.

There are 3 apparent exceptions to the poor fit between observed and simulated posthunt bull:cow ratios. The Jackson and Pinedale herds are supported by feedgrounds in the winter. Native winter range for these 2 herds is very scarce and field personnel feel that most of the elk in the 2 herds spend the winter on the feedgrounds, apparently removing any potential differential distribution. The Baggs herd winters on native range; however, as a result of extensive roading, this winter range is accessible by vehicle for much of the early winter.

Table 1. Average ratio of bulls per 100 cows for 16 Wyoming elk herds for the period 1976 - 1980

	Posthunt		Prehunt	
	Observed	Simulated	Observed	Simulated
Jackson	35.3	36.5		
Fall Creek	11.0	18.1		
Hoback	14.4	58.0		
Piney	18.0	30.3		
Upper Green River	19.0	43.2		
Pinedale	28.0	29.4		
Trapper-Medicine Lodge	9.0	20.1		
Upper Nowood	18.5	28.2	32.0	40.1
Owl Creek	24.8	40.4		
Baggs	18.0	21.3	35.0	35.9
Little Mountain/ Pine Mountain	29.5	58.3		
Laramie Peak	18.8	34.5		
Snowy Range	18.4	44.8		
Ferris Mountain	15.0	47.9		
Wiggins Fork	19.2	25.7		
Muddy Mountain	34.3	64.7		

Simulation models of the 16 herds appear to accurately represent most field data from the populations, including population trend, harvest, and calves:100 cows. However, a comparison of the ratios for herds when both prehunt and posthunt sex ratios are present may give some indication of the accuracy of simulated values.

A comparison of prehunt and posthunt bull:cow ratios is difficult because both prehunt and posthunt data are lacking in all but 2 herds. Table 2 presents prehunt and posthunt data for the Baggs and Upper Nowood herds. In both herds, most simulated posthunt bull:cow ratios fall outside the 90% confidence interval surrounding the observed values. The simulated values for the prehunt bull:cow ratio in the Baggs model more closely approximates the observed values.

The Upper Nowood model presents a slightly different problem. Two of the 3 simulated prehunt ratios closely approximate the observed ratios. The 1979 ratio of 15 ± 4.2 was based on a large sample size and appears to be a more reliable estimate than the observed ratio for 1980.

Table 2. Prehunt and posthunt ratio of bulls per 100 cows for 2 Wyoming elk herds for the period 1976 - 1980

Herd	Year	Prehunt		Posthunt	
		Observed[1]	Simulated	Observed[1]	Simulated
Baggs	1976		43.4	25 ± 8.0	22.0
	1977	37 ± 4.5	37.0	19 ± 4.3	12.2
	1978	40 ± 10.1	33.3	21 ± 6.1	27.9
	1979	30 ± 8.4	37.6	11 ± 2.5	19.3
	1980	33 ± 8.4	35.7	14 ± 8.7	25.1
Upper Nowood	1976	38 ± 9.3	37.5	26 ± 6.2	21.2
	1977		37.7	25 ± 6.0	11.7
	1978		33.8		20.6
	1979	15 ± 4.2	36.7	10 ± 2.6	28.7
	1980	43 ± 19.2	46.1	13 ± 1.9	51.0

[1] Observed values are given with their 90% confidence intervals.

In an attempt to simulate the Upper Nowood herd, it was impossible to fit the model to both pre- and posthunt bull:cow ratios. Simulation trials resulted in one "best fit" with the prehunt values for 1976 and 1980 (Figs. 1, 2, and 3) and another "best fit" with posthunt values for 1976, 1977, 1979, and 1980 (Figs. 4, 5, and 6). The differences in population size (Figs. 1 and 4) are obvious. The estimated posthunt population size in the model fit to prehunt bull:cow ratios is approximately 500 animals (27%) less in 1980 than estimates using posthunt ratios. Both models have acceptable estimates of population trend showing no significant difference in the rate of increase between observed and simulated population estimates (t=.18). In addition to a difference in population size, the models differed in the number of elk removed between pre- and posthunt counts. The only significant mortality between these 2 counts are legal harvest, wounding loss, and illegal kill during hunting season (Table 3). The losses to wounding loss and illegal kill suggested by the simulation using prehunt ratios (12%), are much closer to field estimates of 10% than the 59% necessary to simulate the posthunt ratios. It should be noted that in the simulation using prehunt data, the simulated ratio for 1979 did not closely approximate the observed value. While the sample size was sufficiently high, the distribution of the sample was inadequate.

Table 3. Mortality during hunting seasons in the Upper Nowood herd for the period 1975 - 1980

Year	Prehunt Simulation Legal Harvest	Prehunt Simulation Wounding Loss/ Illegal Kill	Posthunt Simulation Legal Harvest	Posthunt Simulation Wounding Loss/ Illegal Kill
1975	234	29	234	25
1976	240	29	240	25
1977	463	61	463	46
1978	230	27	230	24
1979	248	25	248	637
1980	302	27	302	250
AVG.	286	33	286	168

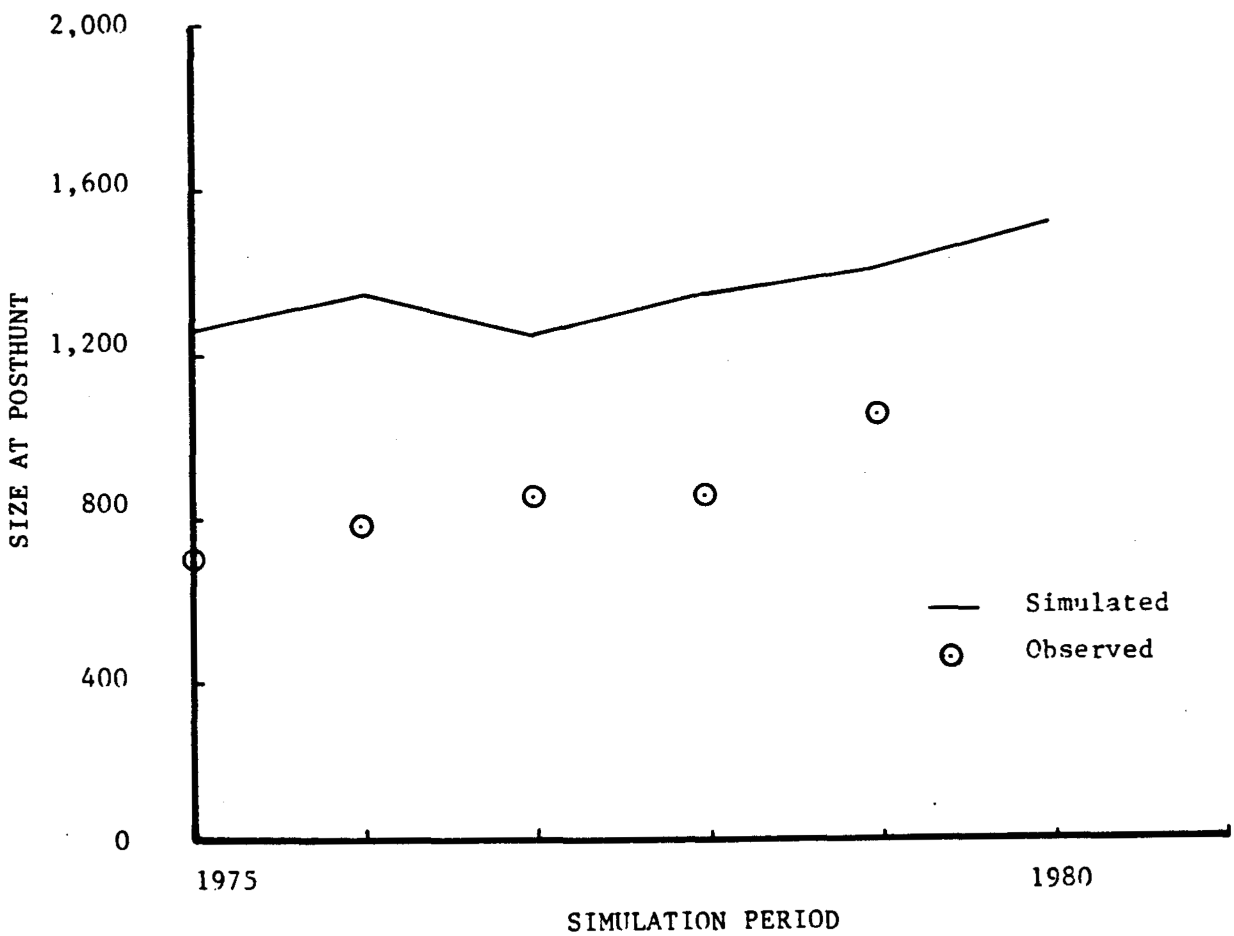

Figure 1. Posthunt population size from the simulation fitted to observed prehunt bull:cow ratios for the UpperNowood elk herd for the period 1975 - 1980

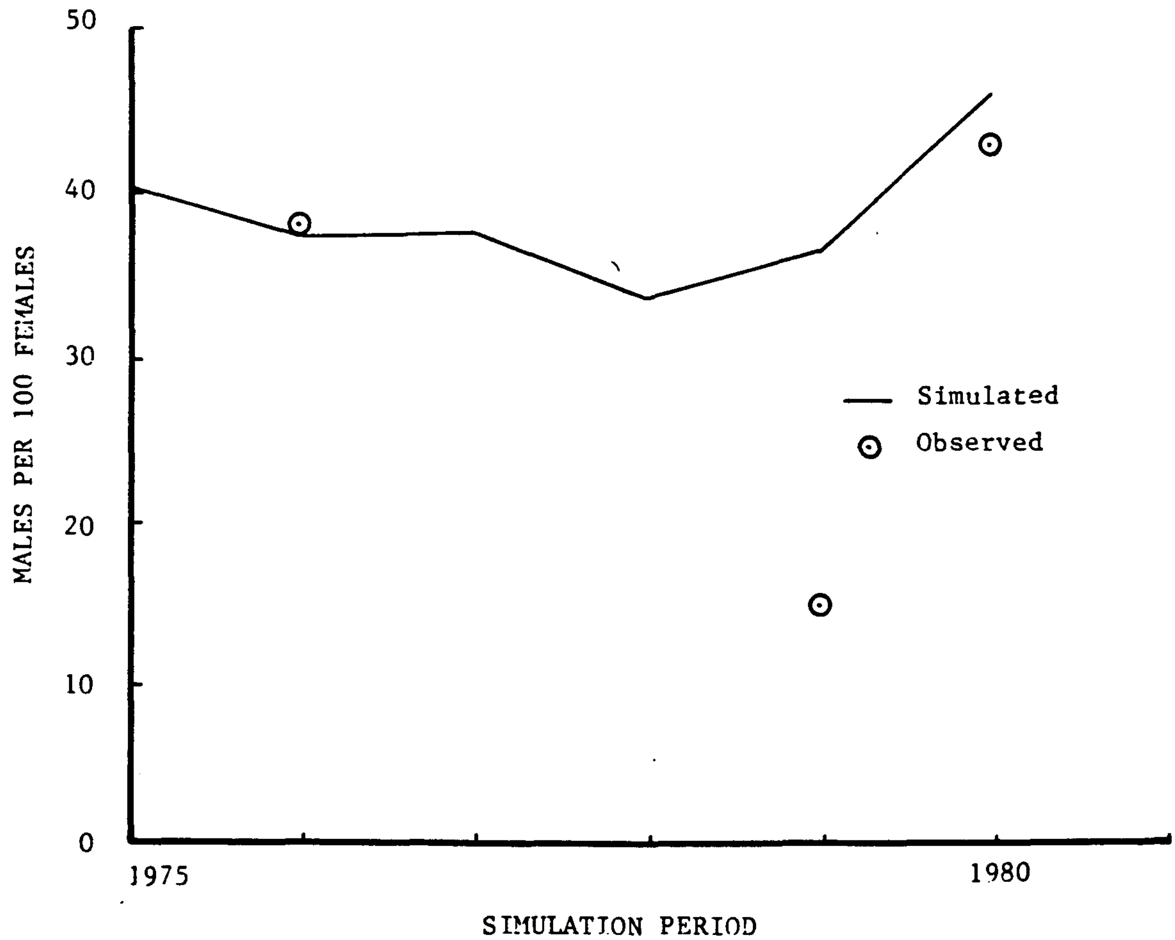

Figure 2. Prehunt bull:cow ratios from the simulation fitted to observed prehunt ratios for the Upper Nowood elk herd for the period 1975 - 1980

