Elk management strategies for sustainable beef cattle enterprises
by Wendy Lea Fuller

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Science
Montana State University


Abstract:
Two computer models and five ranches in western Montana were used to determine the effects wild elk herds utilizing private ranges have on a ranch's available AUM, potential cow herd size, gross margin, and cost of production ($/kg sold). An elk energy metabolism model was developed to mimic forage intake dependent on the animals age, sex, and physiological state, as well as quality of forage, and relate intake to a standard animal unit (AU= 360 kg DM/mo). A beef cow-calf model simulated the performance of the five ranches as they were currently managed with elk present and were simulated again with elk "removed" to quantify the impact of elk on private ranges. A11 ranches significantly ($p<01$) increased cattle herd size, gross margin ($p<01$), and available AUM ($p<01$) when all elk were removed from range; however, none were able to significantly change cost of production. Three alternative elk management strategies: block management, exchange of forage use, and outfitting, were evaluated for their potential to reduce numbers of elk utilizing ranches and recover costs associated with elk. Block management scenarios were simulated with the assumption that more efficient hunting through the program would reduce elk herds by 10,20, and 30%, with ranchers having the potential to earn up to $8,000. Exchange of forage use such as at Wall Creek wildlife management area was evaluated as a method of reducing impact of elk on private lands. Using the fair market value of an AUM ($15 + 3.00), some ranchers would be monetarily ahead accepting cash for AUM provided to elk while others would benefit more by exchanging AUM use. Dollar values for AUM on the ranches ranged from $8.42 to $14.63. Surveys were sent to 100 licensed outfitters in Montana Fish Wildlife and Parks outfitter regions 1,2, & 3, with descriptions of elk herds residing on ranches during hunting season. Outfitters were asked to provide a dollar value for a lease if the ranch were to be outfitted for elk. Mean values for leases ranged from $2,919 to $10,375. Elk do economically impact ranches in Southwestern Montana; however, through alternative management strategies, that impact can be reduced.

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Dr. M. W. Tess M.W. Tess (Signature) 9/2/97 Date

Approved for the Department of Animal and Range Science

Dr. P. J. Burfening Peter Burfening (Signature) 9-2-97 Date

Approved for the College of Graduate Studies

Joseph J. Fedock Joseph J. Fedock (Signature) 9/4/97 Date

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Date 2 September 1997

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# ABSTRACT

Two computer models and five ranches in western Montana were used to determine the effects wild elk herds utilizing private ranges have on a ranch's available AUM, potential cow herd size, gross margin, and cost of production ($/kg sold). An elk energy metabolism model was developed to mimic forage intake dependent on the animals age, sex, and physiological state, as well as quality of forage, and relate intake to a standard animal unit (AU= 360 kg DM/mo). A beef cow-calf model simulated the performance of the five ranches as they were currently managed with elk present and were simulated again with elk "removed" to quantify the impact of elk on private ranges. All ranches significantly ($p<.01$) increased cattle herd size, gross margin ($p<.01$), and available AUM ($p<.01$) when all elk were removed from range; however, none were able to significantly change cost of production. Three alternative elk management strategies: block management, exchange of forage use, and outfitting, were evaluated for their potential to reduce numbers of elk utilizing ranches and recover costs associated with elk. Block management scenarios were simulated with the assumption that more efficient hunting through the program would reduce elk herds by 10, 20, and 30%, with ranchers having the potential to earn up to $8,000. Exchange of forage use such as at Wall Creek wildlife management area was evaluated as a method of reducing impact of elk on private lands. Using the fair market value of an AUM ($15 $\pm$ 3.00), some ranchers would be monetarily ahead accepting cash for AUM provided to elk while others would benefit more by exchanging AUM use. Dollar values for AUM on the ranches ranged from $8.42 to $14.63. Surveys were sent to 100 licensed outfitters in Montana Fish Wildlife and Parks outfitter regions 1,2, & 3, with descriptions of elk herds residing on ranches during hunting season. Outfitters were asked to provide a dollar value for a lease if the ranch were to be outfitted for elk. Mean values for leases ranged from $2,919 to $10,375. Elk do economically impact ranches in Southwestern Montana; however, through alternative management strategies, that impact can be reduced.

# CHAPTER 1

## INTRODUCTION

During the mid 1800's and into the 1900's, the once abundant wildlife populations of North America were decimated by subsistence and market hunters during the "Era of Over-exploitation" (Picton, 1991; Irwin et al., 1994). The introduction of livestock, which brought disease into immunologically naive wildlife populations (Picton, 1991), along with associated grazing and land cultivation, also played a large role in the near extinction of elk in the west (Picton, 1991; Irwin et al., 1994). National concern about declining elk populations reached a peak in the early 1900's when it was feared that the species would disappear (Hawkes, 1986). But now, after years of conservation, elk numbers have risen above their historic levels, creating conflicts with private landowners in the form of competition with domestic livestock and damage to property.

The American legal system developed the concept that wildlife belongs to the state and thus the people (Hawkes, 1984; Lacey et al., 1993). Yet some of the costs associated with the maintenance of these animals are borne by private landowners in the form of forage which would otherwise be consumed by domestic livestock, as well as damage to fences and other facilities (Lacey et al., 1993). Before human settlement, winter elk range included the valley lowlands and adjacent mountain foothills which are now in private ownership and used for crops or spring-fall cattle grazing (Skovlin et al., 1983; Vavra, 1992). In Montana, 75% of grazable woodland and range is privately owned (Lacey et al., 1988). Elk numbers have

increased rapidly in recent years, increasing the incidences of depredation by elk on agricultural lands (Carlson, 1991). At least 80% of wildlife in the United States, excluding Alaska, depend on private land for essential cover, forage and security; the predominant use of these private lands is agriculture (Henderson and O'Herren, 1992). So while wildlife is a public resource, the habitat on which wild animals depend is often privately owned (Rasker et al., 1992).

Multiple-use management of land resources for domestic livestock and wildlife has become an increasingly important issue on private and public lands (Bernardo et al., 1994). Elk have rapidly gained importance for providing hunting recreation and income revenues (Skovlin et al., 1983). In Central Idaho, elk and deer were economically competitive with cattle on public rangelands, meaning that allocating forage for wildlife was as economically viable as allocating it to cattle because of the economic value of hunting in the area (Edge and Marcum, 1990). In addition to its cultural, aesthetic, social and ecological values, Montana's elk resource is a substantial asset to the state's economy (Youmans, 1992). The Montana Bioeconomics Project, conducted from 1985 through 1988, was a major assessment of Montana fishing and hunting resources (Duffield, 1991). The study collected information on actual trip costs and determined that resident and non-resident hunters contributed $58.4 million per year to Montana's economy in the form of transportation, lodging, food, guide fees, and other expenditures associated with elk hunting (Brooks et al., 1991; Youmans, 1992; Hurley, 1994). In 1984, there were 563 licensed outfitters and 1,086 guides in Montana and more than 200,000 licensed hunters (Hawkes, 1986). The outfitting industry's clients had an impact of $114.9 million in 1990 while hunting in Montana for all big game species (Pride and

Taylor, 1991). Likewise, wildlife viewing contributed more than $44 million to Montana's economy in 1990 (Youmans, 1992).

Livestock production also has a very large impact on the economic affairs in Montana. In 1993, the livestock industries grossed $938.4 million, making it one of the largest contributors to Montana's economy (Sand and Lund, 1994).

The objectives of this study were to 1) determine the economic impact of elk on private ranges, particularly to beef cattle enterprises in southwestern Montana; and 2) evaluate different elk management strategies for their ability to help ranchers offset costs associated with having elk utilizing private ranges.

# CHAPTER 2

# LITERATURE REVIEW

## Competition

Habitat has four basic components: food, cover, water, and space (Skovlin, 1982). Though the nature and extent of habitat overlap between cattle and elk vary greatly, overlap has generally increased in recent years as elk have increased in number and distribution (Mackie, 1985). Competition can be defined as the use of a resource (food, water, light, space) by an organism that thereby reduces the availability of the resource to others (Edge and Marcum, 1990). Competition for food resources is a complex interaction of interrelated factors influencing herbivore relationships in co-habitated food resource areas (Vavra et al., 1989), and is subject to much variation (Smith, 1961). Factors that influence competitive interactions among sympatric herbivores include similarity of feeding strategies and overlap of seasonal useage and foraging sites (Mackie, 1970; Edge and Marcum, 1990; Vavra, 1991).

Because of their strong diet similarities, elk probably compete more with cattle than with any other large herbivore (Nelson, 1982). When discussing forage allocation between livestock and big game, competition occurs under three conditions: 1) big game and livestock are using the same area; 2) big game and livestock are using the same forage species; and 3) forage species are in short supply (Murie, 1951; Gordon, 1968; Holechek, 1980; Vavra et al., 1989; Edge and Marcum, 1990). Utilization of ranges or forage plants by big game and livestock need not occur during the same season for competition to exist; forage availability

during any one season may be related to use during a previous season (Gordon, 1968; Mackie, 1970).

## Dietary Overlap

Elk and cattle are both large herbivores (Edge and Marcum, 1990) and have a high probability of dietary overlap (Vavra, 1991), particularly in their preferences of some grasses and browse (Jackson, 1991). Knowledge of dietary habits of livestock and game animals is valuable to the range manager in allocating forage and habitat among potentially competitive herbivores (Stoddart and Smith, 1955; Holechek et al., 1982; Vavra et al., 1989). Extensive studies have shown that elk and cattle have very similar diets on most ranges (Mackie, 1985), particularly in the spring (Loomis et al., 1989), when both tend to seek out new, rapidly growing grasses and forbs on similar range sites (Mackie, 1978) resulting in high levels of dietary overlap between the two species (Pickford and Reid, 1943; Edge and Marcum, 1990).

In general, competition for food is not as serious on summer range as on winter and spring range (Mackie, 1970; Nelson, 1982). Summer diets of cattle and elk usually consist largely of herbaceous plants. Cattle generally prefer grasses and sedges, while elk preferences appear to vary between these plants and forbs (Nelson, 1982). After late May when forbs generally become the most important source of elk forage, habitats diverge and timbered habitats receive significant elk use. Habitats of the two species become increasingly similar during October and November (Mackie, 1970).

Rocky Mountain Elk *(Cervus elaphus nelsoni)*

One of the major driving forces of wildlife behavior is nutrition (Vavra, 1991). Food habits of any given herbivore are a function of forage availability, food preference of the herbivore species, and nutrient demand (Vavra, 1992). The apparent ability of elk to select diets of similar quality from several different vegetation types suggests that they are habitat generalists (Hobbs et al., 1981; Cannon et al., 1987).

Food habits of elk are characterized by extreme variability in selection of feed stuffs and the adaptability of elk to utilize these different foods (Stoddart and Smith, 1955; Smith, 1961). Large herbivores, either wild or domestic, attempt to meet their physiological need for nutrients through selective grazing (Vavra, 1992). Geist (1982) suggested that because elk are an ecotone species i.e., animals that require two or more vegetational communities (Smith, 1986), they are expected to be diverse in food habits and habitat preferences. Elk need to be opportunistic and take advantage of favorable situations. They are among the most broad-spectrum feeders, but tend to be grazers on Montana and Wyoming ranges (Lacey et al., 1988; Ngugi et al., 1992). However, Lyon and Jenson (1980) classified elk in western Montana as browsers, even though elk use considerable amounts of grass when available. Renecker and Hudson (1990), defined elk as intermediate or mixed feeders, showing marked seasonal adaptation.

Elk habitat and diet selection are highly variable and are a function of the inter-relationships of behavioral and environmental variables which, in turn, differ from one population to another and from one area to another (Mackie, 1970; Short et al., 1977; Grover and Thompson, 1986). Many studies have shown that elk food habits tend to overlap those

of all ungulates, and elk are able to vary their diet on the same area according to season and availability of preferred forages and dominant vegetation (Collins et al., 1978; Miller et al., 1981; Peek, 1982; Irwin and Peek, 1983). When forbs, sedges and grasses in open grasslands reach their most succulent stage, they are used extensively. As these species mature, elk preference shifts to forest habitats and dry parks in upslope areas where plants retain their succulence and nutrient value (Korfhage et al., 1980; Hobbs et al., 1981; Frisina, 1992); however, their preferences change when fewer choices are available (Edge and Marcum, 1990).

In New Mexico, the diets of elk in two study areas contained markedly different proportions of graminoids and browse; however, the forages consumed by elk were similar in quality due to their ability to feed selectively (Rowland et al., 1983). Forbs and grasses were important dietary items during summer and grasses remained important in autumn in the Pinyon pine - juniper woodlands of New Mexico (Short et al., 1977).

In the Elkhorn Mountains of west-central Montana, up to 62% of elk winter diets were composed of Idaho fescue (*Festuca Idahoensis*), rough fescue (*Festuca scabrella*) and bluebunch wheatgrass (*Agropyron spicatum*), the most abundant bunchgrasses on the winter range (Dragt and Havstad, 1987).

Yearlong grasses were the most important source of forage for elk in the Missouri River Breaks of Montana, averaging 58% of the mean monthly instances of plant use (Mackie, 1970). Usage of forbs, which ranked second overall, averaged 29% of the mean monthly instances of use. Forbs were the most important class of plant in the diet during summer and

decreased sharply in early fall (Mackie, 1970). Overall use of browse was only moderate, comprising 13% of the total use (Mackie, 1970).

Many Montana studies are representative of elk wintering on grasslands. Climax grasses such as bluebunch wheatgrass, Idaho fescue, western wheatgrass (*Agropyron smithii*), and rough fescue were preferred forage species. Grass constituted from 65% to 100% of the winter diet on these grassland ranges (Peek, 1982). During winter, grasses comprised 72%, forbs 26%, and browse 2% of the diet in Crow Creek Drainage, Montana (Gordon, 1968). The spring diet reflected a transition from winter to summer foods, with grasses being preferred; the diet was made up of 75% grasses and 25% forbs (Stevens, 1966; Gordon, 1968). As summer neared, forbs became important, although leaves of browse species were readily taken; the summer diet consisted of 76% forbs and only 16% grasses (Stevens, 1966). Fall diets reverted to predominately grass or browse (Peek, 1982). Along the east front of the Rocky Mountains in north-central Montana, elk diets in early winter contained 84% grasses and decreased to 65% during late winter (Kasworm et al., 1984).

In the Idaho panhandle, bluebunch wheatgrass, elk sedge, and groundsels (*Senecia* spp.) accounted for about 62% of elk diet during the early spring (Irwin and Peek, 1983). In summer, shrubs and forbs each constituted about 50% of the diet. In autumn, elk were observed less often in open areas and were more often seen in timber stands where forbs and shrubs constituted 42 and 57% of the diet, respectively. Shrubs constituted 98% of the winter diet. In the Sun River Wildlife Management Area (WMA), rough fescue was the most preferred forage for wintering elk (Jourdonnais and Bedunah, 1990). Idaho fescue in the Sun River WMA received significant use by elk only after rough fescue had been heavily utilized.

Bluebunch wheatgrass and other native species received little or no use. In Southeastern Idaho, shrubs and forbs dominated the diet, with grasses contributing only minor proportions (Canon et al., 1987). During the summer-fall grazing period in east central Idaho, mountain big sagebrush (*Artemisia tridentata*)/bluebunch wheatgrass/Idaho fescue received abundant use by elk (Yeo et al., 1993).

