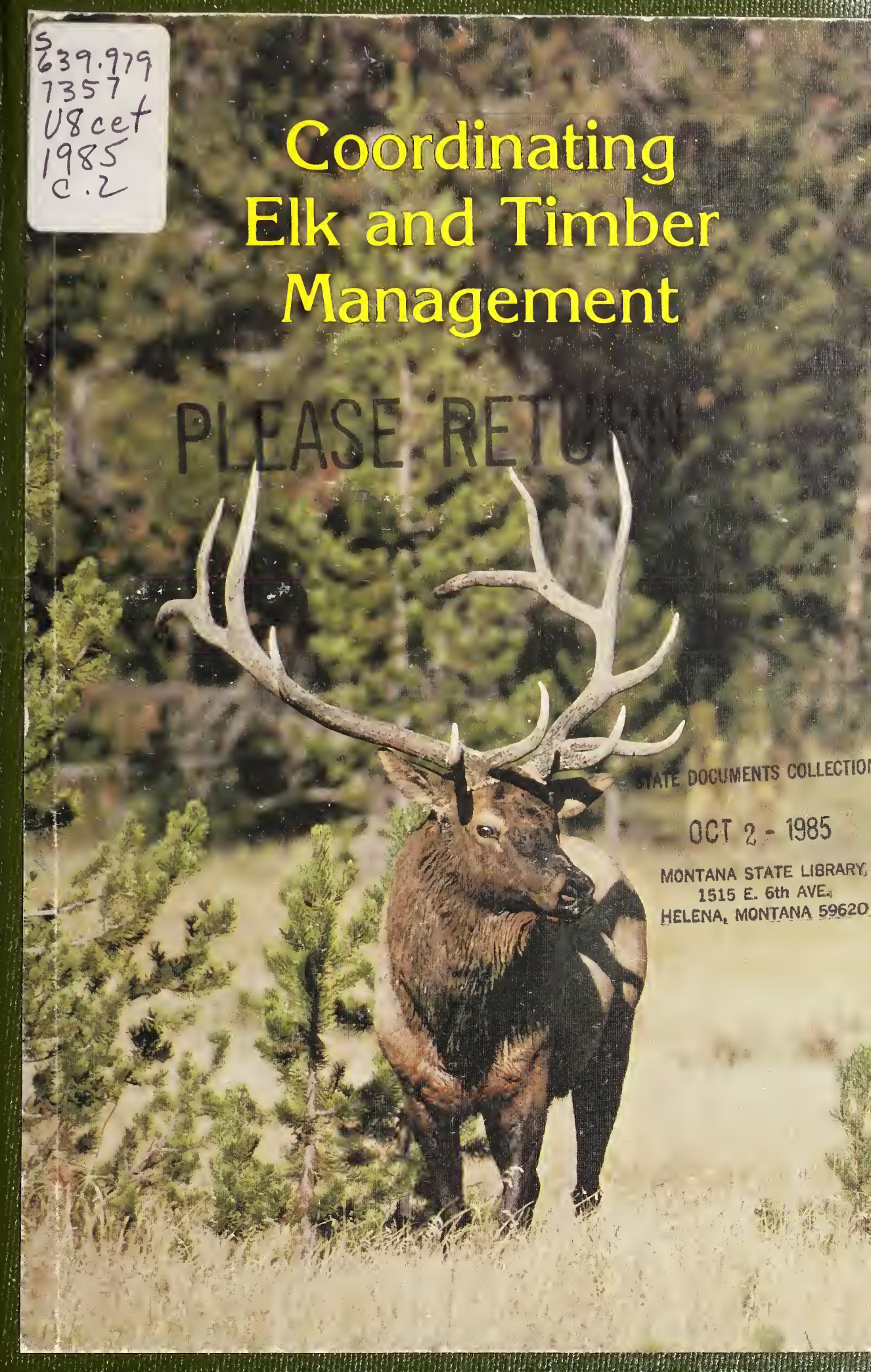
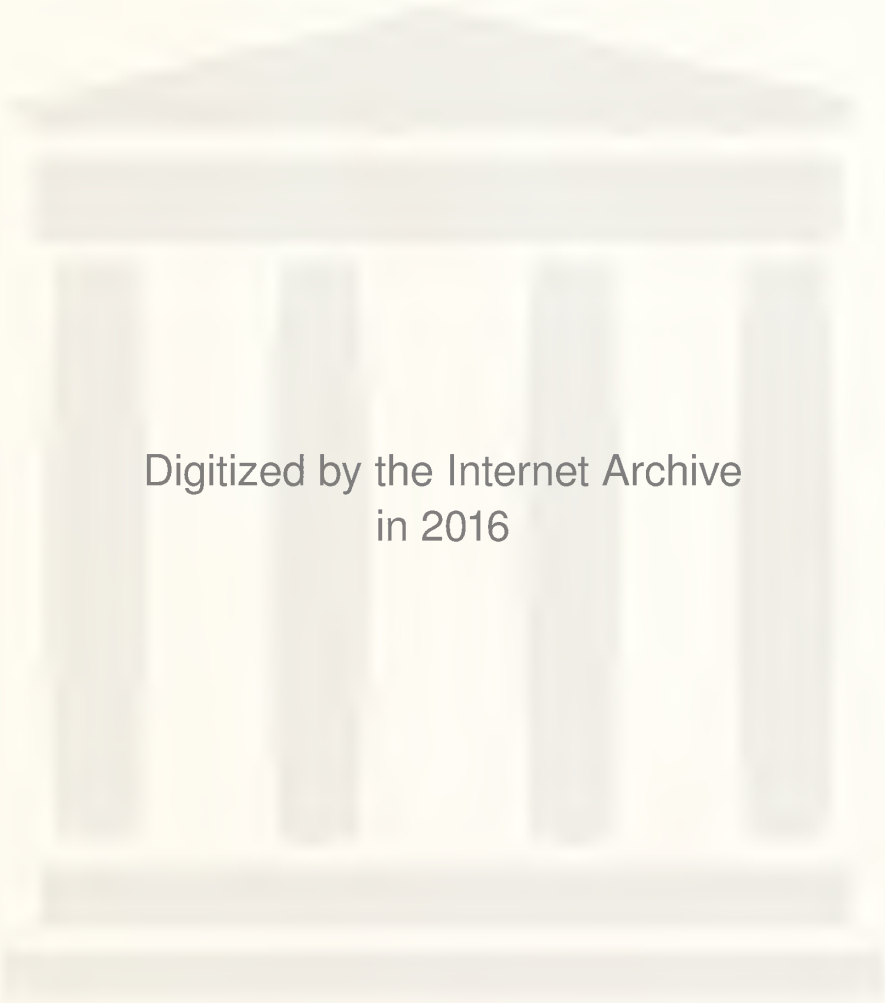
Coordinating Elk and Timber Management





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COORDINATING ELK AND TIMBER MANAGEMENT

FINAL REPORT OF THE MONTANA COOPERATIVE ELK-LOGGING STUDY 1970-1985

by a Research Committee consisting of:

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January 1985

FOREWORD

In the view of many Montanans, the most important resources of our mountains and forests are elk and timber. Both are indispensable to our lifestyle and both require careful management to meet our needs.

Management responsibilities that determine relationships between elk populations and timber production are widely distributed among several agencies and many landowners. Sound decisions based on reliable information and close coordination are required to assure a viable timber industry and healthy game herds.

The report presented here summarizes the results of nearly 15 years of cooperative research involving four public agencies and a private timber company. By almost any standard, this program was a unique accomplishment in that field investigations were jointly designed and mutually conducted, and the results were integrated into management action as the work was being completed. We still do not know all there is to know about habitat management for elk, but this joint venture has brought us to a level of understanding that allows sound decisions based on a demonstrated level of mutual compatibility between timber production and elk management.

Edwin Zaidlicz — Sept 13, 1984
Edwin Zaidlicz, State Director — Date
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ACKNOWLEDGMENTS

It would be difficult or impossible to acknowledge all the individuals who contributed to the Montana Cooperative Elk-Logging Study. Forty to 50 persons helped on the Burdette Creek study; and a similar number contributed to each of the Long Tom, Sapphire, and Chamberlain studies. However, we do want to thank everyone who helped in some way, large or small, in the success of one or more of these efforts.

We would like to especially acknowledge two of our fellow workers, Terry McCoy, and pilot Fred Cooper, who were killed in a tragic airplane accident on August 31, 1974, while radio-tracking elk in the Sapphire Range in western Montana.

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MANAGEMENT RECOMMENDATIONS

Interagency cooperative research on the relationships between elk and logging activities in western Montana was initiated in 1970. Beginning in 1974, this research produced a series of recommendations directed toward influencing the design and conduct of timber sales to minimize adverse effects on elk populations. Over a period of nearly 10 years, the initial recommendations have been modified to improve and clarify the results obtained in management application, and some additional recommendations have been written.

The current recommendations represent a tested and successful composite and are intended as guidelines in the planning and conduct of long-term forest management to maintain elk populations, elk hunting, and timber production. Although each recommendation will stand by itself, combined and thoughtful application of all recommendations will yield more than additive benefits.

These recommendations are directed at wild, free-ranging, hunted, elk populations and will not necessarily apply to artificial elk ranching, captive herds, or park situations. The recommendatons are intended primarily to influence habitat quality for elk. Converting habitat quality variables to population numbers is not likely to be meaningful because population levels are largely determined by hunting regulations and security during the hunting season.

Managers are cautioned that literal application of these recommendations should not be substituted for detailed, onsite discussion by timber, wildlife, and other resource specialists. There may be situations in which one or more of these recommendations may not be applicable to local conditions.

Security During Logging Operations

Recommendation:

Preparation of timber sales in elk summer range should include planning to attain minimum losses in habitat security during the period of road construction and logging.

Findings and Discussion:

Entry to an area occupied by elk, for any purpose, reduces the security of the habitat in that area. Research in four different studies compared elk responses to situations ranging from large-scale logging operations with all roads continuously accessible to small operations in which roads were only open to the logging contractor. Elk responses to road building and logging demonstrated that significant losses in security can be minimized when appropriate restrictions are used by the land manager. The degree of secu-

rity loss is directly related to the number of acres disturbed, to the length of time the disturbance continues, and to the timing of field operations.

Displacement of elk was detected as far as 4 miles from the cutting units in large timber sales in which roads were open to nonlogging traffic. In one study, herd displacement was to an adjacent drainage and then beyond that drainage when the ridgeline was disturbed. In another investigation, displacement was down a ridgeline for 2 miles through undisturbed timber and over a point. In both cases, topographic features provided line-of-sight barriers between elk and the logging activity. Conversely, during relatively small timber sales, and particularly when roads were only open to the logging contractor, displacement of elk was generally less than one-half mile from the center of logging activities. In all studies, the time required for elk to return to the disturbed habitat was directly related to the distance they were displaced.

Security for elk can be satisfied by any habitat in which animals do not feel threatened or a habitat in which they will remain in the face of disturbance. There are a variety of ways in which the manager can reduce the distance moved by elk and simultaneously increase the probability of immediate return by animals displaced:

—disturbance by heavy equipment can be completed in the shortest possible time, and, if possible, during periods of the year when elk are not present. It has been shown, for example, that individual elk tend to use more level ground in the early summer and move to steeper ground in the late summer and fall.

—adjacent drainages or areas into which elk might be expected to move can be made more secure by road closures.

—logging activity can be confined to a single drainage at a time and all work completed in the shortest possible time frame. Intensive activity over a single season has far less influence on elk than a low level of intensity continued over several seasons.

—displacement of elk is significantly reduced where access to the timber sale area is limited and nonlogging traffic is controlled. Recreational use of firearms by anyone working within an area closed to the general public should be prohibited.

Redistribution of Elk

Recommendation:

Timber sales should be planned in a manner that minimizes potential problems arising from temporal redistribution of elk onto adjacent or other nearby property.