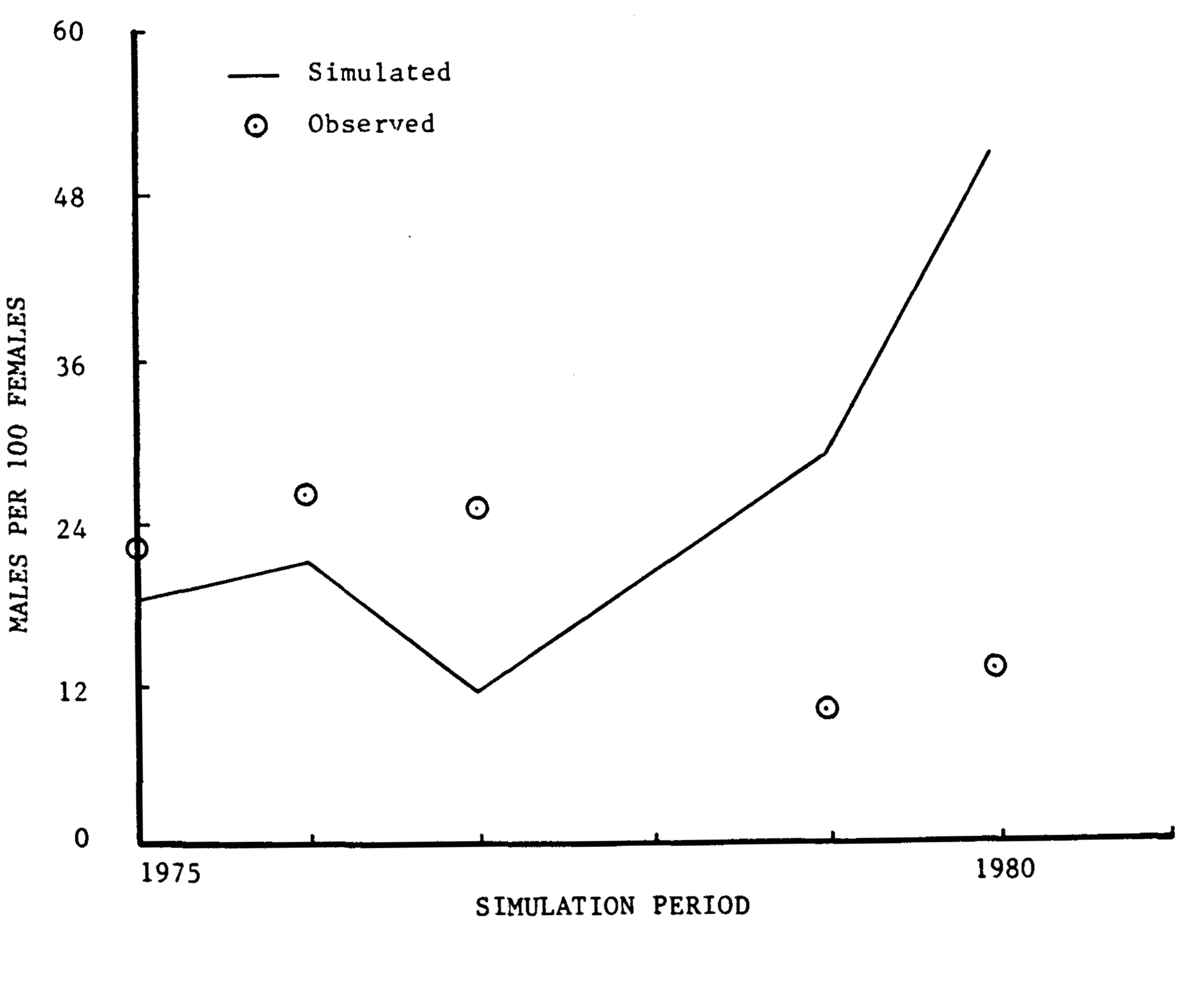

Figure 3. Posthunt bull:cow ratios from the simulation fitted to observed prehunt ratios for the Upper Nowood elk herd for the period 1975 - 1980

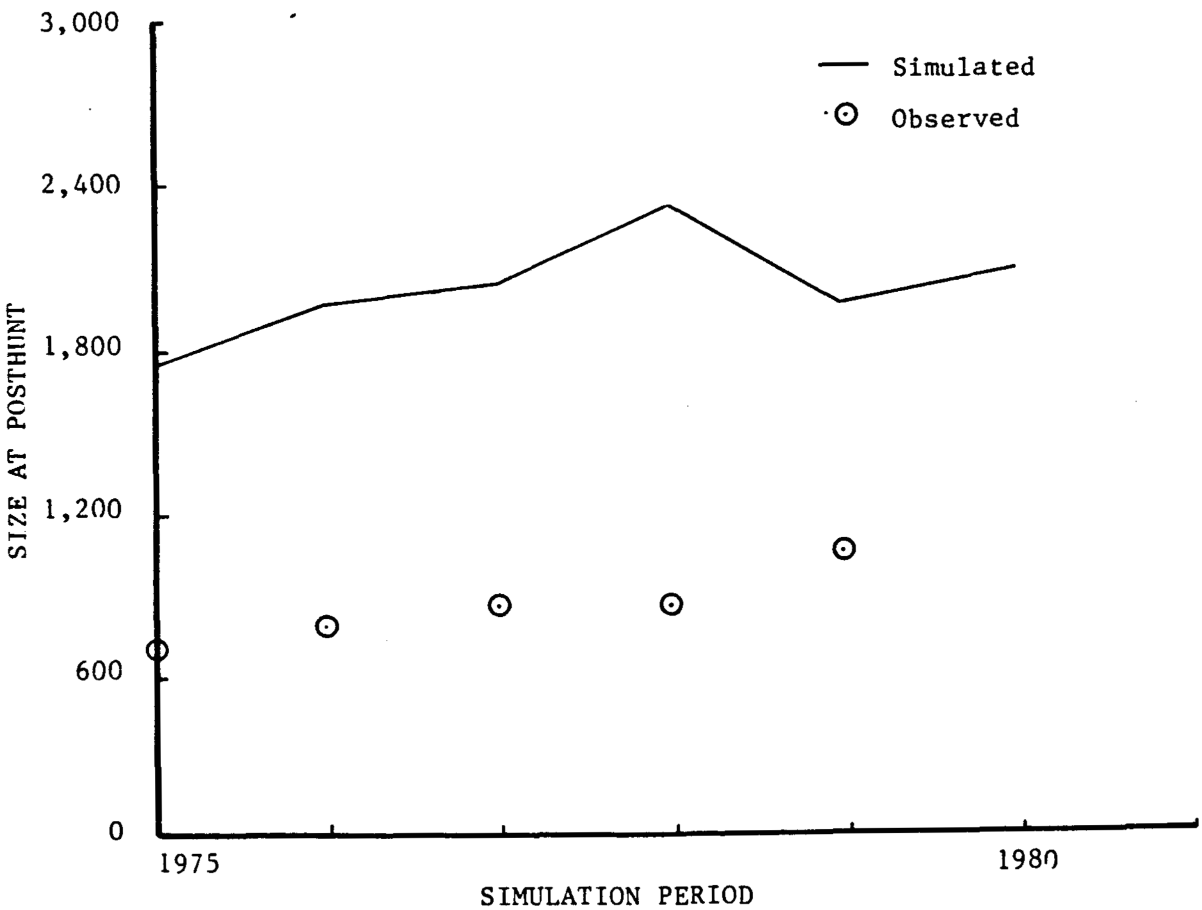

Figure 4. Posthunt population size from the simulation fitted to observed posthunt bull:cow ratios for the Upper Nowood elk herd for the period 1975 - 1980