Graminoids were the most frequently chosen food item in Summer elk diets in Colorado (Baker and Hobbs, 1982). Winter elk diets in Colorado were dominated by browse and grasses (Hobbs et al., 1981). Elk and cattle diet similarities in southern Colorado ranged from 30 to 50% when elk and cattle fed in the same areas. Diets overlapped strongly for sedge (*Carex* spp.), fescue, and bluegrass (*Calamagrostis canadensis*; Hansen and Reid, 1975).

In the northern Great Plains, graminoids were the most important forage class during spring and summer, with forbs becoming the most important forage class during fall and winter; use of browse was low during all periods (Wydeven and Dahlgreen, 1983). In Wyoming, graminoids comprised 84% of elk spring diets and 90% of their fall diets (Ngugi et al., 1992).

In northeastern Oregon, grasses made up 52% of big game diets in March, April, May and June. Thirty-eight percent of the diet was made up of forbs and 10% of browse. From April to mid-May, grasses continued to contribute a major portion of the diet; however, utilization of forbs increased representing almost half of all forage consumed (Miller et al., 1981). In general, forb use was most extensive during late summer by elk in northeastern Oregon (Korfhage et al., 1980). Rocky Mountain elk also made considerable use of Idaho

fescue in winter and used bluebunch wheatgrass in spring and early summer (Holechek et al., 1982). During late summer and fall, elk had a high preference for grasses (Skovlin et al., 1968).

In Lodgepole pine habitat in Utah, forbs were the major forage class in diets in open situations such as wet meadows and clearcuts; however, they were used much less after they matured. Grasses and sedges were usually not preferred, but were used most extensively prior to significant forb production and after forbs matured and became less palatable (Collins et al., 1978).

Hunt's (1979) study of elk in East-central Saskatchewan revealed that browse was the major component in the diet, especially in summer and winter. Grasses and sedges were of minor importance in each season and forbs were of moderate importance. Forbs were eaten mostly in the summer and autumn but were almost as important in winter. Elk ate a variety of browse species; aspen (*Populus* spp.) was most important, with willow (*Salix* spp.) second. Cultivated crops such as wheat, oats, barley, and alfalfa were used extensively in autumn (Hunt, 1979).

Cattle (*Bos Taurus*)

Cattle are generally known as grazers, but will take some browse (Lacey et al. 1988). Summer cattle diets along the east front of the Rocky Mountains in north central Montana consisted of 84% grasses, 12% forbs, and 4% browse (Kasworm et al., 1984). In the Missouri River Breaks of Montana, grasses constituted approximately 76% of the mean monthly instances of plant use and were the most important cattle forage; forbs comprised about 18% of the total instances of use on feeding sites. Shrubs were of minor importance as browsing

accounted for only 5% of the mean monthly plant use (Mackie, 1970). Grasses made up 75 to 62% and forbs 38 to 24% of the total summer diet of cattle in Crow Creek, Montana (Stevens, 1966; Gordon, 1968). Cattle food habits were similar to elk winter food habits in north central Montana. The major differences in diets were in the proportions of each forage class used rather than which species within a forage class was consumed (Kasworm et al., 1984).

Dietary components of cattle grazing summer ranges in the Pacific Northwest indicated reliance on Idaho fescue, rough fescue, and bluebunch wheatgrass, the dominant bunchgrasses (Dragt and Havstad, 1987). In the Blue Mountains of Oregon, Holechek et al. (1982) reported grass as the primary forage class consumed by cattle, but forbs were readily utilized in June and early July. Bluebunch wheatgrass was the forage species most heavily used by cattle followed by prairie junegrass, Idaho fescue, elk sedge, and pinegrass. Cattle during the grazing season preferred grasslands over forest areas; however, forested areas were generally utilized by mid-summer, when heat and/or flies became intense. Elk sedge was highly preferred in the late summer and fall because it remained green and succulent after other grasses had matured. Idaho fescue and elk sedge were the two most important species consumed by cattle grazing forested range in northeastern Oregon (Holechek et al., 1982).

## Forage Intake

Forage allocation for domestic livestock and big game animals has long been a controversial problem. Many early beliefs and solutions to this problem were based on intuitive reasoning rather than experimental evidence (Holechek, 1980). In an effort to quantify dietary overlap and forage offtake by elk, many researchers have attempted to

compare the forage intake of elk to the standard animal unit month (AUM) measure of a cow/calf pair.

Several attempts have been made to equate elk and cattle animal units as a guide to forage allocation on the range (Lyon and Ward, 1982). Theoretically, the forage demand of game animals may be calculated on the basis of body weights (Stoddart and Smith, 1955). Most comparisons have been made during winter by feeding penned animals (Lyon and Ward, 1982); however, almost none of the calculations accounted for yearly physiological changes of elk, and all assumed 100% spatial overlap (Holechek, 1980). It is important to recognize that it is the amount of overlap in forage species consumed and areas grazed by different kinds of animals that determines the potential for competition (Stoddart and Smith, 1955; Holechek, 1980).

During winter feeding on the National Elk Refuge in Wyoming in 1940-41, an experiment was conducted in which the amount of hay fed to elk was compared to the amount of the same hay fed to Hereford cattle. Elk calves consumed 7.8 pounds each per day; adult elk 12.5 pounds, and adult cattle 31 pounds. The figures for the adults in each case suggest ratios of roughly 2.5 elk to one head of domestic cattle giving elk an AUM value of .4 (Murie, 1951). Forage use by one cow generally was assumed to equal that by 1.25 elk (Pickford and Reid, 1943). Stoddart and Smith (1955), determined elk to be .53 cattle purely on an average weight basis. The average intake per adult Rocky Mountain elk equivalent per month was 178kg (Mereszczak et al., 1981). Lacey et al (1988), estimated that 160 elk would consume 576 AUMs in six months, assuming that an elk is equivalent to .6 AU. In a later study by Lacey et al. (1993), mature elk were figured to be .53 AU. Loomis et al. (1989), suggested

that each adult elk consumes between 0.4 and 0.67 AUMs of forage each month, and elk calves consume .27 AUMs. A study by Skovlin et al. (1968), where big game and cattle grazed under dual use, the forage requirement for each animal was derived for comparative purposes. One beef cow with calf (1.0 AUM) was considered equal to two elk (0.5 AUM each). In the Blue Mountain area of Oregon, Wisdom (1992) determined that for every domestic cow-calf pair the range can support, the equivalent weight of 2.5 elk could be supported in its place.

An *in vitro* study on the kinetics of digestion of cattle and elk by Renecker and Hudson (1990), indicated that dry matter intakes by the two ruminants were proportionately about 2.0% body weight during the summer. In winter, forage consumption by elk was lower than cattle. Elk, but not cattle, reduced food intake during winter, using fat reserves in winter as an energy source.

## Spatial and Temporal Overlap

Knowledge of herbivore food habits is one of several necessary factors in establishing competition among herbivores but is not sufficient as the sole criterion for establishing competition. Although food habits indicate the potential for competition among cattle and elk, indices of herbivore distributional overlap indicate the probability of herbivore competition for habitat on seasonal rangeland is less than would be indicated solely from dietary overlap (Vavra et al., 1989).

The competition for forage among animal species with similar food preferences can be reduced due to spatial separation of foraging areas and temporal separation of ungulate grazing (Sheehy and Vavra, 1996). Distributional overlap and timing of use moderate direct

competition between the two species (Vavra, 1991). Elk often use steeper slopes, venture farther from water, eat a broader range of plants, select more specific plant parts and use ranges where cattle are not present (Stoddart and Smith, 1955; Wisdom, 1992). Elevation and exposure are major distinguishing components of habitat use (Wallace and Krausman, 1987).

## Elk Distribution

Elk prefer cover (old-growth, mixed forest, hardwood, and sapling-pole stands combined) during calving and summer seasons, but use less cover during winter and spring seasons (Witmer and deCalesta, 1983).

Movement of elk is not greatly affected by slope. Elk typically prefer upper slopes and ridgetops (Yeo et al., 1993), with use gradually increasing with steepness of slope to a maximum of 30 to 40% with the most frequently used slopes being in the 15 to 30% class (Mackie, 1970; Skovlin, 1982). Use is sometimes noticed on slopes as great as 75%, but rarely higher (Witmer and deCalesta, 1983). Slopes with southern aspects are preferred by elk throughout the year and receive exceptionally intense use due to availability of feed (Mackie, 1970); however, slopes with northern aspects have increased use in summer because forage plants are still succulent and the sites are cooler (Mackie, 1970; Witmer and deCalesta, 1983).

Elk seek out low elevations in winter months when temperatures are at annual lows, palatable forage is scarce, and movement is difficult (Henderson and O'Herren, 1992). Winter elk use is more confined to the ridges and slopes; however, under severe crusting of the snow pack, elk rapidly accumulate along the stream bottoms where the taller browse species are still available (Smith, 1961). In the spring, when temperatures rise and snow

recedes, elk often seek even lower elevations with more southern exposure and less cover because these sites are the first to produce new green foliage (Henderson and O'Herren, 1992).

Elk are known to undertake long seasonal migrations between summer and winter ranges, but some populations are essentially nonmigratory (Peek, 1982). Migratory movement to the upper limits of summer range in mountainous terrain appears to be related to the presence of insect pests and to vegetation development. Migrating groups of elk containing pregnant cows halt temporarily for calving in late May and early June. Researchers have noted that Rocky Mountain cow elk with calves do not resume migration until late June or July (Peek, 1982; Adams, 1982). Cows with calves appear to lag behind other members of a population in their timing of spring movements (Peek, 1982).

Movements onto winter range are often initiated with the first snowstorms. Mature bulls frequently appear first, but most of a population migrates as snow progressively eliminates higher elevations as foraging areas (Peek, 1982). Nonmigratory or resident elk populations differentially utilize various portions of an area during the year (Mackie, 1970), exhibiting local shifts in habitat use rather than pronounced seasonal movements (Peek, 1982).

Seasonally, elk require different combinations of security and thermal cover near foraging areas (Lyon and Ward, 1982). One common factor of elk habitat is an abundance of water (Hurley, 1994). Elk are generally within 190 m of permanent water during calving season, but as the year progresses, they use areas further from water (Witmer and deCalesta, 1983). Most observations of elk during summer and fall are within 1020 m of a water source (Mackie, 1970).

In the Ovando Mountains near the Blackfoot Clearwater Wildlife Management Area, the migratory elk herd generally leaves their core winter range by late April, early May. Winter snow conditions, spring temperatures, and the resulting availability of succulent forage influence the timing and rate of spring elk migration from lower to higher elevations (Murie, 1951; Adams, 1982; Hurley, 1994). Late summer, high elevation habitat for elk is in open snow slides or wet meadow areas and creek bottoms. At low elevation, elk use creek bottoms and green agricultural fields (Hurley, 1994). Fall distribution of elk is determined by weather and hunting pressure (Hurley, 1994). By the end of November, the elk are fairly well established on winter range, with grasses comprising most of their diet (Murie, 1951).

## Cattle Distribution

Cattle distribution on rangeland is influenced by slope, distance to water, and climatic factors such as ambient temperature, wind speed and direction, humidity, precipitation, and barometric pressure (Hart et al., 1991). Areas of greatest cattle densities in the Missouri River Breaks, Montana, include major coulee bottoms and uplands of the *Artemisia-Agropyron* and *Agropyron-Poa* habitat types associated with ridgetops, slight to moderate slopes, and well-distributed water sources (Mackie, 1970). Cattle use is predominantly on level to gently sloping sites (Smith, 1961) and decreases sharply on steeper slopes during all periods of the year; slopes steeper than 25% receive only very minor use by cattle (Mackie, 1970). Most observations of cattle occur within 1209 m of a water source, with the greatest numbers typically observed within 402 m of water (Mackie, 1970).

## Elk and Cattle Interactions

While some studies suggest that elk generally avoid cattle occupied areas (Frisina and Morin, 1991), cattle and elk are socially compatible (Wallace and Krausman, 1987). The preference of elk for habitats not occupied by cattle appears to be related to intensive removal of vegetation by cattle rather than a social intolerance of cattle (Frisina, 1992).

Cattle and elk do not always have a negative impact on each other, there are situations in which they are compatible with one another on the same range (Anderson and Scherzinger, 1975; Vavra, 1991). Interspecific competition between sympatric herbivores may appear to be obvious and may exist; however, relationships between large herbivores are not necessarily competitive and may even be benefitial to one or both of the herbivores (Vavra et al., 1989). Several studies of competition have provided evidence of coexistence rather than competitive exclusion (Mackie, 1985).

Cattle grazing is often suggested as a means for improving big game ranges (Edge and Marcum, 1990). In the Elkhorn Mountains of Montana, highest concentrations of elk were observed on a portion of spring range that was grazed heavily by cattle during the previous summer. This may be the result of decreased residual forage and consequently increased availability of succulent green forage and improved forage quality in spring (Grover and Thompson, 1986).

Similarly in northeastern Oregon during summer, cattle select foraging areas in Idaho fescue plant communities preferred by elk during the winter and spring. Utilization of vegetation standing crop in these plant communities during summer by cattle may have improved vegetation quality for elk use in winter and spring after fall precipitation promoted

growth of preferred forage species (Sheehy and Vavra, 1996). In the absence of cattle grazing, plant litter accumulations in the Sun River Wildlife Management Area became a management problem when elk moved from designated elk management areas to graze on private lands that had been grazed by domestic livestock (Jourdonnais and Bedunah, 1990).

Elk also may have influenced range improvement for cattle in the Elkhorn Mountains of Montana. Considerable regrowth of grasses occur following spring elk use (Stevens, 1966). Elk eat large quantities of big sagebrush and rabbitbrush in winter, and these two shrubs compete with herbaceous forage species preferred by cattle (Nelson, 1982). Summer use of ridgetops used by elk in winter by cattle may reflect improved forage quality on sites in east central Idaho attributable to elk grazing as well (Yeo et al., 1993). Temporal separation of ungulates on desirable foraging areas allows growth of vegetation to occur between periods of grazing that improves vegetation quality (Sheehy and Vavra, 1996).

Historically, most intense conflicts have occurred where domestic livestock and elk were competing for forage on elk winter ranges (Frisina and Morin, 1991). In the late 1950's and early 1960's, concern over competition for forage between elk and livestock increased (Peek, 1982). It was well known that elk and domestic livestock compete for forage when both graze mountainous summer range (Pickford and Reid, 1943), and investigations revealed that the potential for competition for forage between elk and cattle was indeed great (Peek, 1982). Big game have three areas of conflict with private farming and ranching operations: 1) use of cropland as high quality summer and fall range, 2) use of private rangeland in summer and fall as an escape from disturbance on public lands, and 3) the use of private ranges and crop lands for winter range (Vavra, 1992).

Direct negative impacts essentially include what is commonly recognized as direct competition for food, cover, and space (Mackie, 1978). Competition is known to be especially critical when rangeland conditions are poor. Very often, elk populations increase in areas where livestock grazing is ongoing. This causes concern among livestock interests when efforts to improve range condition call for modification of grazing practices or reduction in livestock numbers (Peek, 1982). There is always some, and in at least a few cases, almost complete overlap in forage use between livestock and wildlife (Mackie, 1980). Substantial and significant overlap in diets and range use may occur with very early grazing on many spring ranges (Mackie, 1978).