Findings and Discussion:

In all four of the areas in which elk response to timber sales was studied, some movement away from the sale area was recorded. On these areas, movement by elk created no specific problems because there was adequate space available. Nevertheless, timber sales may result in local

modification of the way elk utilize their home ranges. Such modifications sometimes result in increased use of nearby private lands or public lands not normally used by elk. It is usually possible to achieve greater compatibility in land use if sale planning recognizes, and attempts to minimize, potential problems involving increased elk use on adjacent properties where elk presence is undesirable. Knowledge of habitat use patterns by local elk herds and the availability of other nearby habitats will benefit the land manager; consultation with state and federal wildlife biologists will also be of considerable benefit in such assessments.

Advanced planning in timber sales can help prevent redistribution of elk from secure habitats onto adjacent private cropland, where elk presence may be undesirable, especially in winter. *(Photo by: Dennis Orthmeyer)*

Traditional Home Range Use by Elk

Recommendation:

Before timber sales are established and new roads are constructed, information should be obtained concerning traditional use patterns and distribution of elk harvest so that cutting can be timed and roads placed to have the least undesirable effect on both elk and elk hunting.

Findings and Discussion:

Elk are very traditional in the way they distribute themselves over time and space. Home range size and shape vary considerably among individuals and areas, but there is comparatively little variation in the size and shape of home ranges used by the same animal from year to year. This is true for individuals and for herds as well. Data from frequent relocations of many elk over the course of several years has demonstrated annual home ranges varying from about 5 to nearly 200 square miles, but variation in the location of individual animals in consecutive seasons was very low. Individual elk usually use the same winter and summer areas from year to

year throughout their lifetime, regardless of disturbance and habitat alteration.

Roading and logging of an area with high traditional elk use could lead to undesirable overharvest and a severe decline of the herd if hunting seasons and/or road closures are not adjusted to compensate for the reduction in habitat security. Studies of wildlife throughout the world have shown that habitat preference is learned as well as innate. This learned preference, called habitat imprinting, may be as important a consideration in elk habitat management as innate preferences. If, over several years, mortality of adult cows exceeds recruitment in a group of elk traditionally using a particular area, elk use of that area may decline to zero. Because elk are slow to pioneer and become established in a new area, local elimination may require many years before elk use is reestablished.

Innate and learned use of specific habitats, like this timber-meadow complex, form a composite traditional use area for elk. *(Photo by: Terry N. Lonner)*

Road Construction and Design

Recommendation:

As a part of the location and design of transportation systems, existing habitat occupancy and movement patterns and probable elk crossing areas should be identified and provisions made to maintain security for unimpeded movement.

Findings and Discussion:

Both the location and density of forest roads have been shown to be disturbing to elk security on most elk ranges in North America. On study areas in Montana, most of the elk use of sideslopes in moderate to large drainages occurred above the lower third of the slope. In drainage headwaters the lower third of the slope appeared to provide the most important habitat. Elk travel routes from one drainage to another crossed ridges

through saddles and were often easy to identify. Road construction in these sites resulted in declines or elimination of elk use of such crossings. Elk have also exhibited a preference for crossing ridges in sections where visibility is low and security high, often where dense timber and/or topographic visual obstructions are present. Alteration of such crossing areas can be especially critical during the hunting season.

While any road constructed will tend to reduce the security level of existing elk habitat, losses in security can be significantly reduced if initial road designs and locations recognize existing elk behavior, habitat use, and probable response to new roads. A number of considerations can help to minimize the loss of habitat security:

—locate permanent and high-volume traffic roads in those areas least used by elk.

—design secondary roads, in both construction and layout, to facilitate eventual closure. This is particularly important where roads enter drainage heads.

—maintain frequent dense cover areas adjacent to the road.

—avoid road construction in saddles or low divides frequented by elk in crossing ridges between drainages.

—construct roads to the lowest standard that will meet management objectives. In important elk range this usually implies a low-speed, single-track construction without large cut slopes, fills, or straight stretches.

—dispose of road right-of-way slash so it does not inhibit elk movement.

—locate roads, even temporary roads, to avoid disturbance of moist sites and other areas of concentrated use by elk.

—avoid areas of important elk winter range.

Construction of low standard roads in timber sales will help reduce disruption of habitat use by elk. *(Photo by: Gary Edge)*

Road Management

Recommendation:

Where maintenance of elk habitat quality and security is an important consideration, open road densities should be held to a low level, and every open road should be carefully evaluated to determine the possible consequences for elk.

Findings and Discussion:

It has been repeatedly documented, in Montana and throughout North American elk range, that vehicle traffic on forest roads evokes an avoidance response by elk. Even though the habitat near forest roads is fully available to elk, it cannot be effectively utilized. Declines in elk use have been detected as far as 2 miles from open roads, but significant reductions in habitat effectiveness are usually confined to an area within a half mile. The loss of habitat effectiveness has been shown to be greatest near primary roads and least near primitive roads, greatest where cover is poor and least where cover is good, and greater during the hunting season than at any other time of the year. As a general average, habitat effectiveness can be expected to decline by one-fourth when open road densities are 1 mile per section and by one-half when road densities are 2 miles per section. Losses in habitat effectiveness for elk can be at least partially mitigated by imposing strict design and location standards during road construction. Losses can be greatly reduced through appropriate traffic control and road closures.

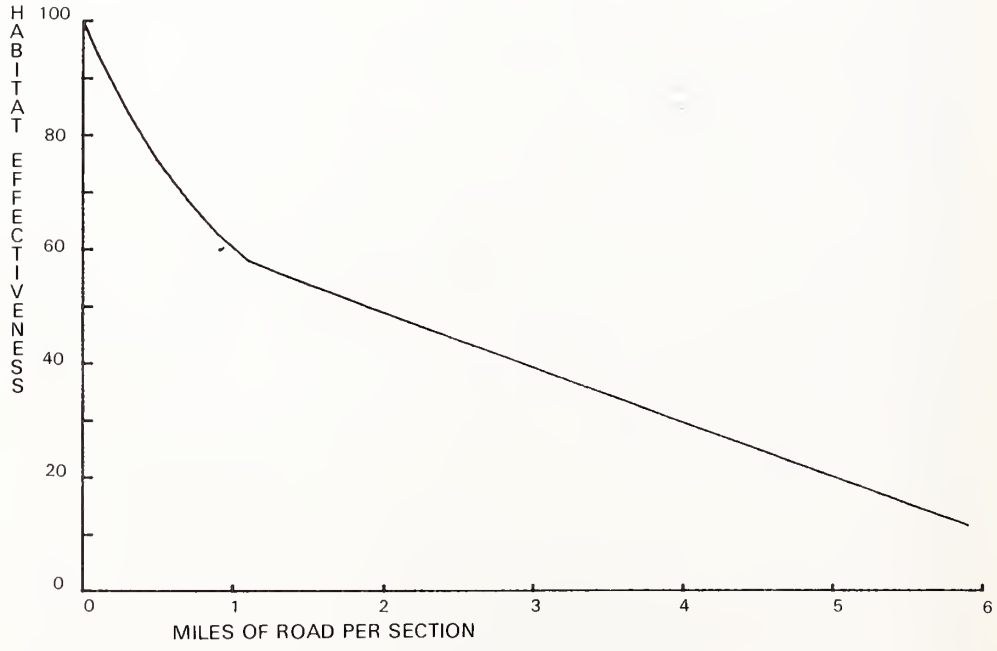


Figure 1. Regression line describing the influence of road density on habitat effectiveness for elk.

Roads, and the people and traffic associated with them, have a more significant influence on elk security than most other factors combined. Few considerations in forest management appear to provide a better opportunity for immediate mitigation in the management of elk habitat than road closures.

Some roads are needed for timber harvest, recreation, fire control, firewood cutting, and other purposes, including access by hunters. Where the maintenance of elk habitat security is an important consideration, requirements for public access should be identified prior to road design and construction, and all roads remaining open should be essential to an identified need.

Criteria for Road Closure Selections

Available data demonstrate that every road constructed in elk habitat is a potentially negative influence for elk. It is also clear that some roads are more disturbing than others. When choices are possible, the following criteria are suggested as guides for selection of roads to be closed in areas where elk habitat is an important consideration. As a general rule, yearlong closure is preferred to seasonal closure, but some specific advantages are possible with certain seasonal closures as noted. High priorities for closure include:

—roads in the heads of drainages, saddles, and low divides
—roads through moist areas and wet meadows
—loop roads that encourage through traffic
—trunk roads with many dead-end side roads under one-half mile in length
—midslope roads in the lower two-thirds of the drainages (especially in fall)
—roads in known calving areas (especially in spring)
—roads in winter range concentration areas (especially in winter)
—roads in areas with poor cover (especially in fall)

Area Closures During the Hunting Season

Recommendation:

Elk management goals and objectives should be clearly defined before imposing travel restrictions.

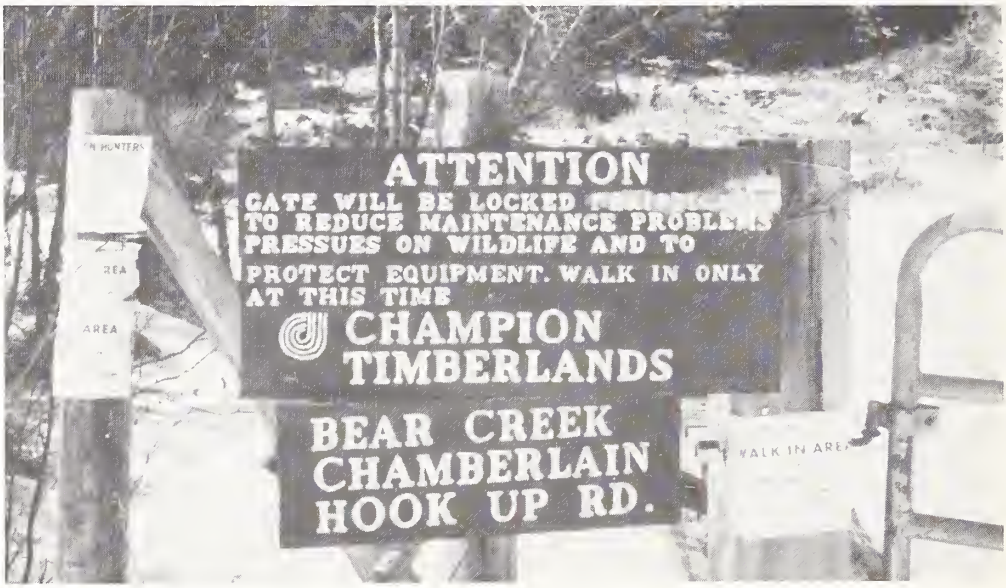
Findings and Discussion:

Two studies in Montana involved area closures that restricted motor vehicles to a few selected roads during the general hunting season. Several other studies involved radio tracking of one or more elk during the hunting season.

The Judith Road Closure Study indicated that travel restrictions did not change elk distribution or temporal distribution of hunters. Apparently this area closure was not needed to "protect" elk where escape cover

was adequate and well distributed (at least two-thirds cover to one-third open). Hunters spent more time walking; consequently they reported seeing and killing more elk under the restrictions than during the unrestricted control seasons. Their unsolicited comments showed a preference for limited access because of the "higher quality" hunt it afforded.

The Ruby Road Closure Study, on the other hand, showed that area closures can cause significant changes in elk distribution and hunter use of an area. This area was characterized by a relatively open, broken forest, with gentle terrain and easy access (one-third cover to two-thirds open). During seasons of restricted vehicle access, elk stayed in the restricted area longer and in greater numbers than during seasons of unrestricted access. This resulted in a more even distribution of hunting pressure, elk sightings, and elk harvest through the season, but did not increase total amounts. Hunters also spent more time walking during the restriction period. Most hunters interviewed believed that the area closure had increased the quality of their hunt.