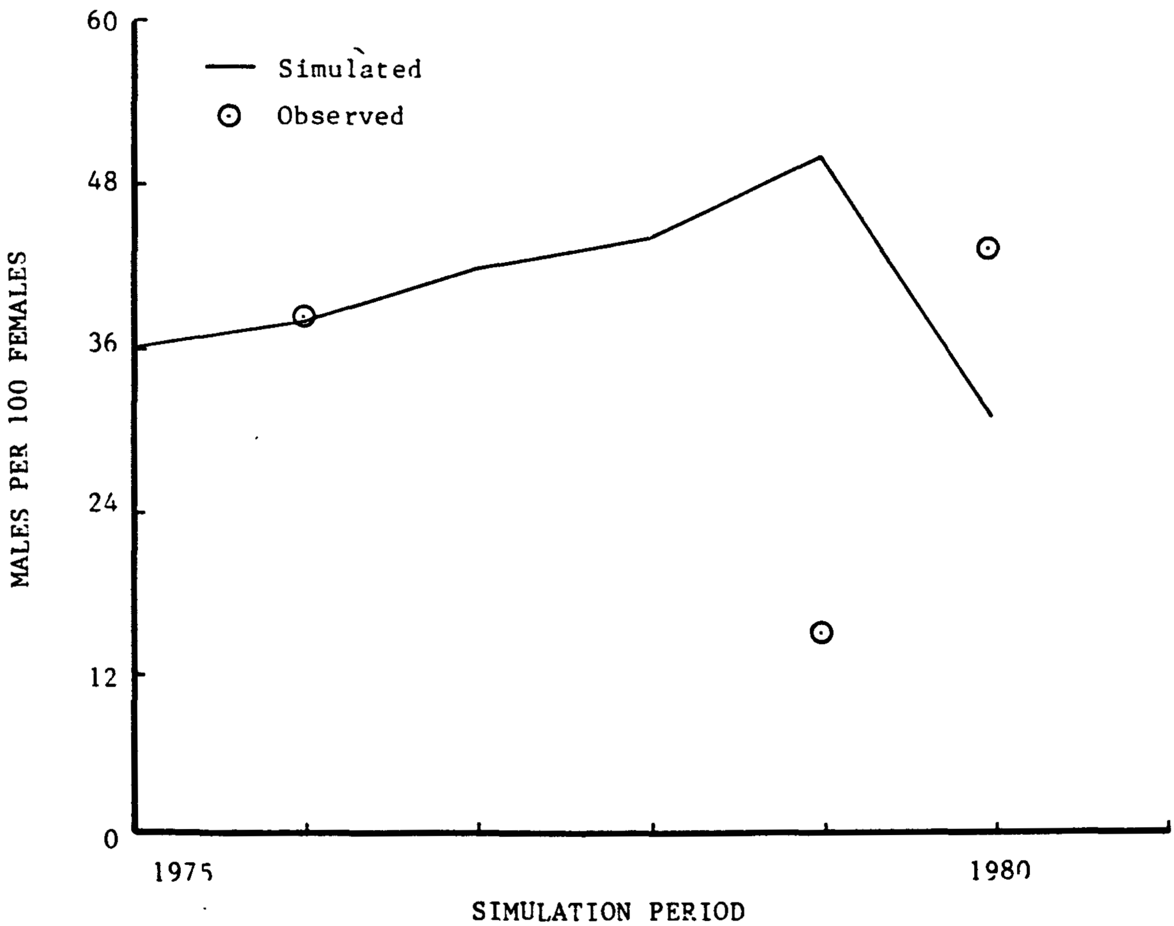

Figure 5. Prehunt bull:cow ratios from the simulation fitted to observed posthunt ratios for the Upper Nowood elk herd for the period 1975 - 1980

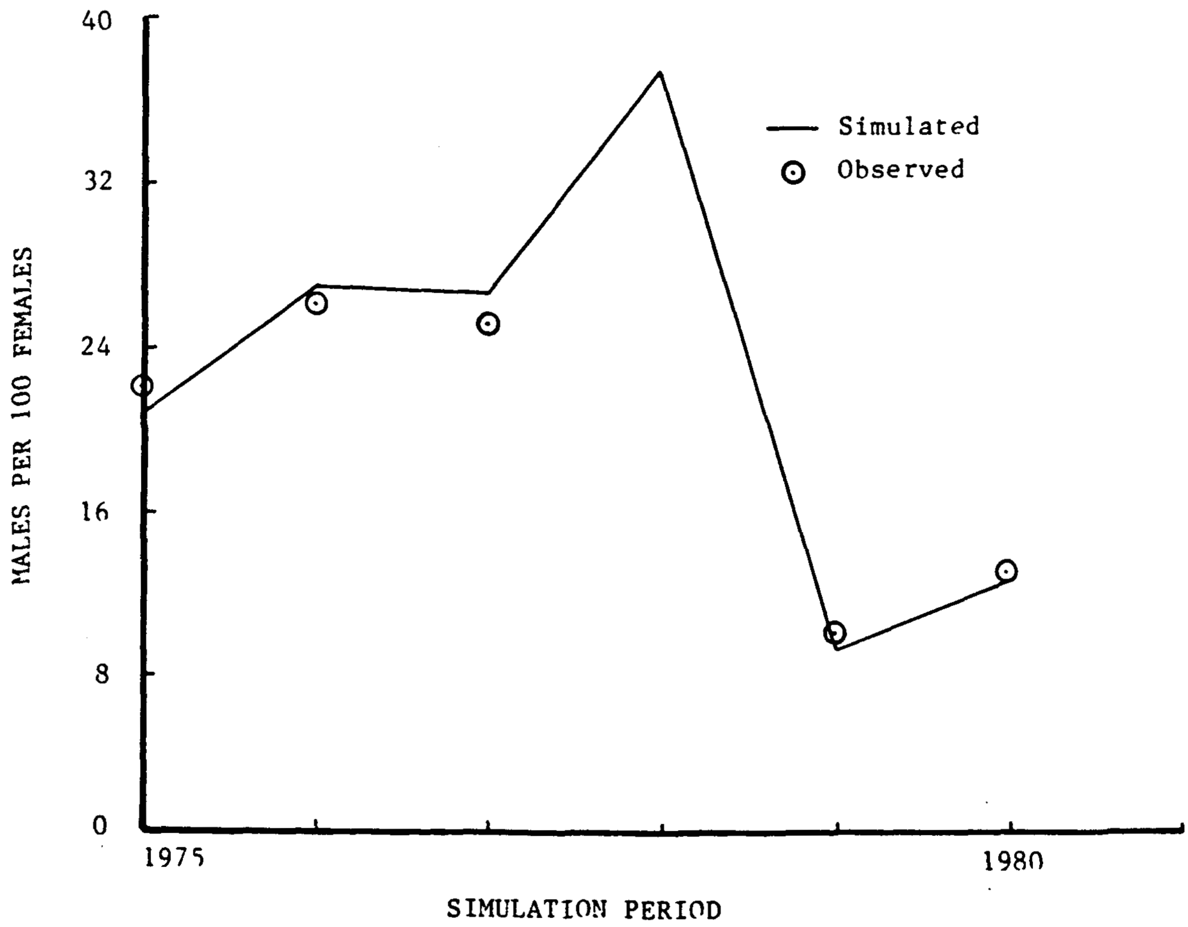

Figure 6. Posthunt bull"cow ratios from the simulation fitted to observed posthunt ratios fodr the Upper Nowood elk herd for the period 1975 - 1980

CONCLUSIONS

Analysis of observed ratios of bulls to cows using simulation modeling suggests that observed postseason bull:cow ratios may underestimate the actual number of bulls in an elk population. This analysis also suggests that observed prehunt ratios may estimate actual ratios more accurately than posthunt ratios. However, the major point of this discussion is not that one specific data point is better than another. It is obvious to most managers that in a given data set there will always be erroneous data points. Rather, it is imperative that elk managers recognize biased data when analyzing the dynamics of elk herds. Additional effort should be made to evaluate the accuracy of posthunt ratios, probably through greater emphasis on the collection of prehunt ratios.

The potential for biased sex ratios has further implications in data analysis. As has been demonstrated, an underestimate of bull:cow ratio using simulation modeling can result in an overestimate of population size and bull mortality. This same bias could result in underestimating the same population when using point estimators as described by Eberhardt (1971).

Above all, the elk manager must avoid placing too much emphasis on one data point or data estimating a single population parameter. Caughley (1974) stated that, "age ratios alone reveal little about the demography of a population, and their unsupported use can lead to serious blunders of interpretation." The same can be said for sex ratios. While the blunders may not be as serious, they are blunders nevertheless.

This analysis also has implication for administrators of wildlife management agencies. Administrators must evaluate existing programs and determine if there are data collected simply by convention. Data collection costs money whether the data are useable or not. Financial conditions today have forced efficiency in the way many agencies operate. This move for efficiency should extend into the area of data collection. The ultimate benefits may include dollars saved but more importantly should include better wildlife conservation due to better management decisions.

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FORAGE ALLOCATION FOR ELK AND CATTLE

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Abstract: Competition for forage between elk (*Cervus elaphus*) and domestic cattle is more severe than with other major domestic and wild ungulates in North America. Data on food habits of cattle and 3 common species of wild ungulates from southern Colorado indicate that dietary overlap between cattle and elk is higher than with cattle and the other two. Furthermore, due to their larger body size and higher forage intake, elk have a greater impact on the forage supply than smaller ungulates and are impacted more by inadequate forage supplies. Thus, forage allocation between cattle and elk is a critical management problem. As elk populations have increased in the West and demand for livestock forage has intensified, the problem has become more acute. The U.S. Bureau of Land Management (BLM) has developed 2 computer-based systems for determining forage allocations between domestic livestock and wild ungulates. Both systems utilize data on forage production, seasonal habitat use and food habits, and animal numbers. The BLM is responsible for habitat management for wild ungulates on public lands it manages and must work closely with state wildlife agencies responsible for population management. For forage allocation decisions, BLM biologists require information on elk population sizes, habitat use, and food habits, as well as herd management objectives. Provision of such information to the BLM in a timely manner by state wildlife agencies will be necessary to ensure that adequate forage is allocated for elk.

INTRODUCTION

Conflict between domestic livestock grazing and wild ungulates has been recognized for many years and has generated much controversy (Mackie 1978, Wagner 1979). A major aspect of such conflict, although not the only one, is competition for forage (Holechek 1980). Thus, the process of allocating forage resources on public lands to 2 or more species of wild and domestic ungulates is an important and controversial aspect of land management. The purpose of this paper is to (1) present evidence that competition for forage between elk and cattle is real, and is a critical problem that must be resolved through forage allocation, (2) describe and compare 2 systems for determining forage allocations, and (3) explain the potential role of state wildlife agencies in determining forage allocations.

COMPETITION FOR FORAGE BETWEEN ELK AND CATTLE

Competition for forage between elk and domestic cattle grazing is probably more intense and widespread than with any other pair of domestic and wild ungulate on rangelands of western North America. Evidence for this assertion derives from 3 types of data: numbers and distribution of animals, dietary overlap, and forage intake rates.

Numbers and Distribution

Both elk and cattle are widespread in the 11 western states. There are approximately 23 million cattle on western rangelands compared to about

7 million sheep, the next most common species of livestock (Wagner 1979). Similarly, there are an estimated 455,000 elk in the 11 western states, second only to mule deer (Odocoileus hemionus) which are estimated at 3,605,000 (Wagner 1979). However, whereas cattle grazing increased steadily in the West since the mid-1800s (Fig. 1), elk have declined substantially during the first 60 years of this period (Fig. 2). Although Wagner (1979) estimates that elk are now at only 25% of pre-Columbian numbers, they have increased substantially since the beginning of the century (Fig. 2). Twenty-five years ago, Longhurst (1957) reported that elk were increasing in 6 of the 11 western states and that the estimated elk population for this area was 303,000. More recently Wagner (1979) estimated the elk population in the same area at 455,000 for an increase of 50% over 20 years.

Dietary Overlap

With regard to food habits, elk are more similar to cattle than to the other 2 common ungulates on western ranges, pronghorn antelope (Antilocapra americana) and mule deer. Although food habits vary greatly among regions, habitat sites, seasons, and years, there are general patterns. Cattle tend to be grass eaters whereas pronghorn and mule deer tend to be forb and browse eaters. Elk are highly variable in their forage selection, eating grass, forbs and browse at various times (Kufeld 1973). However, elk often survive on diets with a high proportion of grass in winter. In northern areas, cattle typically forage during summer on ranges used by elk during winter and spring. Data from southern Colorado on overlap between summer cattle diets and winter-spring diets of 3 wild ungulates indicate dietary overlap of 52% for cattle and elk as opposed to 25% for cattle and mule deer and 18% for cattle and pronghorn (Bailey and Cooperrider 1982).