Indirect negative impacts include: 1) gradual reductions in the vigor of plants and in the amount and quality of forage produced or available; 2) elimination or reduction in reproductive parts or vigor of plants such that future forage supplies are diminished; 3) reduction or elimination of locally important cover types and replacement by less favorable types; and 4) general alterations and reduction in the kinds, quality, and amounts of preferred or otherwise important plants through selective grazing or browsing or other activities (Mackie, 1978). On many western rangelands, cattle and elk use the same forages but during different seasons, placing these species into indirect competition (Dragt and Havstad, 1987).

In the fall, competition for food can be much higher than in the summer, owing to the increased percentage of grass in the elk diet (Stevens, 1966). Cattle and elk both use foothill ranges and prefer similar plants, but generally elk do not graze foothill pastures at high enough density in summer to compete directly with cattle for forage (Hart et al., 1991). In many respects, the range use and food habits of elk have a tendency to overlap those of cattle. Elk

tend to concentrate on foothill pastures in winter months when cattle generally are not present. This presents the possibility of competition because cattle may consume in summer the forage that elk need in the winter. The severity of overlap can depend on cattle stocking rate and feeding distribution during the summer grazing period (Hart et al., 1991).

Big game animals compete with livestock for forage, trample forage, and damage agricultural crops, orchards, and fences (Murie, 1951; Hawthorne, 1980; Palmer et al., 1982; Thomas, 1984; Lacey et al., 1988). Elk utilizing private lands for winter and spring range are perceived as reducing the forage available for livestock that will graze the same range later in the spring (Vavra, 1991). However, competition for native forage on common ranges is only one of the ways elk impact beef cattle operations. There are other losses and costs associated with having wildlife residing on privately owned ranges (Wunderlich et al., 1990).

In early spring, elk congregate on the first bare spots of ground and there seek the new growth at a time when the vegetation can least withstand heavy use, as well as grazing persistently in pastures intended for cattle (Murie, 1951). Winter wheat or hay fields are sometimes badly damaged by trampling and bedding of large herds of elk. In some areas, elk persistently raid haystacks and cattle feedlots (Murie, 1951; Hawthorne, 1980).

Wildlife feeding on alfalfa stands lead to a thinning of the alfalfa, resulting in an increased growth of grasses, thereby lowering the value of the crop both as a foodstuff and a cash crop. Damage to the first cutting generally results in reduced yields of the second and third cuttings (Palmer et al., 1982). Since hay is an intermediate good on most ranches, the economic loss is greatest when the market price is high (and the supply low) due to the high cost of replacing damaged or lost hay. In addition, if a rancher decides to sell the hay at

market, the value of the lost crop material will be greater when the market price is high (Adkins and Irby, 1992). Landowners in Utah reported problems controlling consumption of grain crops, hay, and early spring forage by wildlife (Jordan and Workman, 1989).

Considerable damage to livestock fences occurs as a result of elk movements (Lyon and Ward, 1982). Damage to fences by elk often results in secondary damage by permitting livestock access to other areas (Hawthorne, 1980). In a survey of western Montana by Lacey et al (1993), costs attributed to forage consumption, haystack damage, fencing haystacks, and repairing pasture fences damaged by big game averaged $6,467 per landowner.

Grazing by elk populations on sagebrush rangeland during winter was widely believed to harm performance of livestock using those ranges in spring (Hobbs, 1991). In Hobbs' study, elk grazing during winter and early spring caused reductions in beef calf performance during spring on sagebrush grassland range. Effects of elk grazing on beef cow weights were smaller than the effects on calf weights. Hobbs concluded that elk grazing during winter exerted a relatively small impact on livestock performance during the subsequent year. Although the impacts observed were not statistically different, these small effects, nonetheless, had the potential to be economically significant. A study by the Colorado Division of Wildlife on the impact of elk winter grazing on livestock production over the past three years showed that elk grazing during the winter influenced the performance of cattle during spring. In direct relationship to various elk densities, birth weights of bovine calves declined relative to elk densities (Jackson, 1991).

## Cooperative Management Efforts

Competition for forage between elk and domestic livestock has generated controversy on both public and private lands (Frisina and Morin, 1991; Frisina, 1992). Efforts to coordinate grazing programs and elk populations and to improve range conditions have since become important management issues (Peek, 1982). Such efforts include the cooperation of private landowners and state and federal agencies. Almost all such efforts, where they could be feasibly implemented, brought with them some measure of success.

Special programs to encourage recreational access on private land in an attempt to manage elk herds have been developed in Montana, Oregon, and Washington. An example of state agency efforts is the block management and walk-in program administered by Montana Department of Fish, Wildlife and Parks (FW&P; Lacey et al., 1988). The block management program is a cooperative agreement with private landowners to allow public hunting on private lands (Governor's Advisory Council, 1994).

The Montana 1995 Legislature has since signed into law House Bill 195 which further clarifies the Block Management Program to include the hunting access enhancement program. The program is designed to provide tangible benefits to participating landowners who grant public hunting access to their land. The amount of benefits received by a participating landowner is determined by the number of hunter days provided; wildlife habitat provided; resident game populations; number, sex, and species of animals taken; and access provided to adjacent public lands. Benefits earned by a participating landowner may include payments for weed control, fire protection, and insurance costs incurred for allowing public hunting access;

assistance in construction and maintanence of roads, gates, and parking facilities; and/or a total of not more than $8,000 a year (Montana Session Laws, 1995).

The game damage program addresses wildlife depredation on private lands through technical advice, game damage materials such as elk panels, kill permits, special seasons, and herders. Annually, FW&P spends over $200,000 to help alleviate game depredation problems on private property, assisting landowners who allow public hunting during established hunting seasons or do not significantly reduce public hunting through imposed restrictions (Youmans, 1992).

Livestock loss programs provide taxable value reimbursement for losses of livestock attributable to allowing public hunting on private land (GAC, 1994). Through organized landowner, sportsman, and Department efforts, laws have been passed to assist landowners. Among these are permission to hunt big game, restriction of off-road travel, trespass posting laws, limitation of a landowner's liability if he/she allows free public hunting on his/her property, as well as statutes making it illegal to shoot from a road or right-of-way, (GAC, 1994).

Bureaucratic assistance and Montana State University Wildlife Extension program have helped alleviate some of the concerns of landowners who support wildlife. However, there are other projects initiated by FW&P that have been of even greater value in increasing landowner tolerance of big game populations.

## Coordinated Grazing Efforts

Grazing and sharecropping is done on many FW&P properties across the state of Montana. Projects at Fleecer Mountain (GAC, 1994), Wall Creek Wildlife Management Area

(WMA; Alt et al., 1992), Mount Haggin WMA and Beartooth WMA (Kuntz, 1993; FWP, undated) all serve as models for productive cooperation and the compatability of cattle grazing and wildlife by utilizing livestock as a range management tool (Kuntz, 1993).

The goal of coorperative grazing is to design grazing systems to improve overall management of the range and resolve conflicts between domestic livestock and wildlife on seasonal ranges (Alt et al., 1992; Frisina, 1992). By taking advantage of elk spring preference for pastures grazed by livestock the previous year, elk can be directed to public game ranges and away from adjacent private lands (Frisina, 1992). Periodic grazing by cattle on the elk winter range pastures improves the nutritional value of forage plants by removing accumulated old growth and improves forage quality (Frisina and Morin, 1991; Alt et al., 1992). Coordinated management resulted in substantially increased animal unit numbers, while resolving a landowner tolerance problem (Frisina and Morin, 1991).

While cooperative "exchange of use" is applicable in some situations, it is not the practical answer for other landowners who also provide elk habitat. Charging access fees and/or leasing out their land to hunters is another means of recouping costs associated with elk, as well as increasing landowners' tolerance for having elk on their lands.

## Fee and Lease Hunting

Many private landowners who supply elk habitat, especially winter habitat, have little incentive to encourage the expansion of this publicly owned resource that yields no direct economic benefit to them (Wenders, 1995), and may reduce the return from other sources (Lyon and Ward, 1982). Historically, the United States has expected landowners, public, private, and/or corporations, to bear costs of providing habitat for wildlife (Noonan and

Zagata, 1982). Two Montana Supreme Court decisions ruled that private landowners are expected to accommodate a certain amount of wildlife use on their lands (Youmans, 1992). Even though landowners in the United States do not fully own the wildlife on their lands, they can gain from enhancing wildlife habitat by enforcing access rights to their land for hunting (Lueck, 1995).

There are a number of ways wildlife can benefit the landowner in an economic sense (Knight, 1988). In response to perceived low profitability of cattle production, many landowners in the Southern Plains are seeking alternative income opportunities from natural resources (Bernardo et al., 1994). To the degree that big game interfere with management goals, some landowners are compensated by generating income from wildlife through both non-consumptive use and hunting (Lyon and Ward, 1982; Lacey et al., 1993).

Fee hunting can be an attractive alternative for landowners who provide habitat to large numbers of game animals (Huffman, 1995), and may be the only method for some landowners to recover costs of having wildlife on their land (Rasker et al., 1992). The term fee hunting refers to the charging of access fees to a hunter by a landowner for access to private land for the purpose of hunting publicly owned game (Rasker et al., 1992). Charging fees gives landowners an incentive to actively coordinate with state wildlife management agencies to manage wildlife to their mutual benefit while keeping lands open to hunters (Jordan and Workman, 1989). In Utah, landowners most frequently initiate fee hunting as a means of controlling trespassing or earning extra income and covering costs of having hunters on their land (Jordan and Workman, 1989).

Wildlife has economic value because people are willing to pay for rights to hunt, fish, trap and observe wildlife (Noonan and Zagata, 1982), and with rising human population and an increase in personal income over the past few decades, the demand for quality elk hunting has increased (Wenders, 1995). Unlike the public wildlife manager who has no way of accurately measuring the cost of providing wildlife habitat, the private landowner knows the cost of damage to crops and livestock and can charge accordingly (Huffman, 1995).

Lease hunting is becoming an increasingly important source of income for landowners (Bernardo et al., 1994). Variations in lease agreements can generally be grouped into four types: 1) day leases; 2) season leases; 3) year-round leases; and 4) brokers or outfitters (Severson and Gartner, 1972; Knight, 1988; Wunderlich et al., 1990). Factors influencing the price a landowner can ask include proximity to public land, hunter demand, and the game crop (Severson and Gartner, 1972). Such variables as aesthetics, reputation, and rapport between client and operator are unquantifiable, yet can have a great influence on the price an operator is able to get for a particular hunt (Knight, 1995). Hunter success rates and opportunities to harvest trophy animals are the most important determinants of the amount a landowner can charge (Cory and Martin, 1985; Loomis and Fitzhugh, 1989; (Brookes et al., 1991).

Hunters paying landowners for hunting is common in states having high percentages of private land (Knight, 1995). The best example of this is Texas, where hunters paid landowners more than $200 million in 1983 (Thomas, 1984; Lacey et al., 1988; Wunderlich et al., 1990). In New Mexico, enterprises varied between losing $2,850 to a net profit of $997,250. Habitat type, acreage, existing developments at time of fee hunting enterprise

initiation, and level of commitment of the operator all influenced the net income derived from the fee hunting operation (Knight, 1995).

Fee and lease hunting have been slower coming to the Rocky Mountain West (Davis, 1995), and is less common in states like Montana where federal land management agencies control much of the land (Lacey et al., 1989). However, in a survey of Montana landowners, completed by Lacey et al. (1988), results indicated an increase in the number of private landowners implementing recreation enterprises on their land.

While most landowners desire compensation for providing wildlife habitat and recreational opportunities, sportsmen have felt that game animals are a public resource managed through license fees paid by sportsmen's dollars (Lacey et al., 1989). Recreationalists argue that people should not have to pay for what they have previously received for free; and it is difficult for people to adjust to the reality that providing wildlife habitat has significant costs. Many of these costs have been borne by private landowners without any consideration of how the costs can be recouped (Huffman, 1995).

Charging access fees not only benefits the landowner, but also provides some benefit to the hunter paying those fees. By limiting hunter access through the charging of fees, much of the "opening day" effect is eliminated, thereby increasing the quality of the hunt as well as the success rate (Lueck, 1995). Evidence from existing fee-hunting operations shows that hunters are more than willing to pay the price. Hunters are buying more than an opportunity to do what could be done for free on public lands. They are buying the right to hunt for quality wildlife under circumstances of limited access that greatly improves their chances of success (Huffman, 1995).

## Bioeconomic Models

With rising costs of livestock production and decreasing market prices, recovering costs associated with supporting wildlife on private ranges becomes an issue vital to the sustainability of ranches. In an attempt to quantify the costs and effects that wildlife have on private ranges, bioeconomic models are being developed to be used as management tools, giving land managers ideas on the best routes to take in recovering costs borne from providing wildlife habitat. Computer simulation provides a useful tool for integrating site-specific field data with basic biological data in order to develop predictions about the effects of forage allocation alternatives (Cooperrider and Bailey, 1980; 1984).

Bioeconomic models that integrate biological dynamics and the resulting economic behavioral response have been widely used in theoretical analysis of natural resource problems (Standiford and Howitt, 1992). Tess (1995) defined systems analysis as a branch of science that attempts to address questions relevant to whole production enterprises. Systems researchers attempt to integrate knowledge from several disciplines of science in the study of dynamic and interactive characteristics of real-life production enterprises.

Simulation allows a user to predict the consequences of various alternative allocation decisions. These alternatives and their predicted consequences can then be evaluated by managers and by the public (Cooperrider and Bailey, 1984). Many workers in fields such as animal science and wildlife biology have developed models for predicting the efficiency of converting herbage to animal biomass as a function of herbage quality and animal characteristics. In recent years these models have been incorporated into more comprehensive models of animal production systems. Use of energetic measures of forage quality such as

digestible energy or metabolizable energy to predict animal weight gain and/or survival has been a promising approach for both domestic livestock and wild ungulates (Cooperrider and Bailey, 1984).

Simulation has been used in a number of natural resource fields to assist decision makers in understanding the resources being managed (Cooperrider and Bailey, 1984). Big game management problems have become increasingly complex in recent years, requiring increasingly refined technology to solve them (Nelson, 1982). During the past ten years, computer technology has dramatically improved, facilitating the use of computer models of animal systems (Heyer and Oltjen, 1986).

Cory and Martin (1985), attempted to develop a model evaluating the marginal net benefit of multiple uses on public land, in particular the value of elk versus cattle, in an effort to determine the optimal balance of one resource with another. Bioeconomic models have also been developed as a tool to facilitate the evaluation of selection, culling, and management strategies in various species of commercial livestock breeding systems (Faust et al., 1992a,b; Lamb et al., 1992), as well as measuring the economic efficiency of beef cattle production (Davis et al., 1993a).

Competition for forage between wild ungulates and domestic livestock is a complex, controversial, and continuing problem (Cooperrider and Bailey, 1981). In 1980, Cooperrider and Bailey developed a computer simulation model to predict impacts of selective forage removal by free-ranging big game and domestic livestock. The computer simulation was further developed by Cooperrider and Bailey (1981), to define impacts on weight changes, reproduction and mortality as predicted from diet qualities and nutritional requirements of

animal species. In 1984, Nelson developed a computer simulation model to predict large herbivore competition on the basis of forage preference indexes, timing of use, and height of reach of individual animals.