Walk-in hunting areas provide a high quality hunt, although retrieval of harvested elk may be more difficult, and additional time and money are required to implement and enforce such restrictions. *(Photo by: W. Daniel Edge)*

Road density and pattern, including off-road travel, play an important role in determining the security level an area provides to elk during the hunting season. An area with sparse cover and low road densities may provide as much security as the same size area with heavy cover and high road densities. In the Ruby portion of this study, the security level was significantly increased by reducing the number of open roads and eliminating off-road travel. Road density and cover quality are both important when considering adequate elk security during the hunting season. Managers should be especially cognizant of the following:

I. Restrictions will:
   1. increase the time hunters spend walking, and as a result:

a. increase the number of animals seen.
b. possibly increase the kill.
2. generally be accepted as providing a higher quality hunt.
3. make retrieval of downed animals more difficult.
4. require time and money for implementation and enforcement.

II. Where cover is poor (one-third or less of total area) and road densities are high (more than one-half mile of road per square mile), restrictions will likely:
1. reduce harrassment and emigration of elk.
2. reduce the early elk harvest, but increase the uniformity of harvest throughout the season.

III. Where cover is good (at least two-thirds of total area) and open road densities are low (less than one-half mile of road per square mile), restrictions will probably have less influence on elk distribution and elk harvest. Where possible, elk will seek security at least a mile from open roads.

Clearcuts

Recommendation:

In order to assure that forage produced in clearcuts is in fact available for use by elk, openings should satisfy the following criteria:

—slash cleanup inside clearcuts should reduce average slash depths below 1.5 feet. Slash in excess of 1.5 feet will reduce elk use by more than 50 percent.

—openings should be small, even though openings up to 100 acres may be acceptable where the adjacent forest edge supplies adequate security.

—in western Montana, some security cover is provided within openings by vegetation growth, and elk use increases in older cuttings. In central Montana, the younger openings are preferred by elk; security should be provided by designing clearcuts so that the best available cover occurs at the uncut edge. Thinning adjacent to clearcuts is not recommended.

—additional security, which will significantly increase elk use of clearcut openings, can be provided with appropriate road closures.

Findings and Discussion:

Graphic analyses of the density of elk pellet groups inside clearcuts in central and western Montana have identified several variables that influence elk use of these openings. The relative importance of different variables depends on the environment available to elk and the behavioral patterns associated with their use of that environment.

In central Montana, large natural openings are a normal component of both summer and winter ranges. Elk inhabiting these areas are far more tolerant of large clearcuts than elk in western Montana where large natural openings are unusual. A preference for small openings was indicated, par-

ticularly in western Montana, but cutting units as large as 100 acres may be acceptable when the adjacent forest edge supplies adequate cover.

Large natural openings in forests east of the Continental Divide indicate that cover is limiting and only small clearcuts are allowable if elk use of these areas is to be maintained.
(Photo by: Terry N. Lonner)

Throughout Montana elk ranges, slash within the opening was one of the most important determinants of elk use. There was no indicated preference among slash disposal methods as long as average slash depths were reduced below 1.5 feet. Broadcast burning, however, is considered preferable to mechanical methods.

Elk response to vegetation growth inside an opening differs between central and western Montana in a way clearly related to the habitual feeding behavior of elk in the respective areas. In the west, where new growth consists of both trees and shrubs, and available forage is often browse plants, elk use of openings increases as vegetation height increases. Eastward, where new growth is mostly limited to trees, and available forage is primarily grasses and forbs, elk use of openings declines as tree heights increase and understory plants are shaded. Corollary to the indicated preference for openings lacking tall cover, central Montana elk require the greater security provided by good cover at the edge of the opening. These elk also demonstrate a positive response to openings without vehicle access.

Available data do not demonstrate that clearcuts in any configuration are clearly beneficial to elk, although it is known that forage production is increased in openings. Neither is it possible to show that clearcuts have detrimental effects if the opening can be developed without reducing overall habitat security for elk.

Elk use of clearcut openings west of the Continental Divide was severely depressed by untreated slash, by the presence of open roads, and by inadequate cover at the edge of openings. *(Photo by: L. Jack Lyon)*

Cover Type

Recommendation:

Management efforts for timber and elk should be coordinated to recognize the importance of cover type in addition to habitat type. Important or key areas for elk should be identified on a site-specific basis during the planning and implementation of silvicultural practices.

Findings and Discussion:

Although various classification systems, such as habitat typing, give a reasonable description of forest community composition and ecological potential, the structural characteristics or cover types can vary considerably within the classifications over time. Elk use of cover types is often specific, changing in both space and time during summer and fall. For example, moist sites may be highly preferred from June through September but not necessarily sought out in October and November. Relatively advanced seral stages and more dense timber stands may not be as important June through August as in the fall months. Cover type is usually more important than habitat type in determining elk use during summer and fall.

Moist Sites

Recommendation:

Moist summer range sites, in combination with other habitat components which are heavily used by elk, should be identified and the overall integrity of these habitat components should be maintained.

Findings and Discussion:

Findings from all study areas indicate that elk prefer moist sites during the summer months (June through September). Preferred elk summer range exists when these moist sites are interspersed with other necessary habitat components, including a diversity of timber types and densities, especially near drainage heads. Such sites are often found at the heads of drainages, bordering streams or marshy meadows, or occupying moist swales or benches. These sites are usually found within the *Abies lasiocarpa* habitat type series (Pfister et al. 1977) both east and west of the Continental Divide. In central Montana, these sites are usually found within the ABLA/CACA, ABLA (PIAL)/VASC, ABLA/VASC(THOC), and ABLA/LUHI habitat types. In western Montana, moist sites are generally found within parts of the ABLA/LUHI (MEFE), ABLA/CLUN, ABLA/MEFE, ABLA/GATR, and ABLA/CACA habitat types. Moist types in the *Picea engelmannii* series provide similar habitats.

Moist sites have been identified as a very important component of elk summer range, especially when they occur within the *Abies lasiocarpa* climax series. These habitats are primarily important because of their high forage production, good nutritional quality, diverse species composition, and high cover values when interspersed with trees. Because the forage is utilized after calving and prior to the breeding season, it may be important in both reproduction and winter survival.

The overall integrity of moist sites should be maintained during timber harvest because of their high forage production and nutritional value; high cover values result when moist sites border areas of forest. *(Photo by: Terry N. Lonner)*

Selective withdrawal from treatment, along with protection of peripheral zones to provide continuous cover with the uncut forest, will benefit elk. New or planned roads passing near these sites should be closed to summer-fall vehicular traffic except perhaps for light, intermittent administrative use. Roads that already occur near moist areas should be closely evaluated for travel restrictions.

Moist sites are more critical during dry summers when precipitation from the previous winter and early spring (October through May) approaches 25 percent below normal. During such years, elk will benefit if land managers shift human activities and/or livestock grazing away from moist sites, particularly in areas with little moist summer range.

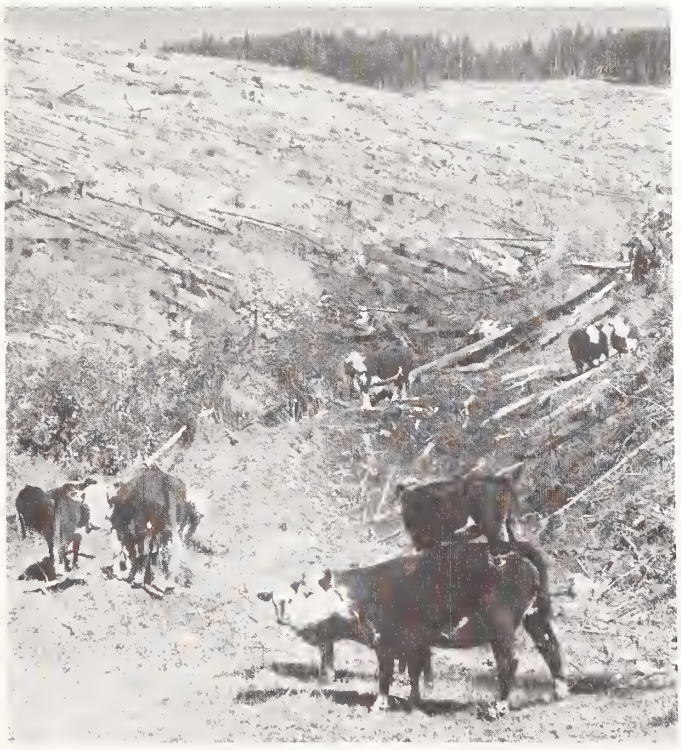
Elk/Cattle Relationships

Recommendation:

The effect of every proposed timber sale on elk and livestock management objectives should be evaluated. Allocation of area may be more practical and ecologically sound than allocation of forage. Cattle use of newly logged areas which have been previously used exclusively by elk should be discouraged.

Findings and Discussion:

The presence and distribution of domestic cattle substantially influenced the distribution of elk on the study area which had summer range cattle allotments. Systematic observation revealed a significant tendency for elk to avoid cattle. In any habitat, the probability of elk use concurrent



Cattle grazing of newly logged areas is discouraged because of potential cattle/elk interactions that would cause elk to avoid the area. *(Photo by: Danny On)*

with cattle use was about one-half the probability of elk use in the absence of cattle.

Road construction and other associated timber harvest activities occasionally "open up" new areas for grazing or alter existing cattle grazing allotments on elk summer ranges. Such activities increase the potential for elk/cattle interactions.

Winter Ranges

Recommendation:

Timbered areas adjacent to primary winter foraging areas should be managed to maintain the integrity of cover for elk. Where timber harvest is acceptable, slash cleanup and logging should be scheduled outside the winter period.

Findings and Discussion:

Elk on winter range in western Montana preferred dense timber stands and larger trees for bedding cover. Bedding sites were usually in close proximity to a feeding area such as a south-facing slope with a good stand of browse or perennial grasses. Timbered areas that received moderate to heavy elk bedding use prior to logging were not used for bedding during winters following heavy selection logging. Elimination of preferred bedding sites subjected elk to decreased energy intake and increased energy output because of increased travel between suitable bedding and feeding sites.

Winter range conditions vary greatly across Montana. To the east, elk forage on grasslands and seek cover in adjacent timber stands. Snow depths are usually low to moderate, and elk wintering in these areas may venture far from timber cover when undisturbed. When snow does get deep, elk will seek cover. Logging adjacent to grassland winter ranges will normally be detrimental to elk. Forage conditions on these ranges may be improved by range rehabilitation, grazing management, or prescribed burning.

Close proximity of forage areas to thermal cover provided by forested areas is highly desirable to reduce energy expenditures by elk in winter. *(Photo by: Terry N. Lonner)*

West of the Continental Divide, on important and already well-used browse ranges, the probability of improvement by logging is minimal. Where winter range quality is declining or is already poor, especially on shrub ranges, several management options offer possibilities for enhancing winter range. The presence of larger trees in a dense multistory stand is desirable. Where winter ranges are heavily forested and forage conditions are poor, the timber overstory can be removed in small patches to enhance forage production on south- to west-facing slopes. The design and layout of these openings should be planned so that adjacent forest cover on benches and finger ridges will provide thermal cover and bedding sites. Slash clean-up and logging should be scheduled outside the winter period.

Because of the relative importance of productive elk winter range and the narrow margin for error, any contemplated modification of timber stands should be planned on a site-by-site basis, with primary emphasis on maintaining adequate cover adjacent to productive forage areas. It is unlikely that winter ranges ever meet the nutritional needs of elk completely, so some winter weight loss will always be experienced. Elk productivity and, under severe conditions, survival will decrease as weight loss increases. Thus, conservation of stored energy as well as energy intake, is important to wintering elk.

HISTORY OF THE ELK-LOGGING STUDY

Prior to 1960, a major big game management problem in the Rocky Mountain West was the perception of game populations too large for the available winter range. Hunting seasons were long, and very often the harvest of more than one animal was allowed. Logging was usually considered beneficial when new foraging areas were created, and logging roads often provided much needed access to areas in which the big game harvest was low.