Forage Intake Rates

Elk are much larger than deer or antelope and their forage consumption is correspondingly higher. An average daily dry weight forage intake for elk in winter is approximately 4 kg (8.7 lb) (Eastman 1981) as opposed to 1.3 kg (2.9 lb) (Wallmo et al. 1977) for deer and 0.9 kg (2.0 lb) for antelope (Hoover 1971). Thus, an elk eats roughly 3 times as much as a deer and 4 times as much as an antelope.

In summary, cattle and elk are widespread and numerous on western ranges, their diets are similar, and the forage intake rate of elk is much higher than that of the other common big game species. These 3 factors suggest that the potential for competition for forage is high. Furthermore, as cattle grazing and/or elk populations increase, competition for forage is likely to intensify.

Evidence for competition between elk and cattle is not purely theoretical. Mackie (1978) cites examples in which elimination of livestock use on state-owned winter game ranges has been accompanied by an average increase in elk numbers of at least 100%. Furthermore, there are numerous other examples of competition between cattle and elk in the literature, although the documentation is often weak.

Figure 1. Conjectured AUM's of cattle on western rangelands of 11 western states (after Wagner 1979)

Figure 2. Conjectured numbers of elk in 11 western states

FORAGE ALLOCATION SYSTEMS

Procedures for allocating forage for livestock and wildlife were not well developed prior to 1976. In recent years there has been increased awareness of potential or real impact of livestock on wild ungulate populations on public lands (Mackie 1978), along with increased public concern about wildlife. However, the demand for forage for livestock has continued, in many cases, increased (Cook 1979). At the same time, new legislation and litigation has provided land management agencies, particularly the BLM, with a new and stronger mandate to manage public lands for a diversity of uses according to sound ecological principles. In response to these new demands and mandates, professional range and wildlife managers have recognized a need for new techniques for allocating forage among competing ungulates (Nelson 1978, Van Dyne 1980).

The BLM has developed 2 new techniques for determining forage allocations. Due to the complexity of the problem and the large amounts of data utilized, both systems are computer based using existing analytical techniques. One, hereafter referred to as the simulation model, utilizes the technique of computer simulation (Naylor et al. 1966) and is described in Cooperrider and Bailey (1980). This model is still being developed at the BLM's Denver Service Center. The other, hereafter referred to as the optimization model, uses the technique of linear programming (Dantzig 1963) and is described in Martinsen and MacPherson (1980). This model is now operational on the BLM's computer in the Denver Service Center and can be used in any field office through the Bureau's telecommunications network. These models are described in detail in these publications. They are described here in terms of data bases utilized, operational concepts, and outputs. Other systems have also been developed (Nelson 1978, Van Dyne 1980), but will not be discussed here.

Data Bases

Since forage allocation decisions are frequently controversial, an important criteria for any allocation technique to be used by public agencies is that it be legally defensible, since some decisions would ultimately be challenged in court. Decisions on natural resource issues are most easily defended when they are based upon quantitative data collected in the field using objective techniques. These data, which are the basis for making allocation decisions, are described below in terms of basic data (data required by both models) and supplementary data (data that can be used by one or the other model).

Basic Data

Basic data is of 5 types: forage production, animal numbers, forage intake rates, food habits, and habitat use.

Forage production. This is the total annual forage production of each plant species expressed as kg/ha (lb/acre) on each habitat site within each allotment. These data are collected utilizing a technique developed by the BLM called Soil Vegetation Inventory Method (SVIM) (Baker 1981).

Animal numbers. Data on animal numbers are the number of animals of each species of wild and domestic ungulate that occupy the range for a given period of time.

Forage intake rates. This consists of the total forage eaten by each animal species per day or per month.

Food habits. The model requires information on the proportion of the diet of a given animal species that is composed of a given plant species (food habits) or the relative preference of a given animal species for each plant species (forage preference). One or the other may be used in both models.

Habitat use data. These data consist of the habitat sites used by each animal species during a season. In the simulation model, this may be expressed as a relative preference for given existing habitat types.

In summary, the basic data consists of the total forage production by area along with estimates of how many animals are eating how much of each plant species in each area.

Supplementary Data

Supplementary data is of 7 general types: plant requirements, animal requirements, weather data, plant nutrient content, animal population structure, plant dynamics, and animal population dynamics.

Plant requirements. These consist of the percent of the annual forage production of a given plant species that must be left ungrazed in order for the plant population to maintain itself. These are commonly expressed by range managers as allowable use factors (AUF). An AUF is defined as the percent of the annual growth of a plant species which could be removed, allowing for the species to regenerate itself.

Animal requirements. These are the nutritional requirements of the wild ungulates for growth, maintenance, and reproduction. The only measure of such requirements used to date is digestible energy.

Weather data. These data may be used to predict or examine year-to-year variations in forage production and also to predict availability of forage to wild ungulates due to snow cover.

Plant nutrient content. These data consist of measures of the amount of key nutrients in each forage at each phenological stage. These are used to determine if animal requirements are being met.

Animal population structure. These data are the percentage of each wild ungulate population that consists of each sex and age class.

Plant dynamics. Two types of data on plant population dynamics may be used. One is data on the change in forage availability as a function of phenology. The other is data on the change in plant species composition as a function of previous grazing pressure.

Animal population dynamics. Data on animal population dynamics consists of the sex and age, specific birth, death, and harvest rates of the wild ungulate populations.

The simulation model has the capability of utilizing more of these data bases than the optimization model, although techniques for utilizing some of them are not well developed (Table 1).

Table 1. Data bases for forage allocation systems[1]

Data Base	Optimization Model	Simulation Model
Basic Data		
Forage Production	R	R
Animal Numbers	R	R
Forage Intake Rates	R	R
Food Habits	R	R
Habitat Use	R	R
Supplementary Data		
Plant Requirements	R	0
Animal Requirements		0
Weather Data	0	0
Plant Nutrient Content		0
Animal Population Structure		0
Plant Dynamics		0
Animal Population Dynamics		0

[1] R indicates the data base is required; 0 indicates the data base can be used by the model but is not required.

Operational Concepts and Outputs

The 2 models, optimization and simulation, operate in quite different manners and are thus used for slightly different purposes and have different outputs.

The purpose of the optimization model is to determine an optimal forage allocation as defined below. An optimal forage allocation is one in which the maximum amount of the total annual forage production is utilized subject to certain constraints. The variables in the solution are the number of animals of each ungulate species. The major constraint is that the plant requirements for sustained yield be met, (i.e., that the allowable use factors not be exceeded for any plant species). The model is thus primarily designed to ensure that the requirements of forage plants are met. However, additional constraints may be added, the most important of which is that a minimum or maximum number of animals of a given ungulate species be supported. For example, a problem might be constrained so that at least 100 elk and/or 100 cattle be included in the "solution."

The principal output from the optimization model is the number of animals of each ungulate species that can be supported on the range. These numbers can then be used by a land manager for adjusting livestock numbers on the range and/or recommending to the state agency that numbers of wildlife be increased or decreased. However, the model will also predict how much of the annual forage production of each plant species would be utilized with the "optimal" mix of animal species.

The simulation model attempts to mimic the grazing system over time. As such, it does not predict an "optimal" solution. Rather, given an initial state of the system (in terms of forage production and animal numbers) and a given management strategy, it will predict what the state of the system will be after a given period of time.

The outputs of the simulation model also include numbers of domestic and wild ungulates and forage utilization. However, since the model is dynamic (i.e., the system is simulated over time),these outputs can be obtained after any given interval (i.e., 1 month, 3 months, 1 year, 5 years, etc.). For example, the predicted number of elk supported on a range might be much different after 5 years than after 1 year. In addition, because the model utilizes more complex data bases, the outputs may also be more complex. For example, the number of elk surviving after 5 years may be broken down by sex and age classes.

A unique feature of the simulation model is that it attempts to relate forage allocation to the nutritional requirements of the wild ungulates. Furthermore, it can incorporate data on population dynamics. Thus, data on nutritional measurements of plants and nutrient requirement of animals are used to link a habitat model with a population model.

ROLE OF STATE AGENCIES

Proceedures for forage allocation were historically developed to allocate forage between 2 classes of livestock (e.g., cattle and sheep). Partly due to such history, many wildlife professionals have considered forage allocation as largely a concern of range managers and have not become involved in the process. This has often resulted in allocation decisions that did not adequately consider or address the needs of wild ungulates.

The BLM is responsible for managing habitat for elk and other wild ungulate species on public lands under its jurisdiction. State wildlife agencies are charged with population management. An obvious result is that BLM biologists generally concentrate on gathering habitat data, whereas state agency biologists usually collect more data on populations. Regardless of the system used for determining forage allocations, both types of data are required. BLM biologists have traditionally relied heavily upon state agencies to provide estimates of elk numbers and seasonal habitat use. In addition, state agencies have often provided information on elk food to help ensure that the needs of wildlife are considered in determining forage allocations. If more data are required, a coordinated approach to collection of such data will avoid duplication and result in more efficient use of the limited funds available for wildlife work at both state and federal levels.

Finally, it is important that the state agency provide the BLM with explicit statements of their management objective. This is often difficult since state agency herd units or game management units typically do not correspond to BLM planning units, wildlife habitat areas, or policies of maintaining elk populations at current levels through antlerless harvest. It is pointless for the BLM to attempt to allocate additional forage for an expanded elk herd when harvest levels will prevent the herd from increasing. On the other hand, it may be futile for a state agency to attempt to increase an elk herd or elk harvest when the BLM has not allocated adequate forage for such an expanded herd.

SUMMARY

Competition for forage between elk and cattle is more severe than with other major domestic and wild ungulates. Thus, forage allocation between elk and cattle is a critical management problem. The BLM has developed 2 new systems for utilizing both habitat and population data to determine forage allocations.

The state wildlife agencies need to provide the BLM with data on elk population numbers and habitat use as well as herd management objectives to ensure that the needs of elk are considered in forage allocation decisions.