The bioeconomic model used in this study is designed to simulate the dynamic relationships among cattle genotype, physiological state, forage quality, and management in a range environment. The model simulates the performance of individual animals, including forage intake, energy metabolism, protein metabolism, growth, reproduction, and changes in chemical body composition over a complete life-cycle (Tess and Kolstad, 1994). Genotypes, mating systems, feed characteristics, and management decisions are input by the user. The model is capable of keeping track of a large number of economic inputs and outputs. Inputs include pasture rent, purchased feed, labor, veterinary, machinery, repairs, taxes, marketing expenses, interest on borrowed capital, and the opportunity cost of owner equity. Outputs include revenues from the sale of calves and females culled from the breeding herd. Bulls are not directly simulated in the model, but annual costs for the maintenance and replacement of bulls is included as a variable expense. The model is representative of integrating a large body of scientific research into a practical tool for studying the performance of alternative beef production systems (Tess and Kolstad, 1994).

# CHAPTER 3

# MATERIALS AND METHODS

Two computer models were used in determining the effects of wild elk populations on domestic cattle ranches. A beef cow-calf model simulated the cattle operation and an elk simulation model predicted forage intake be elk. Five ranches in western Montana participated in the study by providing detailed information of their ranch operations and allowing me to use the ranches as study sites.

## Beef Cow-Calf Model

The beef cow-calf model used in this study, developed by Tess and Kolstad (1994), simulates performance of beef cattle of varying genetic types in response to changes in forage quality and management strategies, and simulates economic performance of beef production systems in response to alternate breeding and management systems. The model uses parameters input by the user describing genotype, mating systems, feed characteristics of native range as well as stored forage to include metabolizable energy (ME), neutral detergent fiber (NDF), crude protein (CP), rumen degradable protein (RDP), and production management decisions to include timing and duration of breeding seasons, timing and use of range resources, and date of weaning and sales.

The model uses a 1-day time step to simulate forage intake, energy metabolism, protein metabolism, growth, reproduction, and changes in chemical body composition over complete life-cycles of individual animals in response to the input. Forage intake is predicted based on

energy requirements and fill limits of the animals as related to changes in genotype and physiology of the animals as well as change in forage quality from spring green-up to senescence. Daily metabolizable energy (ME) requirements for cows are determined through the sum of requirements for maintenance, growth, lactation, and gestation. Metabolizable energy intake per cow is predicted from dry matter intake. Similarly, daily requirements for protein metabolism are computed as the sum of protein requirements for maintenance, hair, growth, gestation, lactation, and fecal protein.

If cows in the model are fed to their potential, reproduction occurs with the percent of calf crop being determined through input by the user. Sex of calves is randomly distributed. Dystocia among cows is simulated stochastically. First calf heifers have a higher probability of dystocia than older cows. If cows are not fed to their potential breeding will be delayed or they will fail to conceive and, if they lose too much weight during pregnancy, they will abort.

Mortality within the simulated herd is determined both randomly with the percent death rate of cows and calves input by the user and as a result of nutritional stress; it is assumed in this model that a minimum of 3% body fat is needed to sustain life.

Biological output from the model includes total number of calves born and their weights. The model will also predict maximum herd size possible when range resources are constrained taking into account additional monetary and feed resources needed to support a larger herd size.

Economic inputs are determined by the user and include sale prices for steers, heifers, culled cows and bulls, interest on opportunity cost on cattle, and value of purchased or sold

feeds. Costs associated with dystocia, hired labor, trucking and feedlot expenses, and shrink are also input by the user.

Economic output from the model includes revenues from sold calves and culled females, cost of purchased feeds or revenue from sale of feeds; it also determines ranch gross margin and ranch net income. Ranch gross margin is ranch gross income minus the variable costs associated with cattle, i.e., vet costs, labor per head of cattle, etc.; fixed costs are not subtracted from gross margin. Ranch net income is determined by subtracting fixed and variable costs, which include land leases, veterinary costs, hired labor, machinery, taxes, repairs, etc., from ranch gross income. Cost of production ($/kg) is also calculated. Cost of production is the economic input required to raise a kilogram of beef on steer-equivalent basis. All costs incurred on a cow-calf operation are divided by the prime source of revenue, steer weight, giving the producer a price to meet or exceed during the sale of calves in order to breakeven or profit from the year's production.

## Elk Simulation Model

The purpose of the computer model is to simulate forage off-take by wild elk on native range and relate the quantity to a standard animal unit month in an effort to quatify dietary competition between wild elk and domestic cattle. The model, developed by Tess and Fuller (1996), uses a one-day time step approach to elk energy metabolism to simulate forage removal by wild elk on native range and equating it to a standard animal unit (AU = 360 kg DM/mo; SRM, 1974). The model takes into account different physiological needs of elk as related to their age, sex, reproductive status, and time of year, as well forage quality measured as Mcal ME/kg DM, and dietary and spatial overlap of elk and cattle.

The model is deterministic, with all cow elk being bred on the same day and all calves being born on the same day. There is no computer generated mortality and there are no feed constraints, i.e., elk will not die or fail to conceive due to nutritional stress. The primary purpose of the model was to simulate forage offtake for a given elk herd, not to simulate the dynamics of a whole herd during a lifetime.

The model contains three sub-routines: bull, non-reproductive female, and reproductive female. A common equation among all three sub-routines is used in the determination of the efficiency of maintenance (KM) and gain (KG) based on Mcal ME/kg DM. The equations are adapted from NRC (1984), with conversion of energy for maintenance being more efficient than for gain.

$$KM = 1.37\,MEDM - .138\,MEDM^2 + .0105\,MEDM^3 - 1.12$$

$$KG = 1.42\,MEDM - .174\,MEDM^2 + .0122\,MEDM^3 - 1.65$$

Where, MEDM = Metabolizable energy per kilogram of dry matter.

The equations used to determine the amount of ME needed for maintenance (MEM) are also common among the three sub-routines. There are four different equations for maintenance because energy requirements for maintenance changes seasonally (Jiang and Hudson, 1993).

Equations for MEM have been adapted from Nelson and Leege (1982) energy expenditures for various activities. In general, more time and energy is spent foraging during spring and fall, and more time and energy is spent traveling during summer. During winter

(December 1 - March 31), elk energy requirements for maintenance is at its lowest, and intake is reduced, partially due to elk living off of fat reserves during harsh weather when movement is limited.

$$MEM = \frac{.1002\,WT^{.75}}{KM}$$

Where, $WT^{.75}$ is the metabolic weight of an animal.

During spring (April 1 - June 20), there is an increased need for MEM as migratory herds begin their movements onto higher ranges and begin to replenish energy reserves depleted during winter.

$$MEM = \frac{.1094\,WT^{.75}}{KM}$$

Summer months (June 21 - September 9) bring with them the highest demands of MEM for elk, with most of the energy expenditure going to traveling (Nelson and Leege, 1982).

$$MEM = \frac{.1138\,WT^{.75}}{KM}$$

A decline in MEM requirements is seen going into fall (September 10 - November 30). This is largely due to the fact that there is less time spent traveling than during summer.

$$MEM = \frac{.1072\,WT^{.75}}{KM}$$

Bull sub-routine

The bull sub-routine simulates the growth of bull elk from weaning until 8 years of age, when it is assumed the elk have reached their adult size, using a Brody-type growth curve. Weaning weight (WT) of male elk calves was 85.2kg and adult weight (AWT) was 350kg (Nelson and Leege, 1982). Using data presented by Murie (1951) and equations by Moen (1973) the equation for weight gain (WTG) of bull calves is:

$$WTG = .003(AWT - WT)$$

Metabolizable energy needed for gain (MEG) was figured using an equation adapted from NRC (1984), with the assumption that for a bovine steer and a bull elk, there is a similar fraction of weight distribution of fat to lean.

$$MEG = \frac{.0493\,WT^{.75}\,WTG^{1.097}\,ARATIO^{.847}}{KG}$$

Where, ARATIO is the ratio of energy conversion to fat and lean tissues; efficiency of energy conversion decreases as the animal gets older and utilizes more ME for fat reserves.

Total metabolizable energy intake (MEI) was determined by adding metabolizable energy for maintenance and metabolizable energy for gain.

$$MEI = MEM + MEG$$

Total dry matter intake (DMI) was a function of the animals metabolizable energy requirements and quality of forage. At the end of a one year simulation, with the year beginning in fall on October 1, the final weight of bulls during the growing season is determined by their weight at the beginning of the simulation plus weight gained throughout the year.

COW1 sub-routine

The COW1 sub-routine simulates all non-reproductive cow elk in a population. Similar to the bull sub-routine, growth of cows is simulated using a Brody-type growth curve from weaning weight until 8 years of age. Adult weight of a cow elk was 260kg, while weaning weight was 79.5kg. Again, using data presented by Murie (1951), and equations by Moen (1973) weight gain for female elk was computed by:

$$WTG = .0035(AWT - WT)$$

Metabolizable energy needed for gain was simulated using an equation adapted from NRC (1984).

$$MEG = \frac{.0686\, WT^{.75} WTG^{1.119} ARATIO^{.869}}{KG}$$

Total metabolizable energy intake was figured by combining metabolizable energy for maintenance and metabolizable energy for gain.

$$MEI = MEM + MEG$$

COW2 sub-routine

The COW2 sub-routine simulates the reproductive cow elk in a population, i.e., pregnant or lactating cows. Growth of the reproductive cow elk is simulated using a Brody-type growth curve from weaning until eight years of age. The equation for weight gain is identical to COW1 sub-routine, as is the equation for metabolizable energy needed for gain.

Sex of calves in this simulation model are randomly distributed among all reproductive females so that 50% would be male, and 50% would be female. Once born, calf weight gain (CGAIN) is determined by subtracting the birth weight of the calf (CWT) from the weaning weight and dividing by 120d (number of days from birth to weaning).

$$CGAIN = \frac{WWT - 16.0}{120.0}$$

where: WWT for male calves = 85.2kg
WWT for female calves = 79.5kg
CWT = 16.0kg for both sexes

Metabolizable energy needed for gestation is measured as uterine energy deposition (UTE) which has a 15% efficiency rate and is modeled after Ferrell et al. (1976). Gain in uterine development (UTEG) is computed by the equation:

$$UTEG = \frac{.06973 e^{DT(.0323 - .0000275 DT)} 16.0}{40} - UTE$$

Metabolizable energy needed to increase uterine development is determined by taking the amount of uterine energy for gain and dividing it by the 15% efficiency rate for conversion.

$$MEG = \frac{UTEG}{.15}$$

Intake of ME through the mothers milk by the calf begins on June 1, the day of birth, and ends at weaning on September 28. The birth date is an assumed average taken from Skovlin (1982) and Taber et al., (1982) and weaning date is an average from Nelson and Leege (1982). When the calf is born, all ME is gained through the milk of the cow, but as the calf grows throughout the year ME is gained from both milk and forage until the day of weaning when all ME is being provided through forage.

Metabolizable energy needed for maintenance by the calf (CMEM) is simulated by the equation:

$$CMEM = \frac{.1138 CWT^{.75}}{KM}$$

Calf weight gain (CWTG) is equal to CGAIN in the previous equation on calf growth.

Metabolizable energy needed for gain by calves (CMEG) is different for male and female calves.

Male calves:

$$CMEG = \frac{.0493 CWT^{.75} CWTG^{1.097} ARATIO^{.847}}{KG}$$

Female calves:

$$CMEG = \frac{.0686\,CWT^{.75}CWTG^{1.119}ARATIO^{.869}}{KG}$$

Total intake of ME by calves (CMEI) is the sum of CMEM and CMEG.

The percent of total MEI being provided from the mother's milk is determined by the fraction equation. As the calf grows, the percentage of milk in the diet decreases as the calf begins to rely more heavily on forages.

$$FRACT = 1.0 + \frac{16.0 - CWT}{WWT - 16.0}$$

Metabolizable energy needed by the cow elk for lactation (MEL) is a function of total MEI by the calf (CMEI) times the fraction of milk being taken in by the calf divided by the efficiency of converting body energy stores to milk (85%; NRC, 1989) times the effeciency of converting ME into maintenance.

$$MEL = \frac{CMEI(FRACT)}{.85KM}$$

Total metabolizable energy intake needed by the cow elk is the grand sum of metabolizable energy needed for maintenance, gain, gestation, and lactation.

$$MEI = MEM + MEG + MEU + MEL$$

## Ranch Selection

Five ranches were selected as representatives of southwestern Montana. Criteria for selection were that the ranch be a beef cow-calf operation with revenues from the sale of cattle its primary source of income, and supported migratory and(or) resident wild elk herds for at least part of the year. Advice on suitable ranches was received from FW&P and Montana State University Extension Specialists.

## Ranch Data Collection

Detailed information was requested of the five ranches as to how the ranches were managed. Information included: size of the breeding cow herd, number of replacement heifers, length of breeding season, and percent calf crop attained. Feeding management data included winter feeding amounts and type of forage, dates of when cattle were moved on and off range, along with how each management group was treated. Management groups were broken down into four groups: replacement heifers just weaned, first-calf heifers (coming 2yr), two- and three-year old cows, and older cows. Breeding dates, weaning dates, and sale dates, along with information listed in Appendix A, were used to parameterize the model.

## Elk data collection

Elk data were collected for the individual ranches from Montana Fish, Wildlife, and Parks (FW&P) biologists as well as from the ranch managers. Yearly flight data taken by FW&P for elk numbers were used to categorize elk herds by age, sex, and ratios of cows to calves, and cows to bulls (Table 1). Bull elk were further classified as spike, raghorns, or

brow-tined antlered. Cow elk age and reproductive status were determined using cow elk life tables reported by Taber et al. (1982).

Amount of time and type of activity elk spent on the ranches was determined through verbal communication with both the rancher and the FW&P biologist in the area. The number of elk months was calculated by multiplying the number of elk by the number of days elk spent using the property, and then dividing by 30 to get the number of months.

The percent of dietary and spatial overlap between elk and cattle was determined through various literature looking at diet similarities (see Literature Review), while spatial overlap was what the rancher and biologist felt was a fair estimation (Table 2). Percent overlap was decided upon on an individual ranch basis and was variable by season of use. Elk use and numbers varied by ranches, with all but one ranch supporting elk year-round.

All ranches showed an influx of elk in late fall that continued to early spring (Table 2). In general, there was a decline in elk numbers during the summer as elk migrated to higher pastures, typically on state and federal lands. The exception to this is ranch 5, which provided calving grounds to 250 cow elk. Four of the five ranches supported both resident and migratory populations of elk.