In the decade of the 1960's, however, game biologists throughout the West began to suspect possible deleterious effects related to logging activities, easy access, and loss of tree cover. Little was known of elk response to timber harvest and roads, but strong opinions had developed. From Arizona to Canada and Montana to Washington there were reports of temporary or permanent reductions of both deer and elk in newly roaded areas despite an apparent improvement in forage quantity and quality. In some cases it was indicated that animals moved to adjacent, undisturbed areas; but there were also suggestions that increased efficiency of harvest would lead to shorter seasons, a lower quality hunting experience, and even herd reductions.

While there were no immediate answers to these developing conflicts in resource management, it was widely recognized that answers were needed. In Montana, the final impetus for action was provided by a proposed timber sale on the Middle Fork of the Judith River, Lewis and Clark National Forest. The Forest Service considered this sale a necessary part of the timber management program, but biologists of the Montana Department of Fish, Wildlife and Parks (formerly the Montana Fish and Game Department) expected an extremely adverse impact on elk. Specifically, it was thought that modification of summer habitat in the Little Belt Mountains might cause a shift in elk winter concentrations from the State-owned Judith Game Range to private lands.

In March 1970, a meeting was held in Great Falls, Montana, to discuss the possible impacts of clearcutting on elk, specifically the elk herd in the Little Belt Mountains, Lewis and Clark National Forest.

As a direct result of that meeting, the Montana Cooperative Elk-Logging Study was initiated in June 1970. During the next 15 years five different government organizations and a corporate landowner cooperated in a program designed to examine the relationships between timber production and elk management in the State of Montana. As a result of that program, 50 professional and popular papers have been presented and more information about habitat requirements is available for elk than any other big game species.

More important, however, is the fact that research findings from the Montana study have been applied in management and planning even before publication was completed. Problems and conflicts still exist, but for most situations information was very quickly made available to assist man-

agers in evaluating the immediate and long-term consequences of proposed timber harvest and road construction in forested elk habitats.

Cooperative research is a common approach to the solution of problems that overlap legal jurisdictions and require more resources than are readily available to a single agency or individual. The Montana Cooperative Elk-Logging Study was unique, however, in that six different organizations were eventually involved. It was also uniquely and extraordinarily successful in analyzing a significant resource management problem, developing a comprehensive research program, conducting the necessary research, and translating results into management recommendations.

In this epitaph and summary for the Montana Cooperative Elk-Logging Study, two purposes will be served. The initial objective is to present a history and a catalog. In effect, to draw together in one place the program, plans, and results of 15 years of cooperative research. A secondary objective is to describe the organization and administration of the program. In some degree, the structure of the Montana Cooperative Study was responsible for the success of the program. Hopefully that structure and the historical record will describe the requirements for future successful studies of other resource management problems.

Organizational Meeting

On March 5, 1970, the Supervisor of the Lewis and Clark Forest sponsored a meeting to discuss both the Middle Fork sale and the possibility of developing a research program to evaluate the influence of logging on elk. In all, 28 representatives of the Montana Department of Fish, Wildlife and Parks, Region 1 and the Intermountain Forest and Range Experiment Station of the U.S. Forest Service, and the Forestry School, University of Montana, were present.

The two main decisions reached by this group were: first, that the elk-logging controversy was of general concern over a much greater area and in many other environmental situations than the Little Belt Mountains; and, second, that the agencies represented were interested in developing a cooperative research program to resolve the problem. An initial working group of three was selected to prepare a prospectus for a State-wide study and a cooperative agreement acceptable to all parties. A deadline of May 30 was specified for completion of these preliminary plans.

Prospectus

The initial draft of a "Study Prospectus for an Interagency Evaluation of the Effects of Logging on Montana Elk Populations" was circulated for review on April 7, 1970. This 32-page document presented two major objectives and outlined a literature review, four intensive field studies, two extensive field studies, and a systems analysis study. The prospectus also mentioned the "challenging problems" of coordination posed by simultaneously involving four different organizations in a cooperative research project. No organizational structure was suggested, although the prospectus

did contain the usual stipulations concerning mutual availability of data and review of manuscripts.

This proposal was available for review and comment for approximately 2 months. When the final prospectus was circulated and accepted in mid-June, the suggested research program was essentially identical to the proposal in the original document. The coordination section, however, had been modified and improved by the Montana Department of Fish, Wildlife and Parks. In the final proposal, the study was organized with a Steering Committee of agency administrators and a separate Research Committee of qualified scientists. Program review and coordination of funding were thus separated from the planning and conduct of research.

Cooperative Agreement

During this same period, some very significant coordinating discussions took place. The formal cooperative agreement was written to specify that the position of chairman for the Steering Committee would rotate annually among the cooperating agencies but the chairman of the Research Committee would be a permanent appointment. Administrators for the Intermountain Station believed that greater continuity would result if the Station filled the position of Research Committee Chairman. Administrators for the Montana Department of Fish, Wildlife and Parks, on the other hand, believed that the position would require the undivided attention of the chairman—and had allocated a full-time position within the Research Section to the cooperative study. Even in retrospect, this cannot be considered a minor point of contention. In cooperative research it is essential to recognize the importance of avoiding any perceived loss of administrative autonomy. In this situation, we were able to avoid an impasse by emphasizing that the Research Committee had no function in "directing" research. The primary functions of this committee were to mutually standardize methods and terminology so that credibility, acceptance, and interest in the research program could be maintained at a high level.

On June 29, 1970, a "Cooperative Agreement for Conducting Research on the Effects of Logging and Roads on Rocky Mountain Elk" was signed by representatives of the Montana Fish and Game Commission; the School of Forestry, University of Montana; the U.S. Forest Service, Region 1; and the U.S. Forest Service, Intermountain Forest and Range Experiment Station. Each organization was required to appoint an individual to the Steering Committee, another individual to the Research Committee, and to participate in various ways in the conduct of the cooperative effort. The Steering Committee was required to meet at least annually to review progress, determine program direction, and provide field support. The Research Committee was required to develop a comprehensive research program, prepare written study plans for all studies, conduct the field research, and prepare, annually, a report of work accomplished and a prospectus of work proposed. Chair positions on the Steering and Research Committees were filled, respectively, by the Forest Service, Region 1 representative and the representative of the Montana Department of Fish, Wildlife and Parks.

In Montana, neither elk nor logging is restricted to National Forest lands. Early in 1971 the Bureau of Land Management approached the Steering Committee with a proposal to evaluate elk response to logging in a previously undeveloped drainage in the Garnet Range northeast of Missoula. Thus, the Bureau of Land Management, through the Montana State Director, became the fifth signatory to the cooperative agreement.

Two additional amendments to the original cooperative agreement were signed. In June 1975 the agreement was extended for 5 years, and in June 1980 it was extended for an additional 5 years. No additional cooperators were added, although Plum Creek Timber Company, Inc. (formerly BN Timberlands) had a representative at all Research Committee meetings after 1973 and provided financial support after 1980. Representatives who served on the two committees are listed in table 1.

Table 1. Steering and Research Committee Members, Montana Cooperative Elk-Logging Study (* indicates chairman one or more years)[1]

Agency	Committee members
	STEERING
U.S. Forest Service Region 1	Foulger (70*), Bumstead (71-76*,77), Schneegas (78,79-81*,82-84), Holder (84)
U.S. Forest Service Intermountain Exp. Stn.	Blaisdell (70-71), Klawitter (72-77,78-79*), Harrington (79-82), Krebill (82-84)
Montana Department of Fish, Wildlife and Parks	Freeman (70-77), Allen (78-84)
Forestry School University of Montana	Wambach (70-76), Forcier (77), Pengelly (77-84)
USDI Bureau of Land Management	Lovell (70-72), McIntosh (73-75,76-77*,78-81), Hoem (82-84*)
	RESEARCH
Montana Department of Fish, Wildlife and Parks	Allen (70-77*), Janson (70-77), Lonner (73-84), Weigand (78-84)
Forestry School University of Montana	Ream (70-76), Marcum (75-84), Edge (83-84)
USDI Bureau of Land Management	Ellison (70-74), Sall (70-72,75-84), Bennett (73), Jones (77-84), McCleerey (84)
U.S. Forest Service Region 1	Schmautz (70), Pond (71-77)
U.S. Forest Service Intermountain Exp. Stn.	Lyon (70-77,78-84*), Basile (70-76)
Plum Creek Timber Company, Inc.	Betty (73-75), Wick (76-78), Hicks (79-84)

[1]Although the cooperative agreement did not terminate until 1985, all committees were disbanded when this final report was completed.

Meetings

Coordination, particularly during the early years of the cooperative study, required a substantial number of meetings. Between March and June 1970, six meetings were required to get the study going; and after the agreement was signed, an additional 22 meetings took place in 1970. Some of these (3) were meetings of the Research Committee required to coordinate studies. Of the remainder, about half were related to selection of study areas and on-the-ground coordination with Forests and Ranger Districts. At least 9-10 of these meetings, however, had as their main purpose to head off potential conflicts between agency personnel in management functions. In all probability, this situation cannot be avoided until a cooperative program begins to generate some level of confidence. Nevertheless, when it occurs it leads to dilution of research because coordination meetings divert efforts from the collection of data.

Annual steering and research committee meetings included field tours of each of the major study areas to improve understanding of study results.

(Photo by: Bureau of Land Management)

In this cooperative study, some measure of success can be suggested by the decline in the number of meetings required (table 2). After 5 years, this function finally began to stabilize, with two annual meetings of the Research and Steering Committees. One of these, usually in April, involved formal presentation of results and submission of plans and budgets. The second, usually in August, was a field meeting to familiarize all personnel with the various study areas and to receive and review the annual report.

Table 2. Activity summary, Montana Cooperative Elk-Logging Study

Year	Meetings	Professional			Graduate[1]
		Talks	Papers	Publications	
1970	28	5	—	—	
1971	21	20	3	1	
1972	18	5	—	1	
1973	20	9	9	9	Denton, Stehn
1974	10	18	—	1	Beall*, Bohne, Zahn
1975	4	8	6	2	Marcum*, Lemke
1976	4	10	2	5	
1977	2	16	1	2	
1978	3	14	1	1	Scott
1979	2	14	1	4	
1980	2	18	4	5	Hammond
1981	2	24	1	2	Lemkuhl, Lieb*, O'Neil
1982	2	33	1	3	Edge
1983	3	18	1	3	
1984	2	?	3	6	

[1]All M.S. except * = Ph.D.

Organization

The formation of a Steering Committee separate from the Research Committee provides several specific advantages to the kind of cooperative research conducted by the Montana Cooperative Elk-Logging Study. First, program direction and support are separated from the design and conduct of research; and, second, administrative and management personnel are kept constantly aware of research progress.

Separation of functions made it possible to design a comprehensive research program under which individual studies could be conducted independently by each of the cooperators. Even though the total program provided for overall continuity of design, linkage among studies did not require simultaneous progress.

The two-committee format also provided a convenient forum to present results and exchange ideas at the management, rather than research level. The Research Committee was required to provide an annual report to the Steering Committee, and this report also became a working tool for land managers. Nominally, five copies of the Annual Progress Report would have satisfied the cooperative agreement, but by printing a larger number it became possible to disseminate results and recommendations directly to users with very little delay.

Finally, the direct involvement of at least 10 different people in program function helped to assure program continuity. Over the period of 15 years, the Steering Committee changed completely (table 1), but there were always enough experienced members to assure that program direction and progress remained consistent. The Research Committee almost always included more than one representative from each cooperating agency, but

there was only one member of the 1970 committee still present at the end of the study.

In addition to the broad involvement indicated by participation lists for the Steering and Research Committees, the Montana Cooperative Elk-Logging Study accomplished a considerable research effort through graduate student projects and provided the catalyst for 10 M.S. and three Ph.D. degrees (table 2). Table 3 presents a summary of scientist/man-months for the cooperative study.