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ELK HABITAT USE IN ROCKY MOUNTAIN NATIONAL PARK, COLORADO

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Abstract: Investigations were conducted on elk (*Cervus elaphus nelsoni*) in Rocky Mountain National Park, Colorado to determine habitat use patterns. Thirty-seven elk were fitted with radio collars over 2 winters. Elk were relocated using triangulation methods with a mobile tracking vehicle. Twelve of the 37 radio collars were equipped with activity tip switches to identify feeding, resting and moving activities. Stratified random sampling was used to estimate habitat use during different times of the day, month and season. A 24-hour period was divided into 4 periods. Morning and evening were defined as 2 hours before and after sunrise and sunset and day light and night hours in between were defined as the other 2 periods. Habitat use was calculated as the percentage of total recorded locations. Summer habitat use was concentrated in Krumholz and spruce-fir (*Picea engelmanii* and *Abies lasiocarpa*). Krumholz areas were used less during daytime and most during the night. A reverse use pattern was observed for spruce-fir. Winter habitat use occurred primarily in lodgepole pine (*Pinus contorta*), Douglas fir (*Pseudotsuga menziesii*), ponderosa pine/shrub (*Pinus ponderosa*), and wet meadow types. Willow, aspen, and grassland types all contributed less than 10% to habitat use. Daytime use in winter was restricted to lodgepole pine, Douglas fir, and ponderosa pine/shrub types. Habitat use during night was dominated by ponderosa pine/shrub and wet meadow types. Ponderosa pine/shrub types were preferred feeding sites during winter.

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IDENTIFICATION AND DESCRIPTION OF NORTHEAST OREGON ELK HABITAT THROUGH RADIO TELEMETRY AND MAPPING BY EARTH RESOURCES SATELLITE

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Abstract: Importance of thermal cover, hiding cover, and forage area habitat components to Rocky Mountain elk (*Cervus elaphus*) was interpreted from observations of elk activity, air temperature amount, and wind speed in the Blue Mountains of Oregon. The quality of habitat components used by elk was described in terms of stand structure and plant species. Availability of habitat components was inventoried by remote sensing techniques. Elk use appeared to be influenced by weather conditions and plant phenology, concentrated near cover-forage edges, highly associated with multistoried cover stands, and equally divided between thermal cover and forage area components. Amount and distribution of habitat components were inventoried on herd ranges as large as 111,292 ha and on timber sales as small as 850 ha. Research results have aided coordination of resource allocations with elk needs and facilitated comparison of alternative strategies for management of elk habitat.

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INTRODUCTION

Rocky Mountain elk herds are a resource that provides the people of Oregon with valuable recreational benefits. Perpetuation of productive herds which will continue to provide the people these benefits at acceptable levels is dependent on adequate amounts of quality summer, transition, and winter habitats.

Modern forest management with its accompanying road systems, increased human access, and livestock grazing has been shown to influence habitat effectiveness in the forested areas of the Blue Mountains. Cover for elk has become increasingly important due to accelerated timber harvest on all seasonal ranges. Increasing emphasis on the red meat production program may increase livestock grazing and affect use of forage areas by elk. It is critical to the welfare of the animals, therefore, that managers incorporate knowledge of elk habitat needs in planning and implementation of programs, particularly regarding thermal and hiding cover, forage areas, and relative values of forest types. In order to compare impacts of various management alternatives, managers need measures of the values of all plant communities and structural conditions relative to elk requirements.

Chapter 8 of Agriculture Handbook 553, Wildlife Habitats in Managed Forests--the Blue Mountains of Oregon and Washington authored by Jack Ward Thomas et al. and published in 1979, describes effects of manipulating vegetation structure and arrangement on use of habitats by elk. Effectiveness of optimum habitats as well as a range for less productive ones are presented to aid decision makers in comparison of management alternatives.

Multiple resource regulations on public lands, especially national forests, constitute a vehicle for immediate application of concepts from Handbook #553 into the resource-allocation decision making process. Those concepts were drawn from evaluations of a mix of results from research studies, literature reviews, and "best estimates" of specialists in the field. Our study was designed to obtain new data to fill in gaps and additional data from which to further interpret habitat use by elk.

OBJECTIVES

The primary objectives of the Eastern Oregon Cover Study are to determine how major seasonal habitats are used by elk and to estimate their relative values to elk. The study is being conducted in the Blue Mountain region of northeastern Oregon on National Forest and interspersed private lands. Information gathered by ODFW biologists that directly observe elk activities and monitor the microclimate and by PNW plant ecologists that describe vegetation composition and structure of occupied sites is analyzed and compared with specific habitat relationships described by Thomas et al. (1979). One secondary objective of the study is to obtain new information for refinement of those relationships.

Another secondary objective of the research is to develop accurate habitat maps of the various sampled areas from correlation of LANDSAT multispectral scanner data with elk and vegetation data. This is being done through contract with ERSAL. Biological and physical characteristics of the habitats occupied by elk provide ground-truth data for interpretation and mapping elk cover and forage components with the aid of aerial photography and earth resources satellite data.

This report is a progress report that is part of a continuing program to provide research findings in a timely manner. The findings herein are based on observations summarized from 4 herd ranges and further analyses of these annual ranges as well as separate analyses of each seasonal range will provide estimates of precision. Readers are cautioned that generalizations contained in this report are subject to revision, and their use in specific applications may be inappropriate.

METHODS

Frequency and duration of occupancy of habitats were sampled by direct observation of elk activities and interpreted as estimates of habitat value. Grazing, browsing, bedding, and other activities were compared with air temperatures, snow levels, and wind speeds recorded during use. They were also compared with subsequent measures of vegetation structure in order to estimate habitat quality. Availability of thermal cover, hiding cover, and forage areas was determined from inventories using remote sensing techniques. The amounts and changes in habitat components were compared with predicted habitat effectiveness.

Between 1977 and 1982, radio-transmitter collars were placed on a total of 53 elk from 5 herd ranges, and each herd sample was followed for 1 year from spring through the next winter. Collared elk were relocated by radio telemetry so that their locations and activities would have equal chance of being sampled regardless of habitat or weather conditions. The same activity, weather, and habitat data were recorded during observation of non-collared elk contacted during radio telemetry.

Vegetation structure of the stands occupied by elk was described about a plot center established during observation of animal activities and weather conditions. Tree heights, crown canopy closure, sight distance, and other values determined whether each of 1,081 classified stands was identified as a thermal cover, hiding cover, or forage area habitat component.

Measurements not easily made in the field were obtained by interpretation of stereo pairs of aerial photographs. These included stand width, distance to cover or forage, and distance to roads.

Reflectances recorded by the LANDSAT multispectral scanner (MSS) were correlated with habitat components in 8,600 subsamples from color and colorinfrared aerial photographs. This analysis produced a 150,000-hectare inventory of distributions of spectral classes, structural conditions, and elk-habitat components. Significantly different reflectance groups were derived through analysis of means and variances of data recorded by the 4 MSS sensors; each of the resulting 60 spectral classes was identified by a unique symbol that was used in mapping and further analyses. Different vegetation groups were determined by interpretation of dominant plant type (tree species, shrubland, grassland), stand structure (height, crown closure, tree layers), and status (natural or disturbed); the 50 structural conditions were assigned unique symbols to be used in mapping and further analyses. Different elk habitats were derived from specifications suggested by Thomas et al. (1979) for cover and forage stands and were refined by review of elk observations; the 3 habitat components (thermal cover, hiding cover, and forage areas) were also labeled with unique symbols to facilitate mapping and further analyses. Regions of mapped habitat were compared with ground-truth data from elk use plots specific to those regions. Inventories were stored on magnetic tapes and displayed in convenient map and tabular forms. Current and projected status of habitat components on national forest and other lands was compared with levels of habitat potential for elk use.

RESULTS AND DISCUSSION

Elk use of habitat on all seasonal ranges appeared primarily influenced by stress from weather factors and by phenology of forage plants. Cover habitats were used most during hot and dry or cold and snowy periods, but forage habitats were used most during mild weather and when most forage was in early growth stages. Elk grazed in forested areas after food plants in adjacent grassland forage areas had attained flowering or seedripening stages. Conversely, elk grazed in open forage areas primarily when the food plants provided young vegetative leaves--fall, winter, and spring. Bedding, ruminating, and traveling were the major activities of elk observed in cover habitats, and grazing, browsing, and traveling were important in forage areas.

Vegetation in the Blue Mountains is comprised of relatively narrow stands and elk appeared to concentrate their use near edges between tracts of cover and forage habitats. Vegetation stands and habitat areas are not synonymous. For example, 3 different stands exist where a sedge meadow is bordered by both a thinned stringer of lodgepole pine timber and a bluegrass scabland. All 3, however, comprise one continuous forage area. Cover and forage areas are tracts of vegetation that meet definitions of thermal cover, hiding cover, or forage area components of elk habitat (Thomas et al. 1979). Minimum stand widths averaged 186 m (610 ft) for thermal cover, 197 m (646 ft) for hiding cover, and 74 m (243 ft) for forage areas. Minimum tract widths estimated by doubling the average distances between occupied plots and the closest cover-forage habitat edges were as follows: 135 m (444 ft) for thermal cover, 159 m (522 ft) for hiding cover, and 347 m (1140 ft) for forage areas. Cover tracts may appear narrower than cover stand widths because elk use was concentrated near cover-forage edges--differences were probably not significant. Forage tracts on the other hand, may be wider than forage stands because most natural openings and created forage areas were narrow--differences are probably significant.

The ability of a habitat to hide elk was measured by that percentage of a sight tube which was hidden by vegetation at 50-foot intervals along 4 radii from the plot center. The interval at which an average of at least 90% of the tube was hidden was defined as the sight distance of the stand (Thomas et al. 1979). The average sight distance measured was 54 m (178 ft) in thermal cover, 52 m (171 ft) in hiding cover, and 93 m (304 ft) in forage areas. Thomas et al. (1979) defined hiding cover as vegetation with a sight distance not greater than 61 m (200 ft).

Minimal sizes of habitats that met sight distance criteria for hiding cover and were used by elk were estimated from ratios of average stand widths to average sight distances. Thermal cover stands were generally 4.5 sight distances wide, and hiding cover stands were 3.9 sight distances wide. Thomas et al. (1979) recommended optimum hiding cover patches would be 3 to 6 sight distances wide.

Tree species common to stands occupied by elk during periods of heat or cold stress were grand fir on summer range and grand fir with Douglas fir on winter range. Bedding was the major activity in thermal cover during high temperatures in summer. Temperatures were as much as 10 degrees cooler and wind speeds up to 20 miles per hour less in thermal cover than in forage areas on summer range. Major use of thermal cover occurred when air temperatures exceeded 15.5°C (60°F). Foraging and bedding were major activities during use of thermal cover in winter. Snow depths were 10% to 50% of those in forage areas, both timber or bunchgrass types of forage areas, where as much as 91 cm (36 in) accumulated. Use increased when temperatures fell below -1.1°C (30°F).

More forage was available in winter range stands occupied during extreme weather stress than such stands on summer range. Elk pawed loose snow away from 1 to 9 square meter areas to feed on pinegrass and elk sedge. They frequently grazed lichen (Alectoria) hanging from conifer limbs and mixed in the litterfall after storms. Lichen was most available in thermal cover on both winter and summer ranges. Feeding on lichen occurred more frequently in summer as well as in winter than use of pine, Douglas fir, juniper, hawthorn, ninebark, or other abundantly available browse.