Table 1. Summary of elk herds on individual ranches.

| Ranch | Age Class | Sex ♂ | Sex ♀1 | Sex ♀2 | Calf:Cow ratio | Bull:Cow ratio |
|---|---|---|---|---|---|---|
| 1 | Y1 | 32 | 32 | 0 | 23/100 | 23/100 |
| | Y2 | 29 | 48 | 6 | | |
| | M | 40 | 128 | 110 | | |
| 2 | Y1 | 129 | 128 | 0 | 23/100 | 23/100 |
| | Y2 | 103 | 165 | 20 | | |
| | M | 120 | 441 | 393 | | |
| 3 | Y1 | 106 | 106 | 0 | 23/100 | 10/100 |
| | Y2 | 92 | 146 | 15 | | |
| | M | 120 | 396 | 347 | | |
| 4 | Y1 | 100 | 100 | 0 | 45/100 | 12/100 |
| | Y2 | 17 | 72 | 8 | | |
| | M | 31 | 193 | 168 | | |
| 5 | Y1 | 101 | 101 | 0 | 43/100 | 16/100 |
| | Y2 | 31 | 77 | 9 | | |
| | M | 39 | 210 | 187 | | |

Numbers are totals of herd use throughout the year.
Y1=yearling; Y2=2 year olds; M=3+years
♀1=non-reproductive female; ♀2=reproductive female

Table 2. Summary of elk use on the individual ranches.

| Ranch | Period of Use | Number of Elk | % Olap | AUM |
|---|---|---|---|---|
| 1 | Oct 1 - Nov 30 | 118 | 90 | 110 |
| | Dec 1 - May 15 | 118 | 75 | 262 |
| | May 16 - May 31 | 118 | 75 | 22 |
| | June 1 - Oct 1 | 71 | 40 | 68 |
| 2 | Oct 1- Nov 30 | 200 | 90 | 186 |
| | Dec 1 - Mar 31 | 347 | 20 | 156 |
| | Apr 1 - May 30 | 421 | 40 | 182 |
| | June 1 - Sept 9 | 331 | 50 | 328 |
| | Sept 10 - 30 | 200 | 80 | 70 |
| 3 | Oct 1 - Nov 30 | 290 | 90 | 271 |
| | Dec 1 - Apr 15 | 298 | 85 | 673 |
| | Apr 16 - Jun 20 | 250 | 40 | 111 |
| | Jun 21 - Sept 9 | 200 | 50 | 169 |
| | Sept 10 - 30 | 290 | 80 | 101 |
| 4 | Oct 1 - Nov 30 | 180 | 90 | 157 |
| | Dec 1 - Mar 31 | 180 | 90 | 333 |
| | Apr 1 - Jun 20 | 49 | 40 | 27 |
| | Jun 21 - Sept 9 | 100 | 50 | 83 |
| | Sept 10 - 30 | 180 | 80 | 61 |
| 5 | Oct 1 - Nov 30 | 195 | 90 | 173 |
| | Dec 1 - Apr 15 | 115 | 85 | 245 |
| | May 15 - Aug 15 | 250 | 40 | 168 |
| | Sept 10 - 30 | 195 | 80 | 66 |

%Olap = the percent of dietary and spatial overlap between elk and cattle.

## Integration of Elk Information with Cow Calf Data

The elk forage simulation model was used to determine the forage offtake by elk from the individual ranches. Forage use by elk was equated to AUM that theoretically could have been eaten by cattle if elk were not present and if elk were eating what the cows could access, i.e., hillsides, remote areas, etc.

Using the cow-calf model, ranches were simulated as they were currently managed. To compare how these ranches could theoretically be run if elk were not present, AUMs eaten by elk on the respective ranches, determined by the elk forage simulation model, were added into the cow-calf model for the individual ranches. I looked at how many additional cattle could be maintained on the ranches due to an increase in AUM if elk were not present, and the effects this had on ranch gross margin and cost of production.

## Analysis of Alternative Management Strategies

Elk management strategies are potential methods with which agricultural landowners can reduce conflict between elk and cattle and(or) recover costs associated with elk on private lands. Variability of available resources on ranches and the number of elk utilizing the ranches makes it a difficult to find a single solution to the problem.

For the purpose of this study, we investigated three possible management strategies. The block management strategy is a state government program that helps ranchers manage elk hunters; the exchange of forage program is a combination of federal and state government cooperation in helping landowners recover forage lost to elk; and leasing a ranch to an outfitter

is a private industry, that while not reducing the elk herd through hunting, has the potential of increasing income derived from elk hunting opportunities.

Block Management Strategy

The block management program was initially devised to keep private lands open for public hunting, while rewarding the landowner for allowing free hunter access. Through management of the number and strategic placement of hunters per area, more efficient hunting would ensue, thereby reducing elk herd numbers (Governor's Advisory Council, 1994). In addition to assisting landowners with hunter management, the program also offers benefits that reduce or eliminate the cost of having hunters on private land, and in some cases offers taxable monetary reimbursement of up to $8,000 (Montana Session Laws, 1995).

Allowing for more efficient hunting, each elk herd was simulated at a reduction rate of 10, 20, and 30%. The equivalent AUMs for the reduced herd sizes were used to determine the effect on the ranches available AUMs, number of beef cattle, and gross margins of the individual ranches.

Exchange of Forage

Coordinated grazing of range lands between state, federal, and private lands allows private landowners to rest their pastures that have been grazed by elk during the fall, winter, and(or) spring. With the exchange of forage, landowners do not have to purchase as much stored forage to replace forage removed by elk. Also, by having an exchange of forage program in place, ranchers can potentially reduce the amount of AUM leases (if they are currently leasing) to support their current cow herd size, thereby reducing their cost of

production. For example, members of the Stock Association participating in the Wall Creek Wildlife Management Area exchange of use program received an additional month of livestock grazing, resulting in an extra 826 animal unit months of grazing by cattle (Alt, et al., 1992).

A major limitation of this scenario is that there must be available state and federal lands close enough to the private landowner that trailing cattle to summer range is not a prohibitive cost.

I compared the current fair market value of an AUM lease on private property to the value of an AUM on each of the five ranches in my study. Elk utilizing the private ranges are costing ranchers the respective values per AUM on each ranch. To recover some of the resources used by elk, a rancher could either be paid the fair market value of an AUM or do a direct exchange of forage on public land, i.e., if elk were taking 100 AUMs off of private land, then the rancher would get 100 AUMs for cattle on public land. Which scenario is most advantageous to the rancher is dependent on the value of the ranch's AUM. If the value of a ranch's AUM is above the fair market value, the ranch would be money ahead to accept a direct swap of land rather than a monetary contribution. For those ranches having AUM valued beneath the fair market value, accepting cash for AUMs removed by elk would be more beneficial.

Outfitter Survey

Leasing private land to outfitters in Montana is a common, if controversial practice. Hunters are willing to pay for the right to hunt bull elk, particularly if they are assured of an uncrowded hunt. The willingness to pay allows outfitters to lease land from ranchers at a value that increases the landowners income.

There are several forms of lease hunting that ranchers could benefit from, however, for this study, we chose only the leasing of the land to an outfitter. This method seemed the easiest to measure monetarily. Once the land is leased to an outfitter it is assumed that no further costs associated with hunters, such as time spent managing hunters, helping haul game out, etc., is incurred by the rancher. Also, the monetary value of the lease is set, whereas if a landowner were to lease hunting rights to individual hunters, the income would be variable dependent on the number of hunters wanting to hunt.

A survey was sent out to 100 outfitters in FW&P hunting regions 1, 2, and 3; where elk hunting is more prevalent. The survey consisted of a cover letter explaining the study and what was being asked of the outfitter; general maps of the individual ranches showing county roads and habitat types; and a description of the elk herd that occupied the ranch during hunting season. The elk herd was described by percentage of bulls in various age classes, i.e., spike, raghorn, or brow-tined antler; as well as number of calves per 100 cows and number of bulls per 100 cows (Appendix B). Six weeks after the initial surveys were sent, follow-up phone calls were made to half of the outfitters who had yet to return surveys.

## Statistical Analysis

Five scenarios were simulated in determining the effects of elk on ranches. To meet objective one, ranches were individually simulated as they were currently managed with elk present. The simulations were rerun with elk removed from the ranch, i.e., forage resources utilized by elk were added into the ranch simulation. As part of objective two, each ranch was run with a reduced population of elk of 10, 20, and 30%. Each ranch/scenario combination was replicated ten times.

Analysis of variance was used to evaluate ranch, treatment, and ranch by treatment effects on dependent variables: ranch gross margin, cattle herd size, animal unit months, and cost of production for each ranch. Duncan's multiple range test was used to evaluate differences among ranch and treatment means for ranch gross margin, cattle herd size, animal unit months, and cost of production.

Regressions of AUM values for each ranch were gained through use of the general linear model. Here the model was ranch gross margin dependent on ranch, additional AUM, and additional AUM by ranch.

# CHAPTER 4

# RESULTS

## Cattle Use and Ranch Resources

Ranch resources that impact profitability and define the sustainability of a ranch are cattle herd size, availability of range resources measured here as number of animal unit months (AUM), ranch gross margin, and cost of production ($/kg). All five ranches were different ($p<.01$) from each other with regards to cattle herd size, available AUMs, ranch gross margins, and cost of production (Table 3).

Table 3. Description of ranch resources as currently operated[a].

| Ranch | Herd Size | RGM | AUM | $/kg |
|---|---|---|---|---|
| 1 | 240 | $52,083 | 1,312 | 1.77 |
| 2 | 367 | $87,576 | 2,109 | 1.56 |
| 3 | 827 | $178,789 | 6,979 | 1.47 |
| 4 | 900 | $226,602 | 3,347 | 1.39 |
| 5 | 1194 | $244,930 | 8,700 | 1.74 |

[a] All ranches were significantly different from each other as evaluated by Duncan's Multiple Range test. AUM = AUM of native range.

## Actual Elk Use

Using the elk forage simulation model, the number of AUMs removed by elk was first determined as if an 100% overlap of resource use by elk and cattle existed. The percent overlap put into the model to moderate the AUMs taken by elk was decided upon on an

individual ranch basis and was variable by season of use. For all ranches, AUMs taken off by elk were decreased after an overlap factor was taken into account (Table 4).

Table 4. Actual numbers of elk utilizing the ranches throughout the year[a].

| Ranch | Elk | Elk Months | AUM w/o Overlap | Actual AUM |
|---|---|---|---|---|
| 1 | 425 | 1,243 | 674 | 462 |
| 2 | 1,497 | 3,913 | 2,189 | 922 |
| 3 | 1,326 | 3,228 | 1,836 | 1,325 |
| 4 | 683 | 1,607 | 857 | 661 |
| 5 | 742 | 1,776 | 987 | 654 |

[a] Elk were equated to elk months, AUM as if elk and cattle shared 100% of the resources, AUM taken off by elk after the actual % overlap of elk and cattle use had been taken into account.

An elk month is defined as the 30 days of forage provided for one elk residing on a ranch. For example, if 100 elk were resident on a ranch for 30 days, the ranch would be providing 3000 elk days, or 100 elk months. There was no differentiation between age and sex of animals in this measurement of animal use.

## Elk Animal Unit Equivalents

A standard animal unit month (AUM) is, by definition, the amount of dry matter (DM) in forage a 454 kg beef cow with a calf will eat in a month, generally 360 kg of DM (SRM, 1974). It is a useful method of measuring forage intake, but it is imprecise. A more accurate measure of what an animal eats would be in terms of its caloric intake. An animal eats to meet its energy requirements (Vavra, 1991). The elk intake simulation model uses an animal's metabolizable energy (ME) requirements when determining the intake of the animal. A cow elk in early gestation has a lower level of energy requirements than a cow elk that is lactating

(Nelson and Leege, 1982). The physiological state of the animal is only one of the factors affecting quantity of forage intake by an animal to meet its nutritional needs.

Quality of the forage is also a large determinant of forage intake by an animal. All animals have a physical limit to how much they can eat dependent on the size of the rumen. An animal on a poor quality forage can eat to its fill limit and may never meet its energy requirements. Conversely, an animal on a high quality diet may meet its energy requirements before it meets its fill limit. In both cases, the same animal at the same physiological stage would have eaten differing amounts of dry matter, thereby giving the same animal a different animal unit value. An animal on high quality forage will have a lower AU than an animal on poor quality forage (Table 5).

Table 5. Effects of variable ME/kg DM and physiological state of animals on animal unit values[a].

| | ♂ | | ♀1 | | ♀2$^{G}$ | | ♀2$^{L}$ | |
|---|---|---|---|---|---|---|---|---|
| | Metabolizable energy per kilogram dry matter | | | | | | | |
| Age | 2.00 | 1.70 | 2.00 | 1.70 | 2.00 | 1.70 | 2.00 | 2.13 |
| Y1 | .47 | .56 | .43 | .49 | N/A | N/A | N/A | N/A |
| Y2 | .59 | .67 | .50 | .57 | .49 | .59 | 1.01 | .89 |
| M | .63 | .79 | .51 | .63 | .53 | .65 | .96 | .87 |

[a]Y1 = yearling, Y2 =two-year old animal, and M = mature animal of five-years old or older. G = gestating female and L = lactating female.

## Additional Resources Gained

Using Analysis of Variance (SAS, 1992), all ranches were different ($p<.01$) from each other in terms of available AUM, cow herd size, ranch gross margin, and cost of production ($/kg; Table 6). The two treatments, elk versus no elk, had significant ($p<.01$) effects on

available AUM, cow herd size, and on ranch gross margin, but did not significantly impact cost of production on any of the ranches. Ranch by treatment effect on AUM, herd size, and RGM were significant ($p<.01$) because the effect of removing elk was not constant for each ranch.

Table 6. Analysis of Variance for AUM, cattle, ranch gross margin, and cost of production ($/kg).

| Source | df | AUM | Herd Size | RGM | $/kg |
|---|---|---|---|---|---|
| Ranch | 4 | .0001 | .0001 | .0001 | .0001 |
| Trt | 1 | .0001 | .0001 | .0001 | .1543[a] |
| Ranch x Trt | 4 | .0001 | .0001 | .0001 | .6675[a] |
| R-Square | | 1.000 | .9998 | .9978 | .9748 |

[a] Values are not significant; Trt - treatment; df - Degrees of freedom; AUM - Animal Unit Month; RGM - Ranch Gross Margin.

By increasing forage AUMs available to ranches used by elk, all livestock enterprises increased ($p <.01$) available AUMs, subsequent beef cattle herd size, and ranch gross margin (Table 7). Cost of production ($/kg) for each ranch did not significantly change with the removal of elk.

Table 7. Additional AUMs available to a rancher if all elk were removed from the range, and subsequent additional cattle and income.

| Ranch | Added AUM | Added cattle | Added income | $/kg |
|---|---|---|---|---|
| 1 | 463* | 86* | $3,892* | 1.77 |
| 2 | 924* | 166* | $13,379* | 1.57 |
| 3 | 1,325* | 159* | $19,392* | 1.47 |
| 4 | 661* | 110* | $8,864* | 1.40 |
| 5 | 654* | 91* | $5,691* | 1.74 |

* All figures significantly increased with removal of elk.

## Economic Value of Elk

The cost per elk, elk month, and AUM used by elk were calculated by dividing total number of elk using a ranch, total number of elk months, and added AUM by the additional income, giving an economic value to the elk and the forage elk use. These figures give ranchers an idea of the value of elk on their lands. The cost per AUM is the monetary value each rancher is contributing to have elk on the ranch. The wide variation in cost is mostly attributable to variation in the cost of beef production for the individual ranches as shown in the previous section (Table 6).