Table 3. Scientist man-months in research directed by the Montana Cooperative Elk-Logging Study

Name	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Allen	6	12	12	6						
Lonner			6	11	12	12	12	12	12	12
Janson	1	1	1	1	1	1	1	1		
Lyon	6	8	8	8	8	8	8	8	6	7
Basile	3	3	3	3						
Stickney	1	3	2							
Ream	4	4	4	3	3	2				
Marcum					6	6	12	12	12	12
Ellison		6	6	6	6					

Name	1980	1981	1982	1983	1984
Lonner	12	12	12	12	6
Lyon	7	6	6	3	3
Marcum	12	12	12	9	5
Edge				3	9

Finances

One of the charges to the Research Committee was the preparation of an annual plan of work and proposed budget for approval by the Steering Committee. These documents were very often an accountant's nightmare, particularly after the federal conversion to a fiscal year beginning in October. Nevertheless, the summary tables provide a considerable amount of information about the program (see appendix I).

Two observations seem particularly significant. First, there was little new appropriation or budget involved in the initiation of the cooperative study. In most cases, the investments shown were a part of already existing programs. Over the years, funds were reprogrammed from other functions but the initial budget for 1970-71 basically represented an efficient pooling of already existing effort.

Second, there was no attempt anywhere in the program to shift funds from the control of one agency to another. The difference may be more semantic than real, but it was also one of the major strengths of the cooperative effort. The annual plan of work specified certain jobs to be done, and

the budgets were based on agency investment in doing those jobs. In some situations it was necessary to develop separate two-agency agreements; for example, the Forest Service and the University had several cooperative agreements and the Bureau of Land Management contracted their field work to the University after 1975. Nevertheless, no agency ever lost direct control of their annual contribution to the overall program.

Studies Conducted

The overall design of the Montana Cooperative Elk-Logging Study was based on a "step-down" problem analysis in which an objective was subdivided into procedures required to reach that objective. These procedures were then restated as objectives and again subdivided into procedures. The process continued until a procedure became a viable problem for research.

The project objective for the study was very broad and inclusive:

> To determine certain ecological requirements of elk; to determine the effects of logging, roads and access on elk populations; and to provide guidelines to forest managers which will insure maximum compatibility between timber harvest practices and elk management.

Procedures required to meet this objective described five further objectives, which were designated Job I through Job V. A few of these were researchable problems, but the majority required still further breakdown into subjobs. The following listing of problems examined under the Montana Cooperative Elk-Logging Study presents the five job objectives and major sub-objectives. Study areas, methods, and investigators are discussed in greater detail in other sections of this report.

Job I — To maintain continuity and coordination in the elk-logging study

Job II.A — To determine the environmental requirements and impact of logging on an elk population in an unbroken forest type (in the Burdette Creek area) of western Montana

Job II.B — To determine the environmental requirements and impact of logging on an elk population in the scattered forest type (of the Long Tom Creek area) of southwestern Montana

Job II.C — To determine the environmental requirements and impact of additional logging on an elk population inhabiting an already partially logged area (in the Sapphire Mountains) of western Montana

Job II.D — To determine the effects of timber management practices on elk use as related to habitat relationships within a previously undisturbed summer range in (the Chamberlain Creek area) western Montana

Job III.A — To determine changes in hunter distribution, elk behavior, and harvest resulting from closure of an existing . . .

A.1...road system in the Gravelly Mountains of southwestern Montana

A.2...logging road system in the Little Belt Mountains of central Montana

Job III.B — To determine and describe elk utilization of forest cover types in areas already logged

Job IV — Prescribe and demonstrate management practices which will provide maximum improvement in the Spotted Bear elk habitat by means of timber management and harvest

Job V — Provide guidelines to forest managers which will insure maximum compatibility between timber harvest practices and elk management

Relations with Land Managers

One of the measures of success for any research program is the degree to which research findings are translated into management action. The Montana Cooperative Elk-Logging Study was especially successful in this area, largely because of almost continuous pressure applied by the Steering Committee. In the normal course of research, the scientist fully expects to collect and analyze the data, write a report, and publish. At the same time, there is always a strong reluctance to prepare a manuscript until all the facts are in.

Throughout this study, but particularly after the third field season, the Steering Committee developed a standing directive that all completed research should be generalized into management recommendations as quickly as possible. Technology transfer has generally fallen into three categories: (1) the effort aimed at promoting public awareness, (2) specific presentations for the use of land managers, and (3) scientific papers and presentations.

As already noted, the annual report of the Montana Cooperative Elk-Logging Study was primarily intended to be a report from the Research Committee to the Steering Committee. Nevertheless, 200 or more copies were printed in most years, and for a number of years the annual report was the main vehicle for transferring research information to field managers.

This was particularly true beginning with the 1974 Annual Report and running through about 1978 when the first formal "Elk-Timber Management Guidelines" were developed. The reason was that the 1974, and all subsequent issues, contained a section entitled "Elk Management Recommendations for the Consideration of Land Managers".

In 1973 the Steering Committee, instigated by Klawitter, proposed that enough research had been completed to allow the preparation of a series of preliminary recommendations concerning the relationships be-

tween elk and logging. Despite the reluctance of the research biologists, the Research Committee was directed to prepare such recommendations for distribution. The only stipulations proposed by the Steering Committee were (1) that the recommendations should be supported by research actually done within the Montana study, and (2) that all recommendations should be phrased in a positive rather than a negative sense (i.e., "this action will produce this result," rather than "don't do this").

The initial recommendations were reviewed, defended, rewritten, revised, and re-revised for more than a year; and by May 1974 a satisfactory version was completed. Then, as a final test of readability, the cooperative study sponsored a 2-day workshop for timber, range, wildlife, and engineering specialists from the Forest Service; Bureau of Land Management; Montana Department of Fish, Wildlife and Parks; and the private sector. Presentations of all available research findings were given by the Research Committee and then workshop groups critiqued each recommendation and suggested revisions.

Some relatively minor changes were made in the recommendations following this workshop. However, it should be noted that only those revisions intended to clarify recommendations were considered. The final version was then included in the Annual Reports.

In 1975 the chairman of the Research Committee attempted to organize a second workshop, on a regional rather than State-wide basis. The original idea was to find a sponsor for a workshop covering discussion and integration of elk/logging research throughout the West. The University of Idaho agreed to sponsor a workshop, but the response was so overwhelming the workshop turned into a Symposium (Elk-Logging-Roads Symposium, University of Idaho, Moscow, December 1975). This, in turn, became an outlet for several papers reporting work in Montana. In fact, 5 of the 17 papers presented in Idaho reported work done within the cooperative study.

Publicity

The numerical summary of talks given by members of the Research Committee (table 2) shows an average of about 10 presentations each year. These presentations were mostly given to sportsmen's clubs and service clubs, although the summary also includes several shows on local television. Additional contact with sportsmen was provided by a three-color fold-out brochure, which was printed in 1971 for distribution at hunter check stations.

Nationally, the Montana Cooperative Elk-Logging Study was featured on the Mutual of Omaha TV program "Wild Kingdom" in 1975. This program received much favorable comment although it is uncertain whether the benefit to the cooperative study was equivalent to the problems of filming the program.

Locally, the Steering Committee requested, with some regularity, preparation of "news release" items by members of the Research Committee. This is one area in which the cooperative study did not particularly

succeed. Considering the amount of effort required to produce them, the "news releases" were not often treated as news—possibly because they were not. On the other hand, the cooperative study suffered through a number of instances in which a newspaper reporter managed to create a controversy by misquoting or quoting out of context. Unfortunately, there appears to be no good technique for preventing this sort of thing.

Finally, the Steering Committee directed, almost annually, that the Research Committee prepare a slide series describing the cooperative study. For a number of years the Research Committee proved just as adroit at dodging this assignment as the Steering Committee was at issuing it. In the period 1972-74, the main purpose of the slide series appeared to be generation of publicity for the program. Several slide collections were, in fact, assembled, but each time a script was proposed some new development in the research made the script obsolete.

By 1974, the objective had shifted to the production of a slide series that would be useful in explaining and promoting the recommendations made that year. Again, the slides were assembled and several different approaches to preparing a script were tested. This time, the problem revolved around developing some basic theme that would hold the whole production together. It could be that because the recommendations were well accepted almost immediately, there was little real incentive to make the slide series work. In any case, nothing was accomplished for 4 more years.

By 1978, at least three locally applicable versions of elk/timber management guidelines had been developed for Montana and north Idaho. These guidelines, following the general format suggested by Thomas et al. (1976) also provided the necessary framework for a slide series on the Montana Cooperative Elk-Logging Study. Five copies, 66 slides and script, were produced in 1978. Reception was generally favorable although the agencies concerned with management were far more enthusiastic than those concerned with research and teaching.

In 1979, Region 1 of the Forest Service had this slide series professionally reproduced as a slide/tape with music and sound effects. A total of 40 copies was produced and distributed. And, interestingly, this series appears to satisfy both public awareness and technology transfer to managers.

Publications

The reference list for the Montana Cooperative Elk-Logging Study includes 24 professional papers (journals, proceedings, transactions, research papers available at most major libraries), 26 papers of more local distribution, and 13 theses (3 Ph.D., 10 M.S.). Additional papers are in preparation. The cooperative study also produced an explanatory brochure (1971), was featured on Mutual of Omaha's Wild Kingdom (1975), developed a slide/tape series on the Recommendations (1980), and has maintained a computer-based bibliography of references applicable to elk and land management. The study was also included in a film produced by Plum Creek Timber Company, Inc. in 1984.

Study Areas

Elk are found in many different forested habitats. Selection of areas for both intensive and extensive study was intended to provide samples from a variety of types. Research ranged from 12 years to a single season on the various study areas. In some situations, several investigators completed simultaneous studies on the same area. The following section provides a brief overview and description for each of the study areas selected and the kinds of data collected. Locations of study areas are indicated on figure 2.

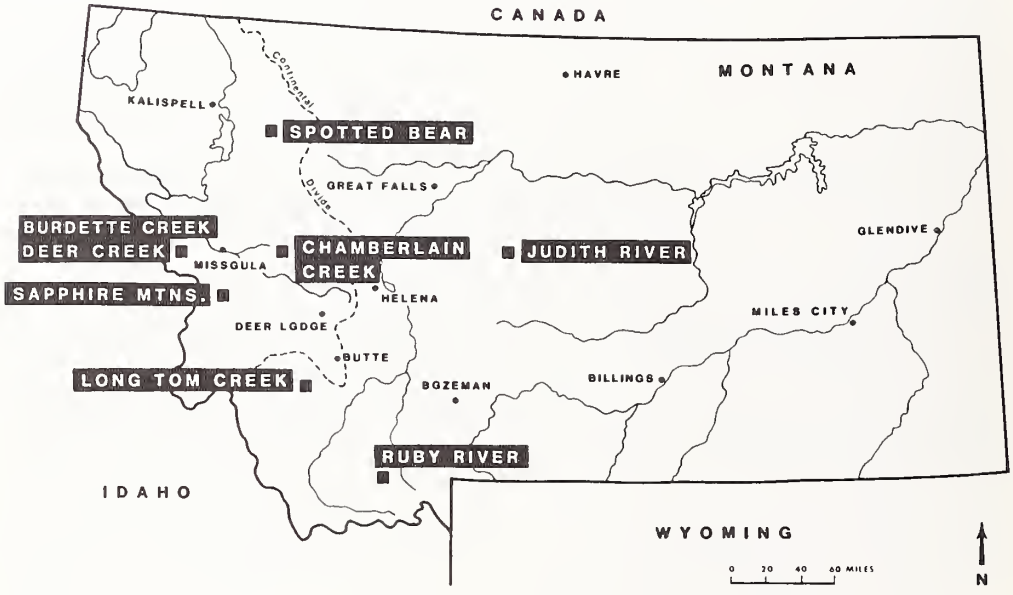


Figure 2. Locations of the seven major elk-logging study areas in Montana.

Burdette Creek-Deer Creek

Area: Burdette Creek-Deer Creek, 25 miles west of Missoula; 80 mi² core area, 200 mi² peripheral

Investigators: Lyon, Janson, Bohne, Zahn, Lemke

Data: Pellet-group distributions
Radio tracking
Observations of unmarked animals
Checking stations during the hunting season
Traffic counts on forest roads

Years: 1970-1977

Characteristics: The Burdette Creek-Deer Creek area of the Lolo National Forest was selected as representative of the drier phases of the more or less continuous forest cover in many areas of western Montana. The area is characterized by steep topography, with Douglas-fir and lodgepole pine forests on north and east aspects, and Douglas-fir or ponderosa pine on south and west aspects. Some natural openings on south aspects are present as the result of old burns, but the majority of openings in this kind of elk habitat are likely to be man-made.