Thermal cover stands were primarily of coniferous timber, but in summer, stands of deciduous trees were also used. Both consisted of a multilayered structure. A tall, $\geq$2.2 m (40 ft), and partially open, <50% crown canopy, overstory commonly occurred above a shorter, 4.6 to 6.1 m (15 to 20 ft), and denser, >75% crown canopy, layer of saplings. Shrubby understories were sparse under the multiple layers of trees. Grasses and forbs varied from abundant to non-existent, apparently inversely with degree of canopy closure.

Minimal size of habitats may be estimated as a circle with a diameter equal to the average minimum stand widths observed. Behavior of the elk and distances to cover/forage edges suggest width is a better criteria of habitat size than is area, but areas are included here for comparison with relationships suggested by Thomas et al. (1979). The average size of occupied thermal cover stands was 2.8 ha (6.8 a), based on minimum stand width. Comparable sizes of hiding cover and forage stands were 3.0 ha (7.5 a) and 0.4 ha (1.1 a), respectively. Minimum habitat tracts derived from observed distances to closest habitat edges were 1.4 ha (3.6 a) for thermal cover, 2.0 ha (4.9 a) for hiding cover, and 9.5 ha (3.4 a) for forage areas (see previous discussion of stands vs. tracts).

When temperatures, wind speeds, and snow conditions were favorable, elk used natural and created open forage areas. If temperatures exceeded about 19°C (65°F), or winds exceeded 8 km/hr (5 mi/hr), or if snow was hard or deeper than about 46 cm (18 in), most elk did not use openings unless forced to cross them by the observer. During hot days, open forage areas were used primarily at night, early in the morning, and late in the evening. If clouds or rain occurred in midday, then elk foraged in open areas throughout the day. Elk used openings during warm sunny periods in winter when green forage was available; they remained in thermal cover when cold, snow depth, and forage availability in openings were unfavorable.

Analyses of influences of human activities on distributions of elk are incomplete, but some observations can be made. Elk from the different herds were observed to use habitats along roads and near various human activities. Elk used logged areas of various ages including very recent ones. Slash from thinnings and timber harvests appeared to restrict use of portions of cut over areas. Elk frequently traveled along logging spurs and improved roads while they grazed orchard grass, smooth brome, and timothy that had been seeded to stabilize the road edges. Although some elk fed, bedded, ruminated, and nursed within sight and sound of roads, campgrounds, settlements, and residences, there was a tendency for more elk to be found further from these sites where human activities were concentrated and prolonged. For example, most sightings of elk were made at some distance from roads and at greater distances from paved or graveled roads than from either unimproved roads or various types of trails. Average distances elk were observed from roads or trails were as follows: surfaced roads 562 m (1,844 ft), unimproved roads 370 m (1,213 ft), trails 306 m (1,004 ft).

Use of plant communities appeared to be in proportion to their availabilities. Similar structural conditions were furnished by different predominating vegetation in each herd range. Thermal cover structure for example was provided in subalpine fir-grand fir/big huckleberry commmunities around Jubilee Lake, in grand fir/Rocky Mountain maple communities above Lookingglass Creek, and in grand fir/big huckleberry or lodgepole pine-grand fir/big huckleberry communities along the North Fork of the John Day River. Cover and forage types that received high use were associated with small moist or wet meadow edges and streamside zones. Such types were comprised of several plant communities that differed among herd ranges.

Elk were observed in 14 of 15 possible habitat-use types defined by vegetation structural measurements including tree height, crown canopy, sight distance, and forage abundance, for example. Use types were condensed into elk habitat components defined by Thomas et al. (1979) by grouping them according to their dominant structural attribute. Thermal cover and forage area components each constituted an average of 45% of the observations and hiding cover comprised 6%.

Habitat components were inventoried with the aid of analyses of remote sensing data. Inventories were displayed in tabular form and as 1:24,000 maps, which are compatible with 7.5 minute topographic and orthophoto quadrangles. Maximum regions inventoried and mapped were 50,588 ha

(125,000 a) of the Walla Walla herd range, 105,220 ha (260,000 a) of the Heppner herd range (Bright 1981), and 111,292 ha (275,000 a) of the North Fork John Day River herd range. Methods were developed that enabled us to inventory thermal cover, hiding cover, and forage areas on small units of interest within the maximum regions, for example, the 3,360 ha (8,303 a) Jubilee Lake Total Resource Inventory compartment as well as a 850 ha (2,100 a) timber sale area within that compartment. New regions are being inventoried and their approximate sizes are as follows: Chesnimnus Unit, 512,755 ha (1,267,000 a); Wallowa-Whitman Unit, 895,132 ha (2,211,840 a); and the Malheur-Ochoco Unit, 1,109,590 ha (2,741,760 a).

The inventories have been used in research and management to evaluate current and projected distribution and abundance of elk habitat components. Evaluations of forest planning and monitoring of changes in elk habitat availability resulting from specific timber harvests have both been based on these inventories. The methods and products have provided data required to coordinate multi-resource allocations with elk habitat needs and to evaluate trade-offs projected to result from alternative timber management strategies. For example, the availability of habitat components within several home ranges of elk from 2 herds was converted to average cover-forage ratios for summer and winter ranges, 84:16 and 44:56, respectively; observed elk use of cover and forage components is being compared to their availability within each home range and to relationships such as cover-forage ratios published by Thomas et al. (1979); and changes in distribution and abundance of habitat components have been compared with elk population trends, influence of roads on habitat effectiveness, and projected impacts of future timber harvests (Bright 1981).

CONCLUSIONS

This report is part of a continuing program to provide managers with timely information and methods for evaluating importance and trends of elk habitat in managed forests. Relationships presented in the wildlife habitat handbook by Thomas et al. (1979) are supported by our preliminary analysis of research data obtained by direct observation of freeranging elk in the Blue Mountains of northeastern Oregon. Coordination of management of wildlife habitat with allocations of other wildland resources should be based on those published relationships until indepth analyses of our data suggest that specific refinements are justified. The information and methods developed in this research can help management specialists produce comprehensive resource surveys and analyses required by the Forest and Rangeland Renewable Resources Planning Act.

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BIG GAME HABITAT MANAGEMENT ON A NUTRITIONAL BASIS--A NEW APPROACH

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Abstract: Diaminopimelic acid (DAPA), an indigestible and unabsorbed byproduct of rumen fermentation, was evaluated under laboratory and field conditions to determine its practical application as an indicator of digestible energy level in diets of ruminant animals. Fecal samples from 18 control-fed wether lambs were found to contain DAPA levels which were directly related to diet digestible energy (DE). DE of *ad libitum* fed sheep averaged 8% higher than DE for maintenance diet sheep with the same fecal DAPA level, indicating a small, but significant, increase in non-DAPA bacteria with *ad libitum* feeding. Partial DAPA profiles were constructed from free-ranging elk and deer which indicated (1) deer feces may have higher DAPA levels than elk feces in winter, (2) an index system for evaluating elk fecal DAPA could have at least 80 significant units, and (3) fecal DAPA levels follow an annual cycle which reflects seasonal changes in diet DE.

INTRODUCTION

The prime objective of big game habitat management is to provide for the needs of the animals in terms of food, water, cover, and space. In order to most effectively achieve this goal, the manager must: (1) know what the needs of the animal are, (2) evaluate the habitat to determine how well it provides for these needs, and, focusing on those segments of the habitat which are deficient, (3) the habitat is modified to better provide for those needs, when necessary (4) the animal population is modified to bring it more in line with what the habitat can support.

Since quantity and quality of food is generally considered the principal constraint of big game herd productivity (Connolly 1981, Nelson and Leege 1982) and subsequent harvestability, much research and management effort has been focused on this subject area. In spite of this, all too frequently we still don't know what animal nutritional needs actually are. Nutritional need standards for our most studied wild ungulate, the white-tailed deer, are yet only crude approximations (Moen 1977, 1981, pers. com.) drawn heavily from the livestock literature. Nutritional standards for elk are even less complete (Nelson and Leege 1982), although Robbins and associates have made significant strides toward developing these standards (e.g., Robbins et al. 1979, 1981, Mould and Robbins 1981).

Many, including these writers, have accepted available nutritional standards as adequate and have proceeded to step 2: evaluating how well the habitat provides for the protein and energy needs of the animal (e.g., Schommer 1978, Gibbs 1978, Davitt 1979, Hobbs 1979, Hobbs et al. 1981). Some have proceeded even further by estimating carrying capacity on a nutritional basis (Wallmo et al. 1977, Hobbs et al. 1982). Step 2, however, requires accurate determination of food habits and digestible protein and energy, either on a forage species-by-time or diet mixture-by-time basis. All methods for quantifying food habits continue to have serious technical and logistic problems (Medin 1970, Rice 1970, Ward 1970, Wallmo et al. 1973, Nelson and Leege 1982). Even with accurate food habits data, it is necessary to express them in terms of digestible nutrients. This is an expensive procedure. It costs at least $300 per diet (including field time) using the least expensive methods; viz., food habits determined by fecal analysis with forage samples in diet mixture subjected to _in vitro_ diegestion of crude protein and gross energy (Wash. State Univ., Wildlife Habitat Laboratory estimate; January, 1982). At best, current methods for evaluating big game food habits on a nutritional basis are expensive and only marginally reliable. There may be a cheaper, more direct method.

Many biologists favor animal indicators for monitoring the wellbeing of big game populations because they are more direct than the usual diet quality approach and simpler, with less opportunity for technical errors to bias results and their interpretation. Some of the more commonly used indicators include ovarian analysis and fetal counts (e.g., Robinette et al. 1977), bone marrow color (Cheatum 1949) or compression (Greer 1968), kidney fat index (Riney 1955), and combinations of indicators (Ransom 1965). Although useful, these indicators evaluate productivity and animal condition after the fact and require the death of the animal. Direct methods for evaluating current nutritional well-being which have been used involve nutrient analysis of the rumen for crude protein (McBee 1964 cited by Moen 1973:312) or volatile fatty acid (VFA) production (Mansfield et al. 1975). These methods also require the death of the animal, unless a trocar is used on darted and drugged animals. In either case, much time and expense would be allocated in acquiring a statistically adequate sample. A method for evaluating current herd nutritional well-being is needed which is direct, inexpensive, and does not require live capture or death of animal subjects.

Fecal analysis has been broadly applied in big game food habits and certain animal parasite studies, but it has also been used to evaluate diet quality. The fact that total fecal nitrogen is related to dietary nitrogen or crude protein intake by ruminants is well known, and that low dietary crude protein levels will result in suboptimal feed energy utilization. The reader is referred to any good animal nutrition text (e.g., Church 1979:25-50) for review of this subject. But efforts to develop a method for evaluating diet quality based on total nitrogen content of the feces (Gates and Hudson 1979) have been unsuccessful. A major reason for this is that phenolic compounds, almost universally present in higher plants (Swain 1965), cross-link with amino acids, rendering them unusable by the ruminant animal (Mould and Robbins 1981). Diets high in crude protein and low in phenolic compounds, as well as diets low in crude protein and high in phenolic compounds, could both result in high total fecal nitrogen levels.