Table 8. Dollar values per elk, per elk month, and per AUM for the five ranches.

| Ranch | $/Elk | $/Elk Month | $/AUM |
|---|---|---|---|
| 1 | $9.15 | $3.13 | $8.42 |
| 2 | $8.94 | $4.41 | $14.51 |
| 3 | $14.62 | $6.00 | $14.63 |
| 4 | $12.97 | $5.52 | $13.41 |
| 5 | $7.67 | $3.20 | $8.70 |

## Block Management

The block management alternative to managing elk herds was simulated with the assumption that through block management more efficient hunting would ensue, thereby reducing the elk numbers utilizing the ranch. Elk herds were reduced by 10, 20, and 30%. The effects of these reductions on the ranches available resources were measured in AUM's, additional cattle, and additional ranch gross margin.

All ranches increased ($p<.01$) their available AUMs by reducing elk 10% or more (Figure 1).

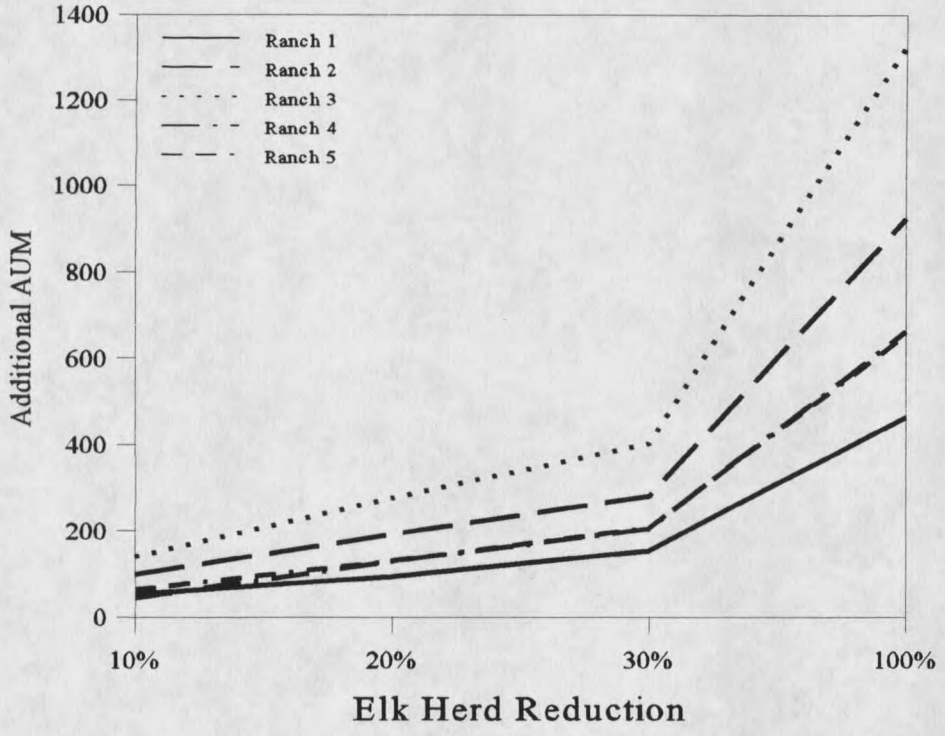


Figure 1. Elk herd effects on available AUM. Note: ranch 4 and 5 lines overlap.

All ranches increased ($p<.01$) their beef cattle herds when elk numbers were reduced by 10% or more (Figure 2).

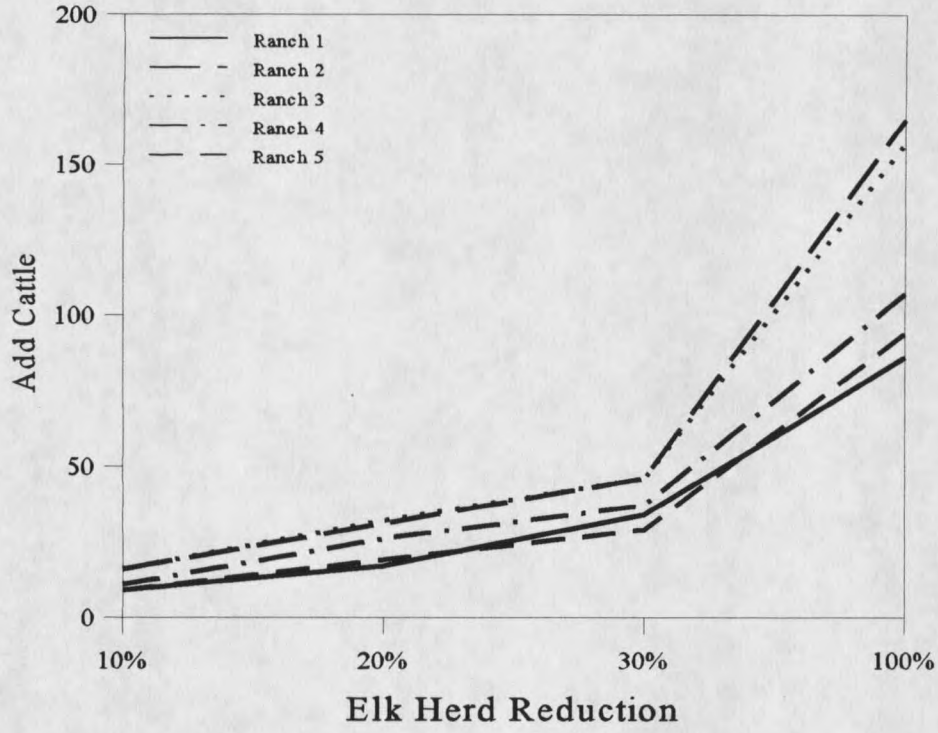


Figure 2. Elk herd effects on cattle herd size.

None of the ranches increased RGM significantly with only a 10% reduction in elk numbers. Ranches 2 and 3 significantly ($p<.01$) increased RGM when elk numbers were reduced by 20% or more. Ranches 1, 4 and 5 were unable to significantly increase their RGM at 30% reduction in elk numbers; however, RGM on these ranches did increase significantly ($p<.01$) with a total elimination of elk (Figure 3).

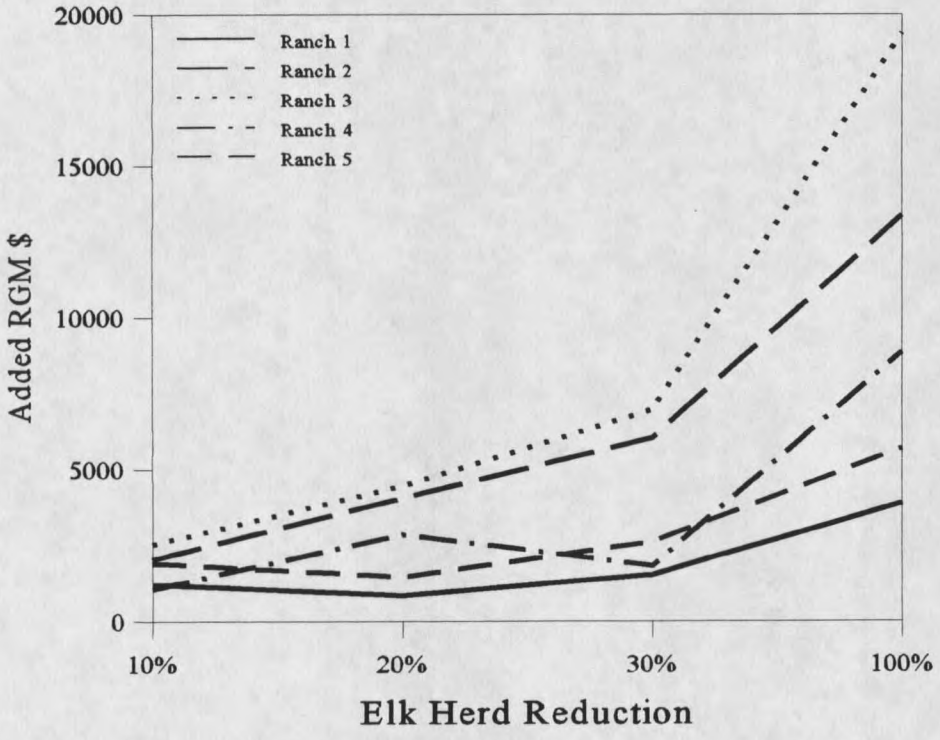


Figure 3. Elk herd effects on ranch gross margin.

## Outfitter survey

Sixteen percent of the surveys were returned with useable information. Outfitters gave conservative estimates as to the value of a one-year lease on the individual ranches for elk hunting only (Table 9).

Table 9. Average lease value of ranches to an outfitter for elk hunting.

| Ranch | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Mean Value, $ | $2,919 | $3,900 | $10,375 | $7,175 | $2,953 |
| Range | $6,700 | $15,000 | $30,000 | $17,700 | $7,500 |
| SD | $2,288 | $3,850 | $7,386 | $5,129 | $2,520 |

SD - Standard Deviation.

A large range of variability among respondents to how much an actual ranch would be worth occurred; ranch 1: $0 - 6,700, ranch 2: $0 - 15,000, ranch 3: $0 - 30,000, ranch 4: $300 - 18,000, and ranch 5: $0 - 7,500. Some of the most common responses to the survey indicated that the ranches would be worth more if: 1) deer hunting was a part of the package; 2) the ranch was part of a larger lease area; and 3) lease period extended over a longer period of time.

## Exchange of Forage Use

The fair market value of an AUM lease is the going price a person would expect to pay if he/she leased land for the purpose of grazing cattle. Using the fair market value of $15 $\pm$ 3.00 for an AUM lease obtained from Montana State University extension specialist, Duane Griffith (personal communication) on private lands, I compared this value to the ranch's current value of an AUM being utilized by elk. It would be more advantageous for some ranchers to accept fair market value of AUMs eaten by elk rather than do a direct exchange of forage use (Table 10). Ranches 1 and 5 should accept monetary compensation for supporting elk on their lands because the values of their AUMs were lower than the going fair market price, $8.42 and $8.70 respectively. Rancher 3 would be better off exchanging forage

use between elk and cattle, while ranches 2 and 4 would breakeven using either alternative depending on the market value of an AUM at the time of determination.

Table 10. Number of AUMs used by elk with corresponding monetary values.

| Ranch | AUM | $/AUM |
|---|---|---|
| 1 | 462 | $8.42 |
| 2 | 922 | $14.51 |
| 3 | 1,325 | $14.63 |
| 4 | 661 | $13.41 |
| 5 | 654 | $8.70 |

# CHAPTER 5

# DISCUSSION

## Actual Elk Use

Numbers of elk utilizing the ranches were conservative at best. With only once yearly flight data to determine the population characteristics of a herd for an entire year, we assumed no recruitment of bachelor bulls took place, and average recruitment through birth occurred.

When spatial and temporal overlap modified dietary overlap, direct competition between cattle and elk was reduced (Vavra et al., 1989). Late fall and winter showed the highest percentages of overlap of up to 90%, with the exception of ranch 2, who felt there was only 20% overlap due to the fact that all hay was stored in "elk-proof" sheds, and elk did not generally intermingle with cattle during winter feeding of hay. In general, summer months showed only a 40% overlap mostly due to changes in dietary preferences of elk from grasses to forbs (Murie, 1951; Mackie, 1970).

## Variations in Cost per AUM

All five ranches had different dollar amounts per AUM on their land ranging from $8.42 to $14.63. This does not necessarily indicate that one rancher is a better land manager than another, but perhaps one rancher has more available resources to work with than another. Ranch 1 fed hay for a longer period of time than the other ranches because of his geographical location; winter comes early and snow covers native vegetation. Thus, ranch 1 had a higher cost of production than the other ranches, reducing the value of an AUM. Ranch 5 may have

more available resources at hand, but reported a 10% death loss of calves. A high death loss will also increase the cost of production in producing marketable beef. The more efficiently a ranch is run, the more valuable range AUMs become, and elk begin to have a greater economic impact on a ranch.

## Block Management

Simulating ranches as if no elk existed enabled us to quantify the economic impact elk had on beef cattle enterprises. However, it is not possible nor legal to remove all elk from a ranch, therefore alternatives for managing elk, not only to reduce herd sizes but to gain some lost income, become vital to the sustainability of Montana ranches.

The block management alternative showed that a removal of 10% of the elk herd had no effect on ranch gross margin, although it significantly increased available AUMs and potential beef herd size. It would take a reduction of 20-30% of the elk herd before 2 out of 5 ranches could significantly increase their ranch gross margins. Even though two of the ranches significantly increased their profits at a 30% reduction of elk, when compared with a total removal of elk, all five ranches were still making a considerable monetary contribution to elk habitat. According to Montana Session Laws (1995) ranches participating in the block management program are entitled to some benefits, including a monetary benefit of up to $8,000, dependent on the type of habitat provided for wildlife, species and number of wildlife present, and access provided to adjacent private and public lands. Depending on the value placed on each ranch, the monetary benefit would help defray the additional cost borne by supporting elk. For example, it costs ranch 1 $3,892 in additional income to support elk. If the ranch participated in the block management program and received a monetary benefit, elk

utilizing the land could now be seen as an asset as opposed to a liability, and as a side benefit, public hunting would be promoted on private lands.

## Outfitter Survey

The initial return of surveys was relatively low. When doing follow-up phone calls to half of the outfitters who did not return surveys, I got a large number of respondents who had no idea how much a lease on private land would be worth because the outfitter only ran his/her business on a public land hunting lease. It was also noted through both written and verbal responses that leases would be worth more if deer hunting were included and if leases were of longer duration than just one year. Most outfitters I spoke with agreed that a ten-year lease was the best arrangement for them. All respondents agreed that it was very difficult to gauge an accurate price quote for a ranch without actually having been on the ranch during a hunting season to see the behavioral patterns and population characteristics of the elk herd. Also, aesthetics, reputation, and rapport between client and outfitter are monetarily hard to measure yet can have a large influence on the price an outfitter is able to get for a hunt (Knight, 1995), which in turn influences the dollar amount for which an outfitter is willing to lease land.

When judging if one elk management strategy is better than another, it is important to note the mean value of the ranches to an outfitter reported in the results section were conservative and may not accurately reflect what a rancher could feasibly gain by outfitting his/her ranch to hunting. However, it is also important to note that some outfitters valued the ranches above what the rancher is contributing to support elk. While the mean values given in the surveys indicated the ranches would be more profitable without elk rather than outfit, several of the ranches are currently outfitted. For example, ranch 3 leased hunting rights for

$25,000/year, and recovered costs incurred by having elk utilize the private range. According to the outfitter survey, this same ranch had a high bid of $30,000 to lease the ranch.

## Exchange of Forage Use

Theoretical advantages of exchanging forage use between elk and cattle have economic and social benefits. The main focus of exchange of use in this study was on the monetary value of such an alternative management scheme. Where feasible, a coordinated exchange of use has other beneficial elements than just recouping costs associated with elk. As noted by Alt et al. (1992), and Frisina and Morin (1991), a cooperative grazing system actually increased available AUM by encouraging a healthy regrowth of forage on the range. This had a secondary effect of keeping elk on wildlife management areas for a longer period of time before elk migrated down to private ranges in search of food. Increased landowner tolerance of elk, while increasing cattle and elk numbers able to use the land (Frisina and Morin, 1991) are other advantages to exchanging use of forage.