The Deer Creek study area included previous clear-cut and roaded areas.
(Photo by: Terry N. Lonner)

This study area also included the 1910 burn area along the Wagon Mountain Road.
(Photo by: L. Jack Lyon)

Long Tom Creek

Area: Long Tom Creek, 25 miles southwest of Butte; 47 mi^2 core area, 500 mi^2 peripheral

Investigators: Allen, Lonner, Hammond

Data: Pellet-group and "elk sign" distributions
Radio tracking
Observations of unmarked animals
Time lapse photography
Vegetation plots and transects
Checking stations during the hunting season

Years: 1972-1981

Characteristics: The Long Tom Creek area on the Beaverhead National Forest was selected as representative of a more open elk habitat common in many areas of central Montana. This area is characterized by a mixture of open dry meadows, wet meadows, and patches of heavy timber cover interspersed with areas of open forest. Lodgepole pine, subalpine fir, Engelmann spruce, and whitebark pine are the main conifer species, although some Douglas-fir is found at lower elevations. The majority of openings in these habitats are natural, and any man-made openings generally lead to a reduction in available cover.

The Long Tom Creek study area, east of the Continental Divide, where large numbers of wet and dry parks interspersed with forest were heavily used by elk.

(Photo by: Terry N. Lonner)

Sapphire Mountains

Area: Sapphire Mountains, 25 miles southeast of Missoula; 76 mi^2

Investigators: Ream, Beall, Denton, Marcum, Stehn

Data: Radio tracking
Observations of marked and unmarked elk
Winter backtracking
Pellet-group distributions
Checking stations during the hunting season

Years: 1969-1976

Characteristics: The Sapphire Mountains in the Bitterroot National Forest provide a full range of habitats from the grassland winter ranges on the lower west slopes to higher elevation lodgepole pine stands along the crest of the mountain range. This study area, by contrast with the Burdette, Long Tom, and Chamberlain Creek areas, had a long history of timber harvest with a well established pattern of roads and cutting units already existing. Ponderosa pine forests at lower elevations are replaced by Douglas-fir on mid-slopes and subalpine fir types at higher elevations.

The Sapphire study area, west of the Continental Divide, where remaining forested areas were intensively used by elk. *(Photo by: C. Les Marcum)*

Chamberlain Creek

Area: Chamberlain Creek, 35 miles east of Missoula; 9 mi^2 core area, 70 mi^2 peripheral

Investigators: Ellison, Marcum, Scott, Lieb, Lemkuhl, Edge

Data: Radio tracking, in part with activity collars
Pellet-group distributions
Checking station hunter survey

Years: 1971-1983

Characteristics: The Chamberlain Creek drainage is located in the BLM Garnet Resource Area. The core area is representative of some of the more mesic elk habitats in western Montana. The core area was heavily forested, unroaded, and contained lodgepole pine, subalpine fir, and Douglas-fir cover types. The peripheral area is drier; vegetation ranges from pasture-hayfields at lower elevations to ponderosa pine, Douglas-fir/larch, and lodgepole pine types which have been extensively logged.

The Chamberlain Creek study area was representative of some of the more mesic elk habitat west of the Continental Divide. *(Photo by: W. Daniel Edge)*

Ruby River and Judith River

Area: Ruby River, 40 miles southeast of Dillon; 112 mi^2
Judith River, 24 miles northeast of White Sulphur Springs; 268 mi^2

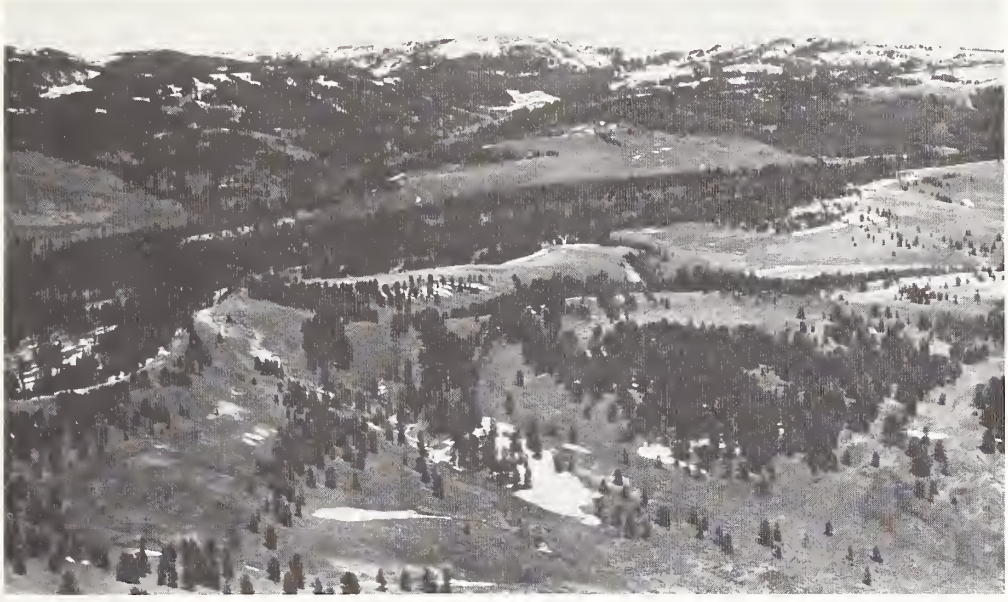
Investigators: Allen, Lonner, Basile

Data: Hunter interviews at checking stations
Radio tracking

Years: 1970-1973

Characteristics: The Ruby River drainage on the Beaverhead National Forest and the Judith River on the Lewis and Clark were selected to represent two extremes of habitat commonly encountered by elk

hunters in Montana. The Ruby is characterized by gently rolling topography and scattered stands of timber in an area largely dominated by open grassland. The Judith has much the same rolling topography, somewhat interspersed by steeply cut watercourses, and is dominated by nearly continuous stands of mostly lodgepole pine forest. In both areas, well-developed road systems provided ready access to almost the total area. The Judith roads were mostly developed as a result of logging operations; the Ruby roads were primarily created by livestock operators and hunters.



Roads on the Ruby River study area were established primarily by livestock operators and hunters. *(Photo by: Terry N. Lonner)*

Timber harvesting (clearcuts) provided a majority of the openings and roads on the Judith River Study area. *(Photo by: Montana Department of Fish, Wildlife and Parks)*

Statewide Clearcuts

Area: State-wide, 87 different clearcuts of various ages on elk summer range

Investigator: Lyon

Data: Pellet-group distributions

Years: 1973 (western Montana)
1975 (central Montana)

Characteristics: Sample areas for the study of clearcuts were confined to elk summer ranges, but were scattered throughout both the heavily timbered areas of western Montana (49 cutting units) and the more open timber types of central Montana (38 units).

Elk use of various age clearcuts on summer ranges were evaluated at 87 different sites.
(Photo by: L. Jack Lyon)

Spotted Bear

Area: Spotted Bear elk winter range, 35 miles southeast of Hungry Horse; 8 mi^2

Investigators: Lyon, Allen, Baglien, Biggins

Data: Vegetation survey in conjunction with Stage II Recommendations by the Research Committee

Years: 1975

Characteristics: The Spotted Bear winter range on the Flathead National Forest was selected as a first opportunity to evaluate and practice some of the early recommendations of the cooperative study in an on-the-ground operation. The Spotted Bear Ranger District, in cooperation with the Research Committee, evaluated all timber stands within the proposed cutting area for potential in improving winter range characteristics, and the final timber sale plan was primarily designed to improve forage and cover characteristics of the area.

Evaluation Areas

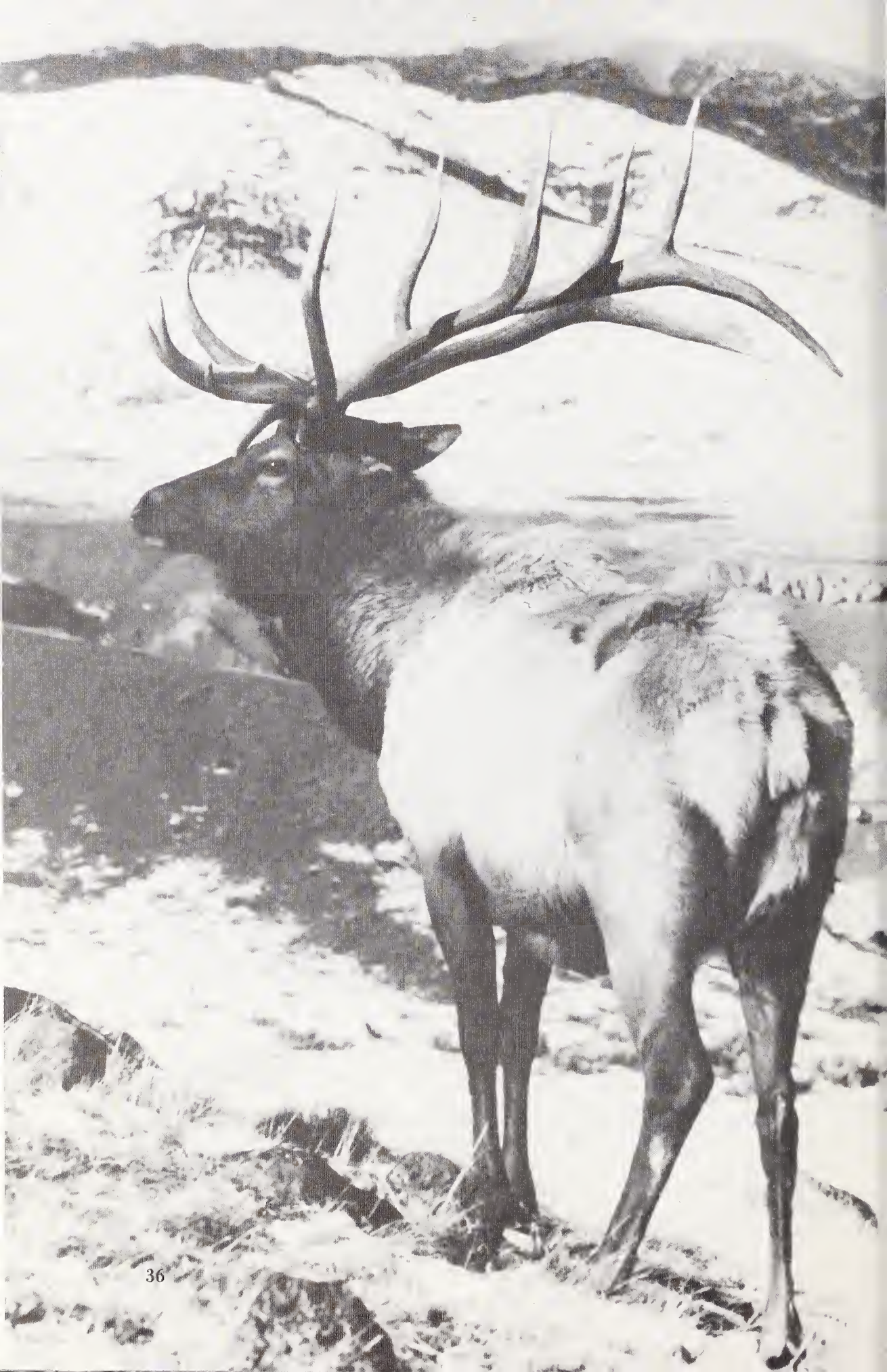
Area: Eight areas in Montana and three in north Idaho. Average up to 25 mi^2 divided into 3-4 subunits

Investigators: Lyon, O'Neil, Young

Data: Pellet-group distributions

Years: 1980-1981

Characteristics: Eleven different study areas in Montana and north Idaho were selected for evaluation of cover/forage and road-density relationships as they influence habitat use by elk. Habitats ranged from the open lodgepole pine types of central Montana, to primarily Douglas-fir types in western Montana, to the more mesic cedar and white pine types of north Idaho.