One form of fecal nitrogen, that of undigestible portions of bacterial cell walls, shows strong promise of being closely correlated with diet quality. The compound, $\alpha-\varepsilon$ diaminopimelic acid (DAPA), is found in most anaerobic bacteria and bluegreen algae but not in higher plants and animals. The ratio of DAPA to total bacterial nitrogen in a mixed rumen bacteria population has been shown to be rather consistently 41 mg per gram. Because of this, DAPA has been used as a marker for determining nitrogen flow to the lower tract of ruminants (Hogan and Weston 1970, Hutton et al. 1971, Lindsay and Hogan 1972). Once diet nitrogen is combined into DAPA, it passes through the animal undigested and unabsorbed (Hutton et al. 1971).

Since at least 80% of a grazing ruminant's digestible energy is derived from bacteria-produced VFA and digested bacterial constituents (Weller 1969) and, since DAPA comprises a small, but consistent and indigestible, proportion of the bacterial mass, it follows that fecal DAPA could be strongly correlated with diet digestible energy. The primary objective of this study, therefore, has been to investigate this relationship and its possible practical application in evaluating nutritional well-being of large herbivore populations. In addition, since nutritional standards have not yet been well defined for large wild herbivores, a second objective has been to develop animal DAPA profiles for wild herbivore herds with known productivity to use for standards.

METHODS

Controlled Feeding Studies

Eighteen wether lambs (avg. wt. 35 kg) were fed controlled rations in digestion metabolism stalls designed to measure feed and water consumption and total feces and urine voided. Rations were composed of varying amounts of smooth brome, alfalfa, rolled barley, and Cereulos (a pure cellulose filler) at maintenance (NRC 1975) and <u>ad libitum</u> consumption levels. Feed and water consumption data and urine and fecal samples were collected the last 7 days of a 35-day feeding period. Feed, feces, and urine were analyzed for proximate constituents to determine diet quality, including digestible energy and fecal nitrogen. Fecal DAPA was analyzed following Czerkawski (1974).

DAPA Profiles for Wild Large Herbivores

Budgetary constraints greatly restricted this phase of the study. It was intended that several herds of each, elk and mule deer, would be sampled for fecal DAPA levels at monthly intervals. Only one herd was sampled June through September 1981 and January 1982. This herd, numbering about 250, summers on Washington State University's Colockum Multiple Use Research unit near Wenatchee, central Washington, and winters on Washington Game Department's Colockum Habitat Management Area (Tarpiscan Creek and West Bar). This herd has been much studied and shown to be in excellent nutritional health (McArthur 1977, McReynolds 1977, Davitt 1979), with annual fall calf-cow ratios of 50% to 65% (K. Killgore 1981, pers. com.).

RESULTS AND DISCUSSION

Controlled Feeding Studies

DAPA content of sheep feces ranged from 0.301mg/g fecal DM for an animal fed 2.20 kcal DE/g feed DM to 0.842 mg/g fecal DM for an animal fed 2.75 kcal DE/g feed DM (Fig. 1). Digestible Energy ranged from 2.20 kcal/g feed DM to 3.37 kcal/g feed DM. Although the range of diet quality examined in this study spanned a significant portion of the variation in expected DE values, higher and lower DE values could be encountered in wild ruminant populations (e.g., Schommer 1978, Miller 1980), as well as sheep on range forage diets. A broader spectrum of diet quality should have been fed in this study in order to extend the observed DAPA-DE relationship. Nevertheless fair correlation was observed between fecal DAPA and diet DE among maintenance level sheep (Fig. 1). The linear DE estimator derived from these data,

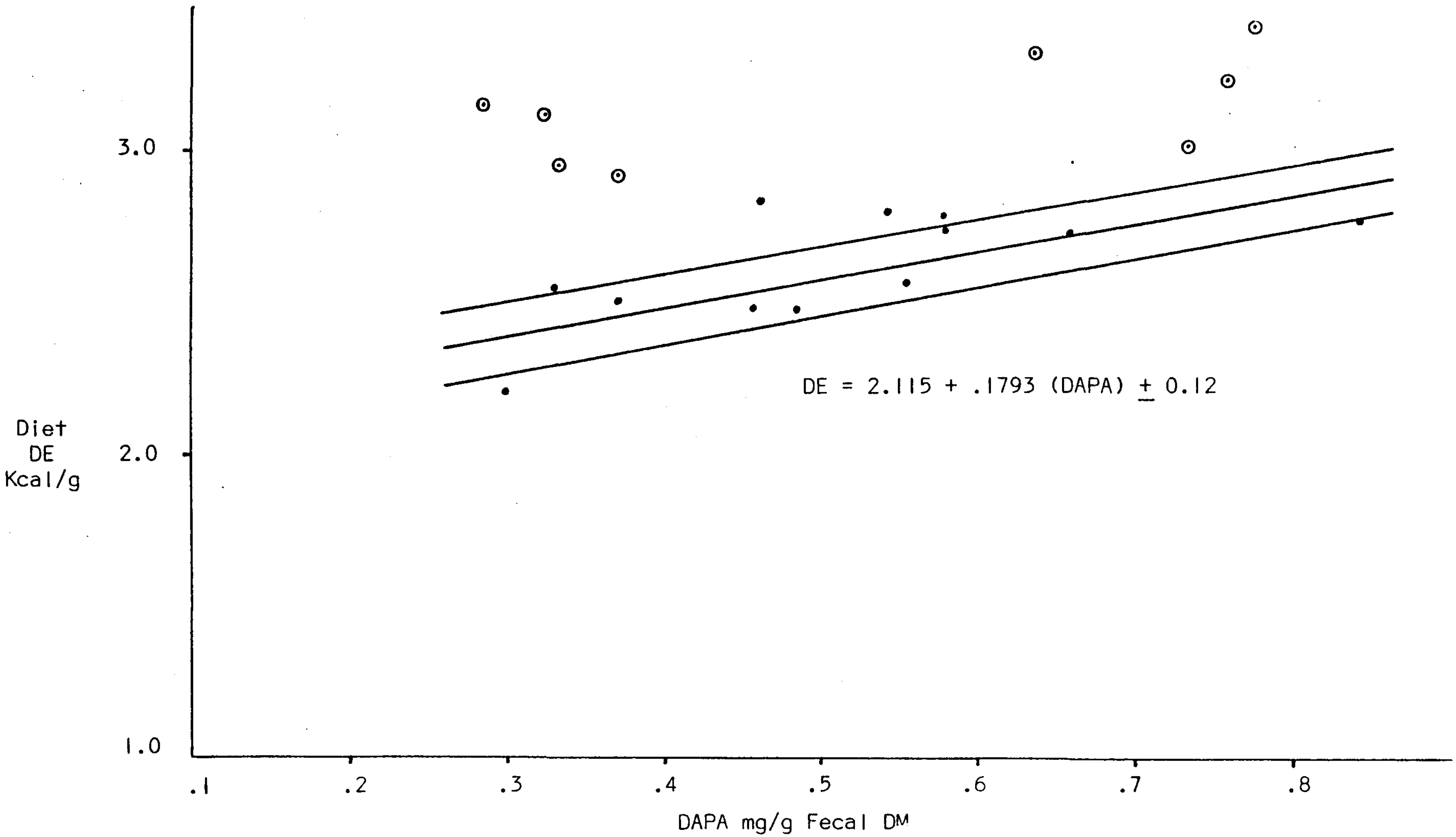

Figure I.--Relationship between diet digestible energy (DE/g DM feed) in controlled fed lambs and DAPA content (9mg/g feces DM) of feces voided from animals fed various diets at NRC maintenance level (•) and ad libitum (⊙).

$$DE = 2.115 + .1793 \text{ (DAPA)}$$

has high precision (s_{yx} = 0.12), but likely overestimates DE at low DAPA levels. We would expect it to be a curvilinear relationship, possibly with its origin at 0 kcal DE.

Less staggering of DAPA output was observed among sheep fed alfalfa _ad libitum_. More important, however, was the significantly (P = .001) higher DE/DAPA ratios for _ad libitum_ rations. Bacteria which carry the DAPA marker in their cell walls are primarily those species which have cellulolytic capabilities (Purser and Buechler 1966). It would be expected that an _ad libitum_ consumption rate would support an above average population of non-cellulolytic bacteria; and, therefore, a higher DE/DAPA ratio would be expected. It is not likely that wild ruminants would encounter forage quality and quantity at such high levels, except very early in the growing season. Even then, the high water content of the forage would likely prevent high consumption rates. Of the 2 data sets, the maintenance-level DE/DAPA ratios would be expected to have greatest application under range conditions.

DAPA Profiles for Wild Large Herbivores

DAPA (mg/g fecal DM) levels found in 12 elk fecal collections and 3 deer collections for various dates and locations are shown in Fig. 2. Elk DAPA levels ranged from lows of 0.24 through 0.27 in winter to a high of 0.99 in late June. The 3 deer fecal collections (Fig. 2A) from Okanogan County, Washington, show what probably represents the last of several months of steady diet quality decline, followed by significant improvement as early green herbage became available in March. The 6 elk fecal samples (Fig. 2B) collected by Idaho Fish and Game personnel from 2 wintering areas near Coeur d'Alene, Idaho, show the same late winter trend. DAPA content differences between the deer and elk samples suggest differences in rumen population composition. Deer rumen communities apparently have higher proportions of DAPA-producing bacteria. Elk, with their slower rate of food passage from the rumen, may have higher protozoan populations than deer (Nelson and Leege 1982). DAPA has not been found in protozoans. A January 1982 elk sample from this same general area in Idaho contained less DAPA (Fig. 2C) than the comparable 1981 sample, though the significance of this is subject to question.