## Areas of Further Investigation

I looked at how much a rancher could increase his/her beef cow herd size if he/she were allocated the AUM taken off by elk. Another aspect of this study would be to ascertain if a rancher could move his original herd onto summer range earlier or take them off later if elk were not present, thus increasing the length of time cattle spent on native range. This would reduce the amount of stored forage in the form of hay a rancher would have to feed his cows. One major assumption is that the rancher is limited to the length of time he turns his cows out by available AUM and not by other factors such as snow cover or lack of water

during late summer/early fall. By increasing the availability of natural resources to a rancher, he could reduce his cost of production, thereby increasing the profitability of the beef cow herd.

The elk simulation model could be further refined to mimic a natural elk herd, with nutritional stresses determining reproduction and mortality. With elk farming growing in popularity as a viable alternative to cattle ranching, a model similar to the cow-calf simulation model could be developed to be used as a tool by elk farm managers in optimizing the production of a domestic elk herd.

Elk are also not the only wildlife species that economically impact agricultural lands; deer, both white-tail and mule, can have a significant impact on the productivity of the land (Jordan and Workman, 1989). A deer simulation model, similar to the elk model could be developed to measure the forage offtake by deer.

We looked at only three options of recovering costs associated with elk utilizing private ranges. There are other options such as placing land into a conservation easement, which would not only pay the landowner for the value of the land placed into the easement, but it would also assure that the land would not be subdivided, thereby protecting crucial habitat for wildlife. Other methods include different types of land leases, to include non-consumptive uses of the land from birdwatching to picture taking.

# CHAPTER 6

# CONCLUSION

Both agricultural and wildlife resource managers are in need of information as to how wildlife impacts the economy of a region. In southwestern Montana, elk do have an economic impact on beef cattle enterprises, with the significance of that impact dependent on how efficiently a ranch is run. The more efficiently a ranch is run, the higher the economic impact of elk.

This knowledge is valuable in the fact that it gives managers a tangible range of numbers with which to work. Knowing how elk economically impact private landowners will help wildlife managers to put a price on the value of elk as related to hunting and other non-consumptive uses of wildlife.

There is not a catchall, clear-cut answer to this question, and each ranch should be evaluated on an individual basis as much as possible. Just as every ranch is paying a different amount of money per elk and per AUM, every ranch will have a different solution to the problem. While one ranch may not have the wildlife resources or land base to entice a high price from an outfitter, the ranch may benefit by joining the block management program, exchanging forage, or if possible, both. Other ranches may have the resources and desire to lease their land to an outfitter. Also, ranches, such as ranch 4, may be more heavily impacted by elk during non-hunting seasons, therefore reducing elk numbers through hunting is not always a viable option.

In this study, ranch 1 could increase RGM by $3,892 if all elk were removed. The mean value of their ranch to an outfitter was $2,919, with the maximum lease value at $6,700. The rancher has potential to recover costs associated with elk through outfitting if an outfitter were willing to pay an above average value for the hunting rights; however, under the block management program, the rancher has greater opportunity to reduce elk numbers while receiving a monetary benefit. If a direct exchange of forage use was also incorporated into the elk management scenario, ranch 1 would in effect increase the forage base for his/her cow herd.

While ranches 2 and 4 had greater potential to recoup costs associated with elk through outfitting, $3,900 and $7,175, than did ranch 1, these values fall short of the $13,379 and $8,864 ranches 2 and 4, respectively, are losing to elk. Of the two, ranch 4 would be the most likely to recover costs through outfitting. Ranch 2 should follow a scenario similar to that of the first ranch.

Ranch 5 had the potential to increase his/her ranch gross margin by $5,691, if all elk were removed, while the value of the land to an outfitter was only $2,953. By participating in the block management program, ranch 5 would reduce elk numbers impacting the ranch through managed hunting, as well as recover costs of having elk if he/she were to receive monetary benefits. Another beneficial option for ranch 5 would be a direct exchange of forage use on public land.

Ranch 3 has the greatest potential for covering expenses associated with elk through outfitting, given an average value of $10,375, and a maximum value of $30,000.

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# APPENDICES

# APPENDIX A

# RANCH DESCRIPTIONS

Table 11. Ranch Management Input.

| Ranch | Herd Size | Cow/Bull Ratio | Repro % | Length of Breeding | % Death Loss | Wean & Sale Dates |
|---|---|---|---|---|---|---|
| 1 | 240 | 28 | 92% | 75d | 2.5% | 293 |
| 2 | 367 | 27 | 93% | 60d | 3.0% | 293 |
| 3 | 837 | 23 | 92% | 90d | 3.0% | 312 |
| 4 | 900 | 30 | 92% | 50d | 5.0% | 298 |
| 5 | 1140 | 25 | 95% | 90d | 10.0% | 305 |

Table 12. Ranch Feeding Management.

| Ranch | Mgmt group | Range Turnout | Aftermath Grazing | Begin Winter Feeding | Total Days on Hay |
|---|---|---|---|---|---|
| 1 | 1 | N/A | N/A | Oct 20 | 208 |
| | 2 | May 15 | Sept 24 | Nov 1 | 196 |
| | 3 | May 15 | Sept 24 | Nov 1 | 196 |
| | 4 | May 15 | Sept 24 | Nov 1 | 196 |
| 2 | 1 | N/A | N/A | Oct 20 | 194 |
| | 2 | May 1 | Sept 16 | Nov 1 | 182 |
| | 3 | May 1 | Sept 16 | Nov 1 | 182 |
| | 4 | May 1 | Sept 16 | Nov 1 | 182 |
| 3 | 1 | N/A | N/A | Nov 8 | 145 |
| | 2 | May 1 | Dec 1 | Dec 31 | 122 |
| | 3 | May 1 | Dec 1 | Dec 31 | 122 |
| | 4 | May 1 | Dec 1 | Dec 31 | 122 |
| 4 | 1 | N/A | N/A | Oct 25 | 190 |
| | 2 | June 8 | Oct 1 | Dec 15 | 145 |
| | 3 | June 8 | Oct 1 | Dec 15 | 145 |
| | 4 | June 8 | Oct 1 | Dec 15 | 145 |
| 5 | 1 | N/A | N/A | Nov 1 | 154 |
| | 2 | June 2 | Dec 2 | Dec 31 | 136 |
| | 3 | May 15 | Dec 2 | Dec 31 | 136 |
| | 4 | May 15 | Dec 2 | Dec 31 | 136 |

# APPENDIX B

# OUTFITTER SURVEY

June 13, 1996

Dear Outfitter/guide,

I am a graduate student at Montana State University studying for a master's degree in Animal Science to complement a Bachelor's of Science degree in Wildlife Biology earned from the University of Montana. My thesis project at MSU includes evaluating and quantifying the costs and benefits of elk utilizing private ranges. My professor, Dr. Mike Tess, and I are evaluating various management schemes to recover costs. One of these schemes requires determining how much hunting privileges on a particular ranch would be worth to an outfitter such as yourself. Giving elk a monetary value to the rancher turns the elk into an asset as opposed to a liability.

In the following pages, you will find five different ranch scenarios, each one representative of a ranch in my study. Elk population characteristics were obtained from Montana Fish Wildlife and Parks biologists from each of the areas. I would greatly appreciate your help in determining the value of each ranch as it relates to elk hunting only, from an outfitters standpoint. When evaluating the ranches, assume that they are close to you or other leased property of which you have control. Please do not discount an area because it is not in your specified hunting region.

Please return the "scenario" portion of the questionnaire to me in the enclosed envelope. If you have any questions, or would like clarification about any of the data presented, please call me. During the days I can be reached at Linfield Hall: **994-3728**, or during the evenings at my home: **585-9397**, where you may also leave a message and I will return your call. Thank you very much for your time and consideration.

Sincerely,

Wendy L. Fuller

MAP INDEX

**DSL**: Department of State Lands

**FWP**: Montana Department of Fish, Wildlife, and Parks

**NFS**: National Forest Service

**HAY MEADOWS**: Domestic crops, primarily alfalfa and mixed grass hay.

**TIMBERED PASTURES**: Coniferous forests with some logged meadows interspersed.

**POTHOLE PASTURES**: Native ranges with ponds and wet areas throughout.

**X**: Marks the ranch house

**Double lines**: Indicate roads

**Single lines**: Indicate bodies of water and creeks/rivers

All land within the marked boundaries is deeded unless otherwise stated as being leased. Surrounding lands have been marked as to the ownership (i.e. privately owned vs. publicly owned).

SCENARIO 1

LOCATION AND HUNTING REGION: HD 2XX; The ranch lies northeast of Missoula, and is adjacent to the Blackfoot-Clearwater Wildlife Management Area.

RANCH SIZE:
DEEDED: 3447 ac
LEASED: 1280 ac Lease is on Plum Creek Timber land

NUMBER OF BEEF COWS: 230
DATE TAKEN OFF RANGE: Nov. 1st; begin winter feeding.

NUMBER OF ELK USING LAND DURING HUNTING SEASON:
TOTAL: 100-120
DATE ON RANGE: mid-September through mid-May.

HERD CHARACTERISITICS:
AGE/SEX RATIOS:
COW: 69%
CALF: 15%
YEARLING BULL: 7%
RAGHORN BULL: 2%
MATURE BULL: 6%
CALVES PER 100 COWS: 23/100
BULLS PER 100 COWS: 23/100

HABITAT PROVIDED TO ELK: Security cover in timbered areas and pothole pastures with natural water source; Agricultural fields.

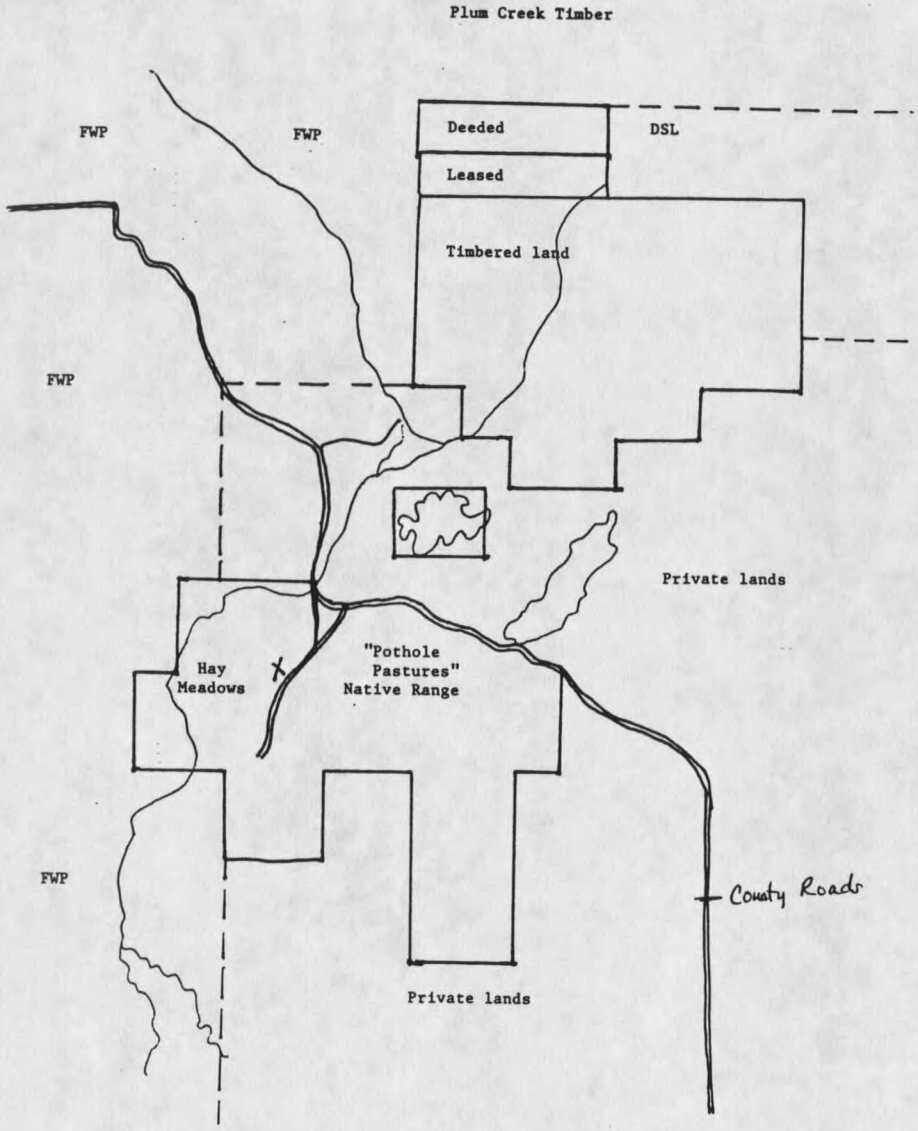
ACCESS AND FACILITIES AVAILABLE TO OUTFITTER AND CLIENTS: Outfitter has access via logging roads to all areas of deeded lands. There are no facilities available such as cabins or temporary corrals for horses. Outfitter determines number of hunters per season. Outfitter would have full control of hunting, including family mambers.

OTHER: * Ranch is currently participating in the Block Mgmt Program with FWP.
* Once disturbed, the elk move onto FWP lands or onto adjacent private lands which are also participating in the Block Mgmt Program.

MONETARY VALUE FOR A SEASONAL LEASE:_____

PLEASE COMMENT ON ANY OTHER FACTORS THAT WOULD MAKE THIS LAND MORE OR LESS VALUABLE TO YOU AS AN OUTFITTER ENTERING INTO THE LEASE.

SCENARIO 1


Plum Creek Timber
FWP
FWP
Deeded
DSL
Leased
Timbered land
FWP
Private lands
Hay
Meadows
"Pothole
Pastures"
Native Range
FWP
County Roads
Private lands

SCENARIO 2

LOCATION AND HUNTING REGION: HD 2XX; The ranch is located near Ovando.

RANCH SIZE:
DEEDED: 4500 ac
LEASED: 480 ac Lease is on Plum Creek Timber land

NUMBER OF BEEF COWS: 350
DATE TAKEN OFF RANGE: Nov. 10

NUMBER OF ELK USING LAND DURING HUNTING SEASON:
TOTAL: 200
DATE ON RANGE: Early August through the end of November.

HERD CHARACTERISITICS:
AGE/SEX RATIOS:
COW: 69%
CALF: 15%
YEARLING BULL: 7%
RAGHORN BULL: 2%
MATURE BULL: 6%
CALVES PER 100 COWS: 23/100
BULLS PER 100 COWS: 23/100

HABITAT PROVIDED TO ELK: Riparian areas, security cover in timbered areas, agricultural fields.