RESULTS

Results of the various studies conducted within the Montana Cooperative Elk-Logging Study have been consolidated in a series of recommendations and management guidelines. These are summarized in the following modification of a paper presented to the North American Wildlife and Natural Resources Conference by Lyon (1980).

Results from all of the studies relied on at least one, and more often a combination of techniques: radio-tracking, aerial and ground observations of marked and unmarked elk, pellet group distributions, elk tracks and other sign, checking stations during hunting seasons, traffic counters on forest roads, periodic measurements on vegetation plots and transects, and time lapse photography.

A variety of field procedures, including radio telemetry and observations of unmarked elk, were used extensively in determining elk responses to logging and roads.
(Photo by: Terry N. Lonner)

Timber Harvest and Road Construction

The immediate responses of elk to disturbances associated with timber harvesting were investigated in five different studies. By varying study designs, it was possible to assess the separate effects of road construction, logging, and recreational traffic during the timber sale period. In all studies, elk either avoided the area of activity (Ream 1973; Marcum 1975; Lyon 1975, 1979b; Lemkuhl 1981; Lonner IP) or moved away from the disturbance (Beall 1974; Lieb 1981; Edge 1982).

Logging activities resulted in temporary displacement of elk; therefore, short logging periods are preferred to lengthy periods. *(Photo by: W. Daniel Edge)*

Measured displacements ranged up to 5 miles, with the greatest movement detected when heavy equipment on a ridgeline between Deer Creek and Burdette Creek was visible over a large area (Lyon 1979b). Most often, the distances elk moved appeared to be the minimum necessary to avoid visual contact with men and equipment. Individual animals, however, demonstrated a considerable tolerance toward logging activities, and ". . . in no case did a disturbance result in complete abandonment of a subunit . . ." (Lyon 1979b:11). In timber sale areas where traffic was limited to logging equipment, Lonner (IP) detected very little response beyond a mile. Edge (1982) found displacement to two-thirds of a mile, while Lieb (1981) found average displacement of 0.9 mile.

Displacement response also appeared to vary seasonally and in relation to topographic differences near logging areas. In the Long Tom Creek area, displacement was least in July and greatest during the fall (Lonner IP). Movement distances during winter logging on the Sapphire Mountain winter range were somewhat restricted by snow depths and topography, while movements were not restricted on the Sapphire summer range (Marcum 1975).

Patterns of return movement to logged areas further confirmed the variability of the response and the temporary nature of the displacement. Beall (1974) reported elk moving back to a logged area on the Sapphire Mountain winter range within 2 days after logging ended. He also detected several animals drifting back to a cutting area while logging was still in progress. Edge (1982) reported a tendency for elk in Chamberlain Creek to return to areas close to logging units during weekend shutdown. The more common sequence on summer range, however, was that elk did not return

until the disturbance ended and men and equipment were removed (Marcum 1975; Lyon 1979b; Lonner IP). Lonner found that elk use of Long Tom Creek in the postlogging phase was similar to prelogging use. Lyon noted, however, that full recovery to prelogging use in Deer Creek was delayed when roads remained open and planting and burning crews were active. Based on a comparison of five different timber sales in the Burdette Creek-Deer Creek area, Lyon concluded that continuing sporadic disturbance in a sale area could eventually condition elk to avoid logged areas for one or more years after all activity ended.

Postlogging activities, like piling and burning slash, extends the time logged areas are not used by elk. *(Photo by: W. Daniel Edge)*

Although these results suggest that displacement of elk during road construction and logging is temporary, there are some hidden costs. Allen (1977) pointed out that displacement means a reduction in usable habitat and an increase in stress. Permanent displacement would be detrimental. The manager, however, has a number of alternatives that can help reduce the distance moved and the total time of displacement. We recommend providing undisturbed security areas adjacent to the area of activity, concentrating management activity into the shortest possible time, and confining disturbance to the smallest area possible within a single drainage.

Road Design, Road Management and Area Closures

After roads were constructed for timber harvest or other purposes, subsequent management of those roads proved to be extremely important to elk. We completed two specific studies of road closure during the hunting season, an indirect evaluation of hunter attitudes concerning roads, and

other studies in which roads proved to have significant influence on elk use of available habitat.

Travel restrictions during the hunting season were evaluated in simultaneous studies on two different areas. Initially, elk and hunter distributions were determined during 2 years of unrestricted vehicle use. Many roads were then closed and off-road vehicle travel was restricted for 2 years. The effects of these restrictions provided a strong contrast between situations with different forest cover conditions (Basile and Lonner 1979). The Judith River area is two-thirds forested while the Ruby River area is nearly two-thirds open grasslands and sagebrush. In the Judith, travel restrictions resulted in increased hunting pressure, more foot travel, and more elk seen and killed per hunter. But, elk did not leave the study area in appreciable numbers and elk distribution reported by hunters was little affected by the closure. In the Ruby, travel restrictions produced more foot travel by hunters, but hunting pressure and numbers of elk seen and killed per hunter declined in the restricted area. Most important, however, "With travel restrictions in force, elk no longer left the Ruby area en masse for other areas . . ." (Basile and Lonner 1979:159), and the elk harvest became more uniform over the course of the hunting season. Under some circumstances, a uniform harvest rate can be considered indicative of good habitat security, and good security, in turn, of low bull turnover rates which are usually considered desirable (Lonner and Cada 1982).

Imposed travel restrictions were apparently well accepted in all areas where hunters were contacted. Stankey et al. (1973) found that successful elk hunters in the Sapphire Mountain area rarely hunted from roads and considered excessive road development to be undesirable. Initially, some hunters objected to a road closure in the Chamberlain Creek study area. They thought elk would be too far from the closure points to hunt if the roads were closed. After the closure was established, elk were found in areas they had not used when roads were open. The redistribution of elk in relation to open roads was rapidly detected by experienced hunters (Marcum 1980). Basile and Lonner (1979:159) reported unsolicited hunter opinions of the Judith and Ruby closures ". . . were to the effect that the experience had been enhanced." They also noted, however, that the restrictions may have attracted hunters already favorable toward closures. Some of their data for the Ruby area suggest that closures may simply transfer hunting pressure to unrestricted areas.

In studies not limited to the hunting season, elk demonstrated an avoidance response wherever roads remained open to vehicle traffic. Marcum (1975) reported elk in the Sapphire Mountain area avoiding system roads and the area within 550 yards. In Burdette Creek-Deer Creek, Lyon (1979a) found elk use within 0.1 mile of open roads reduced by 60-80 percent, with depressed use extending to more than a mile in some cases. This avoidance response has been detected on most North American elk ranges (Lyon 1983).

The degree to which any specific road may reduce elk use of adjacent habitat varies by season and according to the size and the location of the road, amount of traffic, and cover availability. In the Sapphire Mountains, open spur roads and jeep trails with little traffic were not avoided except

during the hunting seasons. Elk favored roads closed to vehicle traffic (Marcum 1975). Edge (1982) reported that closed and lightly traveled roads were not avoided in Chamberlain Creek. Roads in the Burdette Creek-Deer Creek area were 2 to 3 times as disruptive for elk feeding in openings as for elk located in any kind of tree cover (Lyon 1979a). And in central Montana, roads passing through clearcuts depressed elk use of the openings by up to 90 percent (Lyon and Jensen 1980). Seasonally, Marcum (1975) found that elk were more tolerant of roads in June and July, increasingly intolerant through August to October, and more tolerant again in November. Similarly, Lemkuhl (1981) and Lonner (IP) found that elk avoided roads during the rutting and hunting seasons but not during the calving and summer seasons. Throughout most of the year, however, vehicle traffic on forest roads measurably reduced habitat effectiveness for elk.

Elk tend to avoid logged areas where roads remain open to vehicle traffic by the general public. *(Photo by: Terry N. Lonner)*

One additional phenomenon, potentially related to roads, was not originally programmed as a part of this research. Allen (1973a) and Lonner and Mackie (1983) repeatedly detected a strong negative response by elk in the Long Tom Creek area when cattle appeared on summer range. In situations where the construction of new roads makes a previously inaccessible range available to cattle, habitat effectiveness for elk may be seriously impaired.

Unlike the temporary displacement of elk by logging activity, displacement by roads is likely to be continuous as long as the roads are open to vehicle traffic. Permanent closures or gates provide one method of reducing this habitat loss, but other alternatives are available. For instance, displacement can also be reduced through road designs based on low-standard, single-track construction and through road locations that do not im-

pede elk movement. Preferred locations avoid existing game trails or movement routes. Preferred roads have frequent dense cover patches and no windrowed slash.

Road management can be used to control or enhance hunter access, to significantly modify the perceived quality of the hunting experience, and to increase or decrease effective utilization of available habitat by elk. Although closures are a powerful management tool, they will not completely compensate for losses of security cover, especially during the hunting season. We recommend that all road closures be based on clearly defined management goals.

Elk Behavior and Habitat Requirements

Throughout 15 years of cooperative research, we have been increasingly impressed with the behavioral adaptations exhibited by elk in various Montana forest habitats. Most studies included a provision for detecting habitat preferences—the assumption being that preferences can be interpreted as a demonstration of requirements. Many analyses, however, confirmed Allen's (1977) contention that a new perspective in habitat management is needed—one that includes information about elk behavior within the existing physical environment.

Data from several study areas (Marcum 1975, 1976; Lonner 1976a; Lyon 1979b) confirm Scott's (1978:53) observation that all available habitats are used at one time or another, but that elk ". . . become much more selective during periods of stress." Further, some habitat components ". . . which receive little regular use may be critically important . . . during brief periods" (Marcum 1975:129). In short, while selective use of one habitat component may, indeed, demonstrate a habitat requirement for elk, the same requirement is sometimes satisfied elsewhere by different behavior within existing habitat components. In preparing the following summary of study results, the word "cover" was judged extremely inconvenient as a descriptor of elk requirements. Security, shelter, food, and water proved to be more useful for categorizing the apparent needs indicated by elk. In addition, traditional behavior has been recognized as a major factor in determining distribution, movement, and habitat selection (Lonner IP; Edge et al. IP).

Security

Although "security" has not been defined, other than freedom from disturbance, most studies indicate that full utilization of available elk habitat does not occur where security is inadequate. The influences of timber harvesting and roads have already been mentioned as disruptive of habitat use. In a different context, both Beall (1974) and Lyon (1976) found that elk use of logged areas was depressed where slash restricted elk movement. Lyon and Jensen (1980) also noted that elk use of clearcuts is greatest for smaller openings, for openings with good cover at the edge or internally, and for openings where roads are closed. During the hunting season, several investigators recorded increased elk use of dense tree cover (Bohne 1974; Marcum 1975; Allen 1977; Lyon 1979b; Lemkuhl 1981; Lieb 1981; Lonner IP) and movement to less accessible areas.

Evaluation of the security requirement is essentially subjective because there were no studies in which elk were unable to leave areas considered inadequate. Nevertheless, recorded movement does suggest less than potential utilization of favored habitats and concurrent crowding in less desirable situations. "Security is important to elk year around, . . ." (Allen 1977:200) and should be one of the basic considerations in elk habitat management. Hiding cover alone, however, is not necessarily secure, and several investigators (Allen 1977; Basile and Lonner 1979; Edge 1982) concluded that both topography and size of undisturbed area can contribute to increased security.

Shelter

As used here, the requirement for shelter is indicated by elk response to changing weather conditions. Daily movement and seasonal habitat selection patterns on most study areas demonstrated few situations in which habitat selection by elk was not oriented to the weather. Beall (1973) reported that elk on winter range continuously seek the most moderate area they can find and proposed that "other welfare factors are secondary to ambient meteorological conditions, as influences on habitat selection and use" (Beall 1974:2). Similarly, on summer range, Lyon (1979b:10) concluded that "maintenance of body temperature at some relatively constant level may be comparable to feeding as a daily preoccupation for elk." In fact, Lieb (1981) found that "elk shifted the timing of feeding bouts in response to changes in ambient air temperatures."