Best comparison of DAPA content of all feces among dates for 1 herd is shown in Fig. 2D. Samples were collected on 4 dates, June-September, 1981, on and adjacent to a calving ground at 1524 m (5000 ft) elevation. The area is located on the Colockum Wildlife Habitat Management Area (Game Dept.) near Wenatchee, WA. Elk moved into the area before it was snow-free in late May and remained throughout the summer. Fecal DAPA levels dropped from 0.99 mg/g fecal DM on June 24 to 0.56 mg/g on August 18, reflecting a steady deterioration in forage quality as the summer progressed. Limited range greenup occurred in early September, following unusually early rainfall in late August. The period from August 20 to September 1 received nearly 1.02 cm (0.4 in) precipitation, and it was cloudy most of that time. Elk diet quality evidently improved by September 12, as a result of this greenup, as indicated by a significant increase in fecal DAPA on September 12. This herd was not sampled again until January 9, 1982, on winter range. Usually winters in this area of Washington are relatively open and mild, but the 1981-82 winter was severely cold, with deep snows covering herbaceous forage through January. Diet at this time was largely browse, with about 20% rye stubble from a nearby

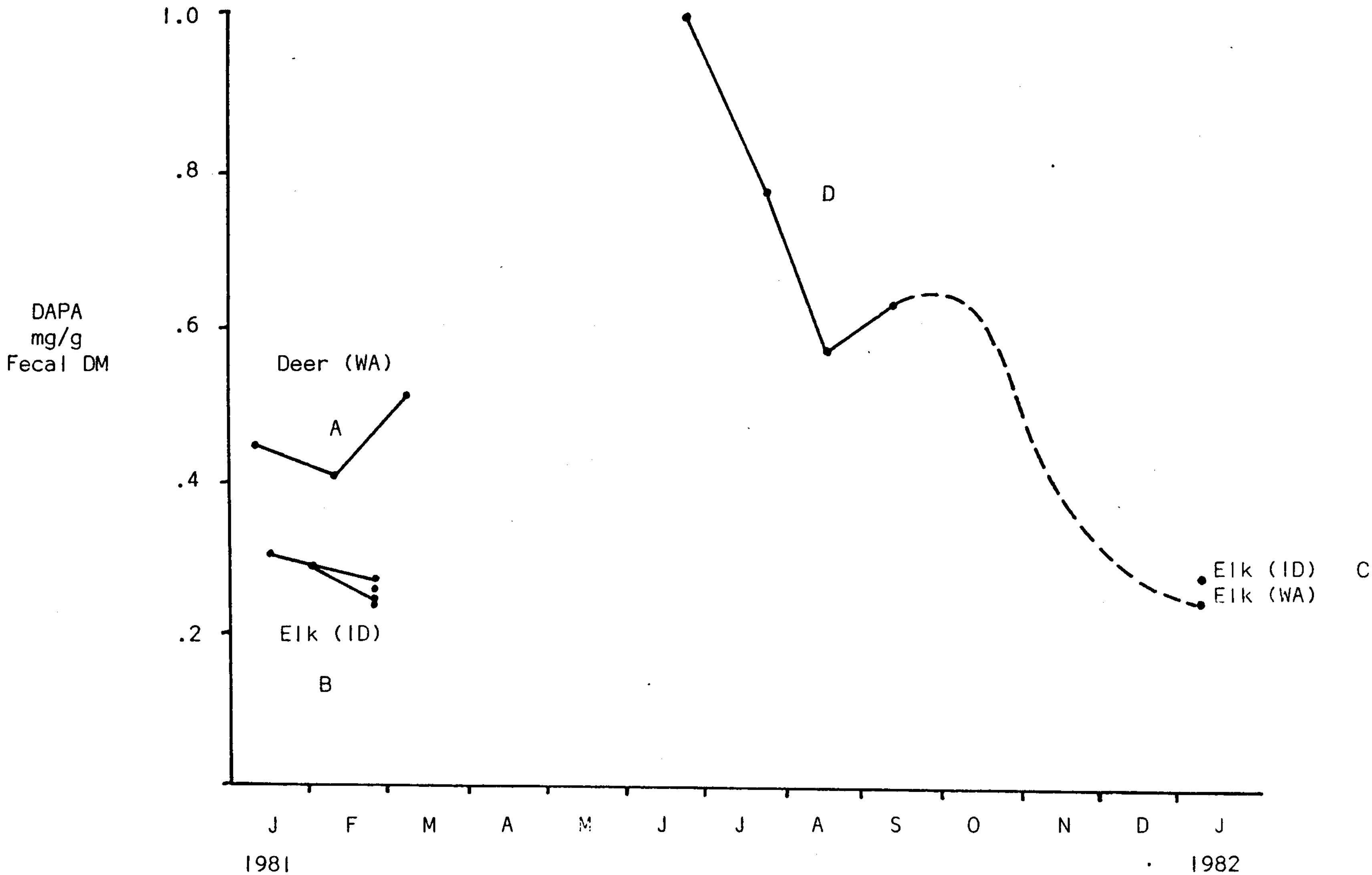

Figure 2.--Partial DAPA profiles for deer and elk from various sources. A, Okanogan Highlands, WA; B and C, Coeur d'Alene area, ID; D, Wenatchee area (Colockum), WA.

wildlife planting. Diet quality, as evidenced by fecal DAPA, was probably not significantly lower than that for Idaho (Fig. 2C).

Although these profiles are not complete, certain assumptions can be made from them. First, deer fecal DAPA levels (probably a mixture of both white-tailed and mule deer in our sample) are higher than those for elk, at least in winter. If DAPA profiles become a practical basis for comparing nutritional health of big game herds, separate profile standards will be needed for each species. Secondly, fecal DAPA levels range from about 0.2 to over 1.0 mg/g fecal DM for elk. Assuming adequate herd fecal samples are collected, its fecal DAPA can be estimated to the nearest 0.01 mg/g, using our methods. This provides an index system with over 80 significant units. With improved DAPA analysis methods, significant index units in the system could be increased. And, thirdly, there is an annual cycle in fecal DAPA levels which, if compared among years with herd vital signs (natality, mortality, etc.,), could provide insight into herd performance.

Figure 3 shows estimated elk DE for 4 summers (1973-1976) on the Colockum Wildlife Habitat Management Area. These estimates were obtained using *in vitro* digestion treatment (Tilley and Terry 1963) of forage samples which were mixed in proportion to diet composition. Diet composition was estimated by fecal analysis (Davitt 1979), and forage samples were collected within a few days prior to diet fecal sample collections. DE was determined by comparing gross energy of the appropriate undigested and digested diet forage mixtures.

Elk diet DE, estimated (equation 1) from fecal DAPA samples from the Colockum area for 1981, are consistent with the 1972-1976 estimates (Fig. 3). We make this comparison, not necessarily in support of using the sheep-derived equation for estimating elk DE (however feasible that may be), but as a demonstration of applicability of using an elk derived equation for estimating elk diet DE from elk fecal DAPA. It appears likely that, once such equations are available, large herbivore diet DE could be estimated for management purposes, at least, just as effectively and with considerably less cost than with the established method. Based on 1982 dollars, laboratory cost for each 1973-1976 DE value was about $150. DAPA analysis costs about $15 per sample.

CONCLUSIONS

Fecal DAPA level appears to be closely related to the digestible energy level of the ruminant diet. This, plus its relative low cost, promises to make fecal DAPA analysis a cost effective alternative to other field methods for evaluating large herbivore diet quality and estimating carrying capacity. Regardless of accuracy, herd diet DE by any method would have only tentative application in management until DE standards are developed.

More immediate and direct application of fecal DAPA analysis in large wild herbivore management could be possible if fecal DAPA standards were developed for each animal species, based on fecal DAPA profiles from obviously healthy herds. These standard profiles could be developed by the management agency involved, alone or in cooperation with another research group with DAPA analysis capabilities. Because of probable regional differences among herds of the same species in energy expenditures associated with homeothermy maintenance in winter and, perhaps, migration, regional standards would likely be needed. For example, most Washington elk and deer herds would be expected to have lower daily energy expenditure in winter than (say) Montana or Wyoming herds.

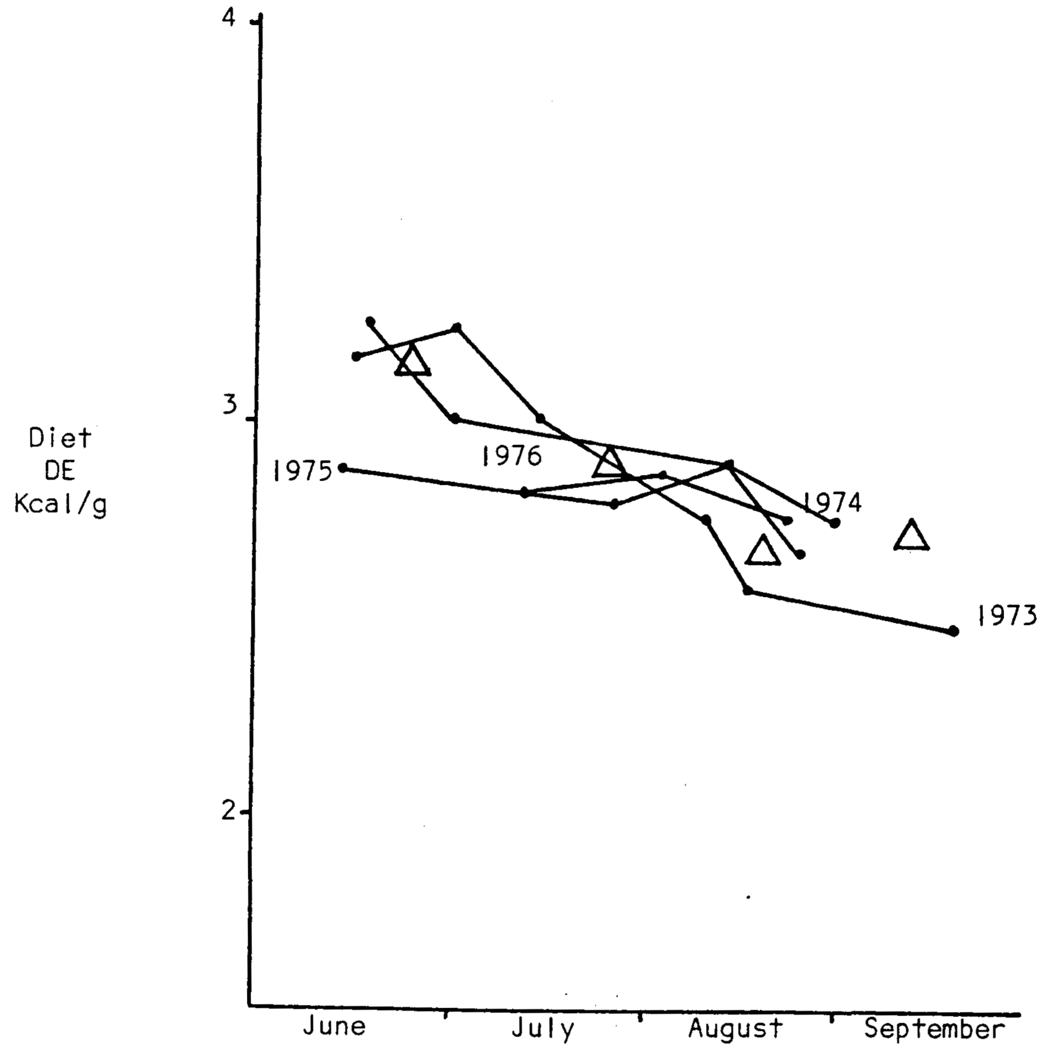

Figure 3.--Comparison of summer diet digestible energy (DE) estimates (△) from 1981 fecal DAPA samples with DE estimates from *in vitro* digested diet mixtures determined by fecal analysis

Other management problems would also be approached using fecal DAPA data. Social interaction between cattle and elk is difficult to quantify in terms of impact of one animal species on the well-being of the other (Nelson 1982). Elk fecal DAPA levels could be compared before and after elk leave an area into which cattle have been released. Fecal DAPA might be substituted for animal weight or delta (Nelson 1982) in validating formulary models of exploitation (competition for food).

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