Evidence of the importance of energy conservation on winter ranges is provided primarily by Beall's work (1973, 1974, 1976) on the Sapphire Mountain area. In both the Sapphires and the Burdette Creek-Deer Creek areas (Bohne 1974), the first heavy snowfall resulted in elk movement to open slopes and lower elevations. Beall (1974) proposed that elk winter range may be limited as much by the energy expenditure required in deep snow as by available forage.

In winter, elk move between foraging and shelter areas for bedding sites, in response to changing ambient temperatures, increasing snow depths and to enhance control of body heat. *(Photo by: John P. Weigand)*

Once elk reached the winter range, they sought dense timber clumps on the upper third of slopes for bedding (Beall 1974) and then selected bedding areas as a direct response to ambient air temperatures (Beall 1976). These selections were so specific to ambient conditions that the location of bedding areas on north or south aspects and even the north or south side of timber clumps could be predicted. Specific bedding sites were usually located beneath the largest available tree (Beall 1974). In all situations on winter range, Beall (1976:97) found that elk "react to changing ambient air temperature . . . by selecting bedding sites which enhance control of body temperature"—even if this selection requires abandonment of areas with the best forage.

Site and cover selections during the summer provided similar evidence of strong response by elk to ambient conditions. The often noted preference for moist areas (Allen 1973a; Lonner 1976a; Marcum 1976; Scott 1978) is partially related to forage productivity, but several observers report a preference for cool northerly aspects in warm weather (Marcum 1975; Scott 1978; Lyon 1979b; Lonner IP), and Stehn (1973) found radio-marked elk in the Sapphire Mountains at consistently higher elevations at midday than at daybreak. Lieb (1981) found that heart rate varied seasonally and correlated well with ambient temperatures. In all cases, the recorded responses are consistent with a continuous active search for moderation of body temperature. Both topography and tree cover are utilized year around in this search for moderate conditions.

Food

Selection of habitats for forage alone was a far less specific requirement of elk than selections for shelter and security. Phenological variations and the relative omnipresence of forage made this component of habitat very difficult to define. And, since interrelationships between food and cover are dynamic and time dependent, no one component or combination could be singled out as critical year-round. The most specific relationships identified were seasonal feeding site selections.

Open timber types provide significant feeding sites for elk from early summer through fall. *(Photo by: Terry N. Lonner)*

Feeding activity in spring through midsummer usually occurred in more open timber types and meadows (Allen 1973a; Marcum 1975; Lonner IP). In one study area, the nutritional quality of both forbs and graminoids was at a seasonal high during early summer (Hammond 1980). Moist sites or wet meadows were used extensively by elk during summer months (Marcum 1975; Lonner 1976a). Good nutritional quality, high forage production, high security, adequate thermal cover, and a diverse species composition all contributed to the importance of this type to elk on summer range.

Other cover types were also found to be important to elk during the summer months, but with considerable variation among study areas. Scott (1978) found that north-aspect clearcuts in Chamberlain Creek were heavily utilized by elk. In contrast, in the Sapphire Mountains, Stehn (1973) used 24-hour ground tracking to record only 6 of 408 elk locations in clearcuts. In this same area, Marcum (1975) found that aerially monitored elk were completely avoiding clearcuts and treeless openings. Observations from Long Tom Creek showed that elk avoided new clearcuts almost entirely but used older clearcuts after herbaceous vegetation had become established (Lonner IP). Hammond (1980) asserted that, "although cut-through wet meadows were similar in most qualitative and quantitative parameters to uncut wet meadows, the reduction in security and thermal cover resulting from clearcutting may reduce the attractiveness of these sites to elk."

Security, in the form of timber, seemed to play an important role in selection of foraging sites by elk during the spring through midsummer months, but appeared to play an even more important role during the late summer and fall. Lyon and Jensen (1980) found that pellet-group densities averaged 37 percent lower in clearcuts than in the adjacent uncut forest, and Lonner (IP) reported negligible fall elk use of recent clearcuts.

Elk use of dense timber stands increased during late summer and fall in response to the rut and hunting season. *(Photo by: Terry N. Lonner)*

Results from the Long Tom Creek study (Lonner IP) showed late summer-fall elk use increasing significantly on sites where timber stands were dense. Although increased elk use of these sites was largely related to the rut and hunting season, it may also have been linked to forage conditions. Hammond (1980) found that the delayed phenological development of forbs and grasses during late summer and early fall made timbered sites attractive. He suggested that, "the highly nutritious but lower quantity of herbaceous forage on forested types . . . would enable elk to sustain a high quality diet into the fall. Moreover, forested types provide security cover during the rut and the fall hunting season."

Although openings in forested areas usually provide more and better forage for wildlife, these findings emphasize the importance of adjacent cover in determining forage availability. Allen (1971a:5) suggested that "pattern and juxtaposition of cutting units may be more important than... quantity" and Marcum (1979:60) pointed out that elk in the Sapphire Mountains can apparently "obtain the . . . forage they need . . . in the absence of . . . seral openings on the summer range." Thus, while clearcuts often increase forage production, demonstration of either beneficial or harmful effects of logging and clearcuts on elk populations requires a far more complex evaluation than forage production estimates (Lyon 1976; Marcum 1976; Lonner IP).

Water

Elk preference for cool, moist habitats has been detected on most study areas (Allen 1973a; Marcum 1975; Lonner 1976a; Scott 1978; Lyon 1979b). Marcum (1975) detected a preference for areas within 350 yards of water, and Allen (1973a) reported elk bedding in 4 to 6 inches of water. The preference for such areas was especially apparent during hot, dry years (Lyon 1979b; Marcum and Scott IP). Scott (1978) found that areas greater than 450 yards from water were avoided, but he also noted that 90 percent of the Chamberlain Creek area is within a quarter-mile of standing water.

Because moist areas provide opportunities for regulation of body temperature as well as lush forage, the role of surface water in elk habitat has not been particularly clear. Commonly, on productive elk ranges in Montana, surface water is readily available to elk as long as security is adequate. Even though the specific relationships between elk and moist areas have not been identified, it seems certain that the integrity of such areas in elk habitat should be maintained.

Of the four habitat requirements identified, security and shelter appear to be the more basic—but all are inseparable. Productive forage areas and moist sites can be selectively protected to enhance elk habitat, but such areas may be only marginally available to elk where poor cover interspersion, high road densities, or untreated slash reduce accessibility. We recommend selective protection of certain habitat types and moist areas on summer ranges, slash disposal on clearcuts, road management, and protection of thermal cover on winter ranges. More important than individual recommendations, however, is the concept that *productive elk habitat can-*

not be evaluated in separate parts. During any season it is important that all recognized components of elk habitat be considered simultaneously.

Integrated Evaluation

Several procedures have been developed by management biologists for quantifying the applied effects of elk habitat/timber management recommendations. Among the most widely used evaluation procedures are those that express habitat quality through a comparison of cover and forage relationships over fairly large areas. A model of this type must necessarily assume that site-specific recommendations, such as road design, protection of moist areas, and slash disposal have been properly applied and that habitat quality can be expressed at some higher level of habitat integration.

While it was not possible to evaluate all the available localized prescriptions, a composite elk-habitat/timber-coordination model utilizing several different cover/forage functions and road density models was field tested during the summers of 1980 and 1981 (O'Neil 1981; Lyon 1984). On 11 study areas in Montana and northern Idaho, we compared habitat utilization by elk, as predicted in the model, to actual utilization as demonstrated by pellet-group densities on the ground. Unequivocal evaluation of cover/forage relationships was somewhat limited because the study areas selected all had productive elk populations. The relatively narrow range of cover forage values tested all indicated high habitat quality. In this situation the research proved to be a powerful test of road density models; and within the range of cover/forage values tested, the better road density models predicted over 50 percent of the variation in habitat selection by elk.

Coordination with Timber Management

One problem for any research organization is transfer of results to management action. The Montana Cooperative Elk-Logging Study was assisted in this area by the continuing efforts of many biologists not involved directly in the research. When Black et al. (1976) and Thomas et al. (1976) described elk management guidelines for the Blue Mountains of Oregon and Washington, they provided a format for locally applicable management guidelines throughout the West. Instead of waiting until the research was done and publications were out, management biologists in many different areas have worked as teams to integrate and utilize available information as quickly as possible. Representatives of the USDA Forest Service, USDI Bureau of Land Management and Fish and Wildlife Service, State game departments, universities, and private timber companies have cooperated in writing such guidelines. Between 1976 and 1984, one or more versions and revisions of general coordinating guidelines were developed for the Eastside Forests and Central Zone in Montana, and for northern and central Idaho. Specific guidelines were prepared for the Bitterroot, Kootenai, and Bridger-Teton and many other National Forests. In most guides, elk management/timber management coordination was the

primary consideration, but some also treated specific local problems, such as long migration routes between summer and winter ranges, special protection for known concentration areas or specialized habitats.

The major strength of this localized interagency approach to management planning is that results from many different studies of elk can be integrated with local knowledge of habitats and elk behavior. Research in Montana is generally confirmed by other studies in North America, but local guidelines represent a further level of precision and a potential for managers to recognize the importance of elk behavior in relation to local environmental conditions. Almost without exception, prescriptions for maintaining productive elk habitat now include both the physical components (thermal cover, hiding cover, foraging areas) and some components related to elk behavior within the physical environment (cover interspersion, road density, livestock management, and traditional use). Many prescriptions also recognize the influence of habitat change on recreational hunting, with the result that land managers and game managers are working together to integrate hunting seasons and harvest goals. Strong cooperative relationships between informed and involved agencies and landowners are essential where maintenance of elk populations is a management objective.

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APPENDIX I

Annual[1] Budget Summaries for the Montana Cooperative Elk-Logging Study

Fiscal year	Job								
	I	IIA	IIB	IIC	IID	III	IV	V	Total
	thousands of dollars								
1971	No formal budget prepared. Similar to FY 1972.								
1972	10.5	19.9	14.1	39.5	12.2	11.7			107.9
1973	14.1	18.6	35.8	32.4	18.3	15.3			134.5
1974	14.1	15.0	26.8	30.6	15.3	26.9			128.7
1975	11.0	10.7	31.5	17.6	7.1	14.0	21.5		113.4
1976	12.9	7.5	30.9	18.5	27.3	14.8	9.6		121.5
1977	12.4	9.3	35.7	3.3	66.7	1.0			128.4
1978	10.2	5.5	40.3	.5	52.1	.7			109.3
1979	7.7	4.0	40.5		63.8	.2			116.2
1980	7.1	2.0	46.5		63.8	.5			119.9
1981	8.1	1.0	55.5		73.0			11.0	148.6
1982	11.0	1.0	50.1		78.0			8.0	148.1
1983	7.1	.5	41.0		89.0			1.0	138.6
1984	2.0		21.8		74.0			.5	98.3

Fiscal year	Organization					
	FWP	INT	R-1	UM	BLM	BN
	thousands of dollars					
1972	36.7	26.0	17.3	15.9	12.0	
1973	46.0	31.4	21.0	18.1	18.0	
1974	44.8	31.4	21.0	16.5	15.0	
1975	49.1	29.4	15.8	11.5	7.6	
1976	46.4	15.9	18.4	12.8	28.0	
1977	42.6	7.4	8.8	25.3	44.4	
1978	45.3	5.9	4.0	20.2	34.0	
1979	45.0	5.3	1.0	27.0	37.9	
1980	48.5	5.0	1.0	19.6	44.0	1.8
1981	58.5	11.5	4.0	20.0	51.3	3.3
1982	56.1	8.5	4.0	21.5	54.8	3.3
1983	44.0	3.0	1.0	24.5	62.8	3.3
1984	22.4	.9	.2	35.2	35.4	4.2

[1]Fiscal year. After 1976 the federal and state fiscal years do not coincide.