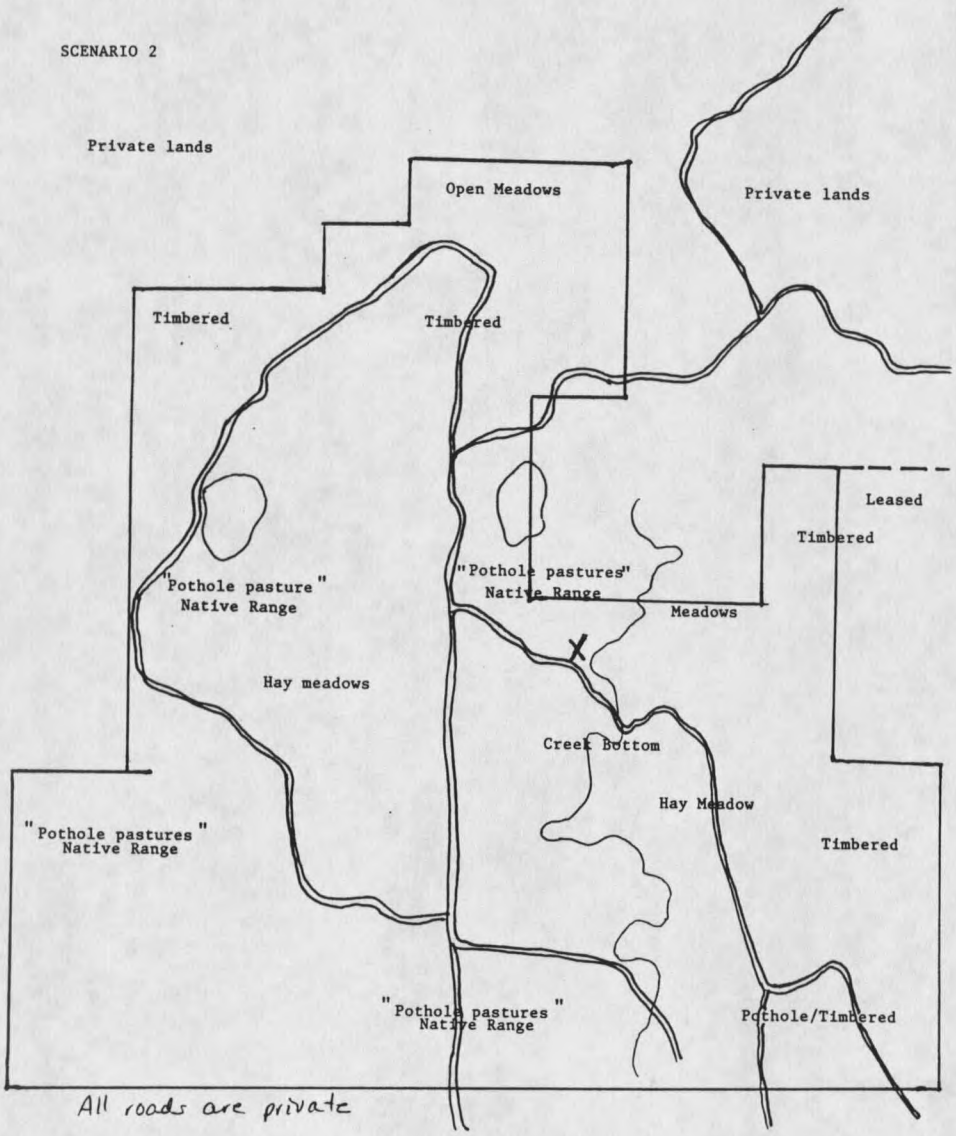
ACCESS AND FACILITIES AVAILABLE TO OUTFITTER AND CLIENTS: No facilities are available. Outfitter has access to all roads via motorized vehicles or horses and is restricted to deeded land only. Four family members would hunt at their own discretion; outfitter would control the rest.

OTHER: * Ranch is currently participating in the Block Mgmt Program with FWP.
* Once elk are disturbed, they move onto the other private lands; there is very little cover for them on this ranch.

MONETARY VALUE FOR A SEASONAL LEASE:_____

PLEASE COMMENT ON ANY OTHER FACTORS THAT WOULD MAKE THIS LAND MORE OR LESS VALUABLE TO YOU AS AN OUTFITTER ENTERING INTO THE LEASE.

SCENARIO 2


Private lands
Open Meadows
Private lands
Timbered
Timbered
Leased
Timbered
"Pothole pasture"
Native Range
"Pothole pastures"
Native Range
Meadows
Hay meadows
Creek Bottom
Hay Meadow
"Pothole pastures"
Native Range
Timbered
"Pothole pastures"
Native Range
Pothole/Timbered
All roads are private

SCENARIO 3

LOCATION AND HUNTING REGION: HD 3XX; The ranch is located adjacent to the Bridger Mountain range.

RANCH SIZE:
DEEDED: 21160 ac
LEASED: 3840 ac Lease is on National Forest Service

NUMBER OF BEEF COWS: 500
DATE TAKEN OFF RANGE: end of January

NUMBER OF ELK USING LAND DURING HUNTING SEASON:
TOTAL: 300
DATE ON RANGE: late August - April

HERD CHARACTERISITICS:
AGE/SEX RATIOS:
COWS: 68%
CALVES: 16%
SPIKE BULLS: 7%
BROW-TINED BULLS: 9%
CALVES PER 100 COWS: 23/100
BULLS PER 100 COWS: 10/100

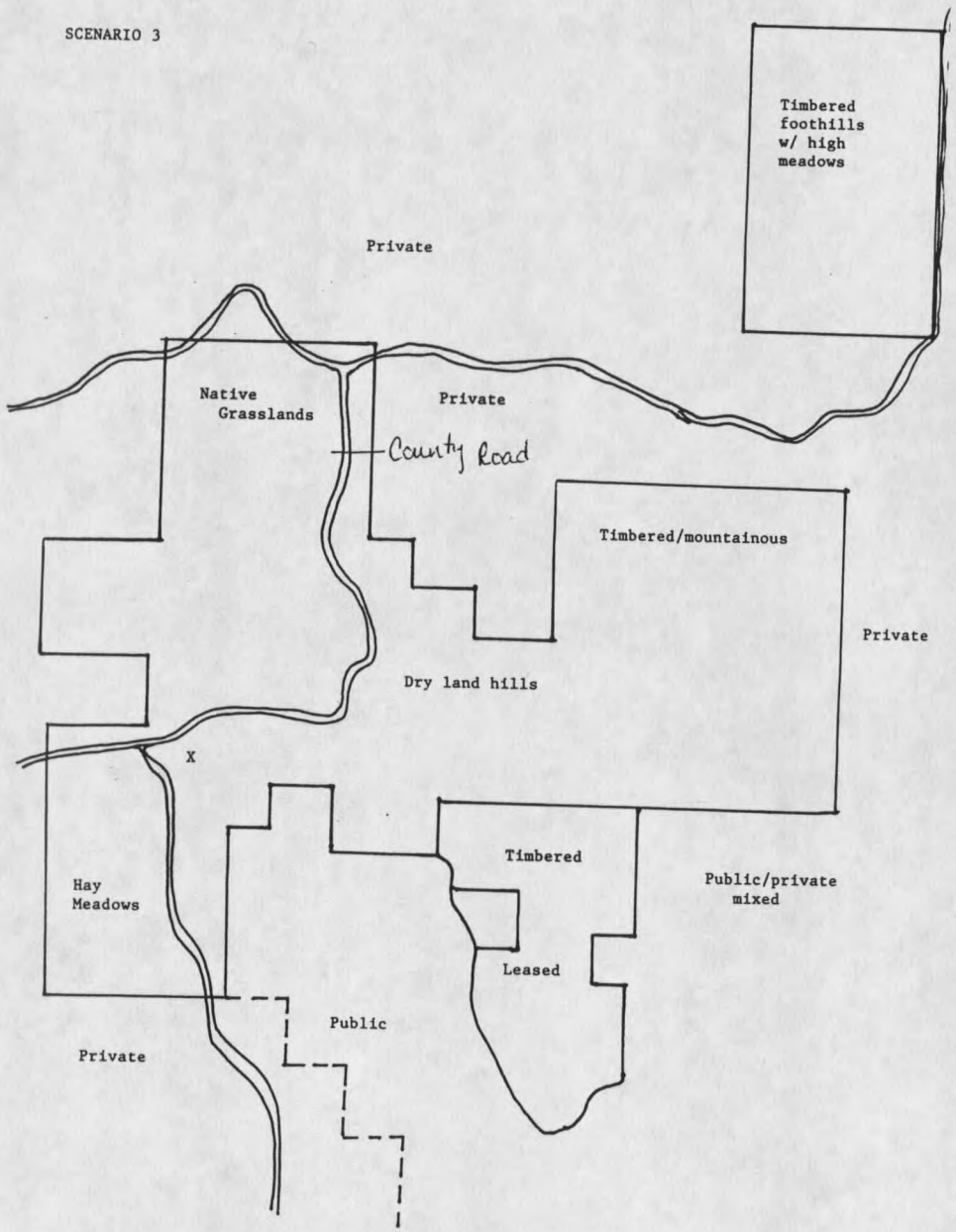
HABITAT PROVIDED TO ELK: Security cover in timbered areas; agricultural fields, open range with sagebrush/bunchgrass type vegetation.

ACCESS AND FACILITIES AVAILABLE TO OUTFITTER AND CLIENTS:
Outfitter has access to all roads on the ranch, as well as room for horses. Basic cabin with room for seven hunters plus outfitter.

OTHER: * Family participates in late season cow hunt.
* Ranch is currently being outfitted with an 82% success rate for cow elk and a 63% success rate for brow-tined bulls.

MONETARY VALUE FOR A SEASONAL LEASE:_____

PLEASE COMMENT ON ANY OTHER FACTORS THAT WOULD MAKE THIS LAND MORE OR LESS VALUABLE TO YOU AS AN OUTFITTER ENTERING INTO THE LEASE.


SCENARIO 3
Timbered foothills w/ high meadows
Private
Native Grasslands
Private
County Road
Timbered/mountainous
Private
Dry land hills
X
Timbered
Public/private mixed
Hay Meadows
Leased
Public
Private

SCENARIO 4

LOCATION AND HUNTING REGION: HD 4XX; The ranch is located near White Sulpher Springs.

RANCH SIZE:
DEEDED: 6000 ac
LEASED: 4000 ac Lease is on private land.

NUMBER OF BEEF COWS: 800
DATE TAKEN OFF RANGE: first of December

NUMBER OF ELK USING LAND DURING HUNTING SEASON:
TOTAL: 225
DATE ON RANGE: late August - June

HERD CHARACTERISITICS:
AGE/SEX RATIOS:
COW: 64%
CALF: 29%
BULL: 7%
CALVES PER 100 COWS: 45/100
BULLS PER 100 COWS: 12/100 (refers to all antlered bulls)

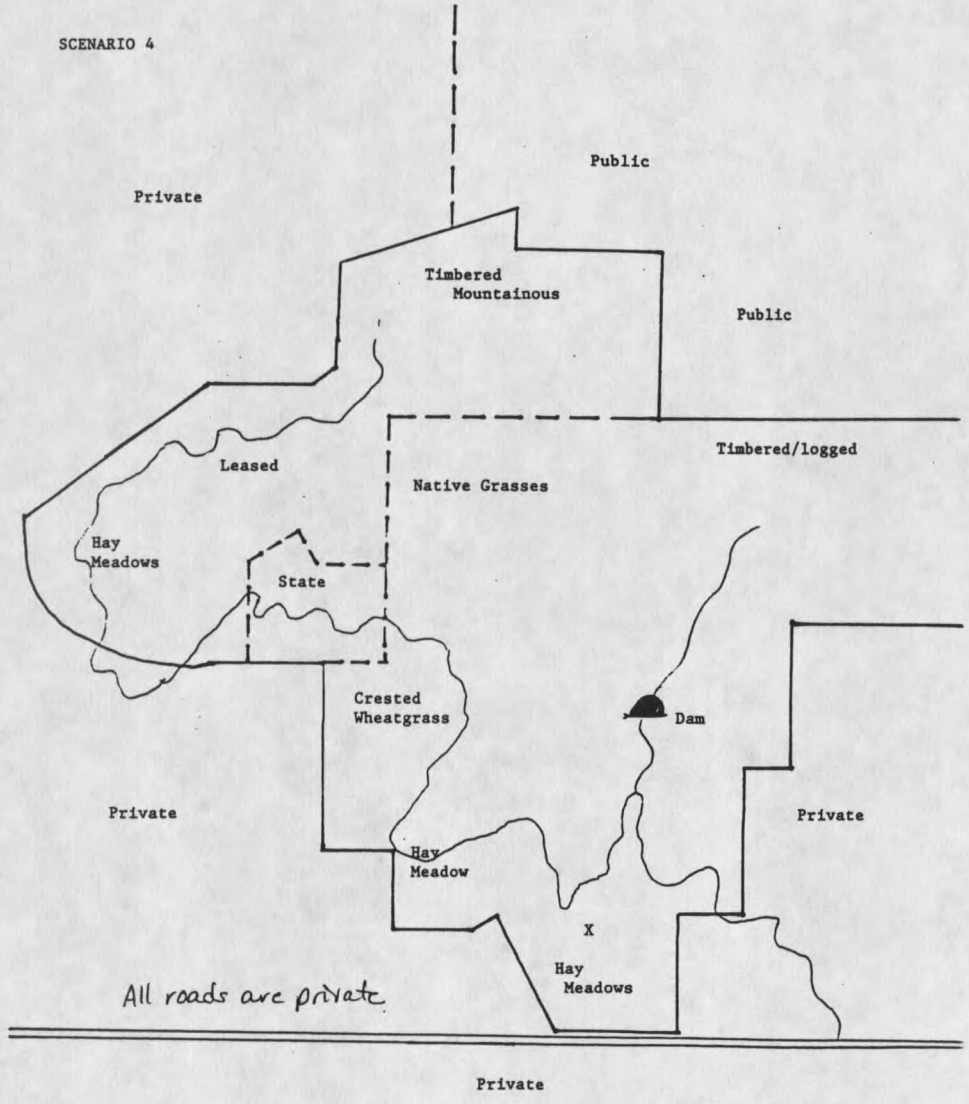
HABITAT PROVIDED TO ELK: Security cover in coulees, timbered areas, and agricultural crops, along with native grasses.

ACCESS AND FACILITIES AVAILABLE TO OUTFITTER AND CLIENTS:
Outfitter has access to both deeded and leased lands via motorized vehicles and horseback. There is one cabin which will accomodate six clients plus the outfitter.

OTHER: * Ranch is currently being outfitted for archery and rifle sesaon.
* Family members hunt when outfitter okays it.

MONETARY VALUE FOR A SEASONAL LEASE:_____

PLEASE COMMENT ON ANY OTHER FACTORS THAT WOULD MAKE THIS LAND MORE OR LESS VALUABLE TO YOU AS AN OUTFITTER ENTERING INTO THE LEASE.


SCENARIO 4
Public
Private
Timbered
Mountainous
Public
Timbered/logged
Leased
Native Grasses
Hay
Meadows
State
Crested
Wheatgrass
Dam
Private
Private
Hay
Meadow
X
Hay
Meadows
All roads are private
Private

SCENARIO 5

LOCATION AND HUNTING REGION: HD 3XX; Ranch is located south of Livingston.
RANCH SIZE:
DEEDED: 15000 ac
LEASED: 4092 ac Lease is on Department of State Lands and National Forest Service land.

NUMBER OF DOMESETIC COWS: 1050
DATE TAKEN OFF RANGE: December - January 1

NUMBER OF ELK USING LAND DURING HUNTING SEASON:
TOTAL: 123
DATE ON RANGE: Mid September through November.

HERD CHARACTERISITICS:
AGE/SEX RATIOS:
COWS: 64%
CALVES: 27%
YEARLING BULLS: 4%
MATURE BULLS: 5% (defined as 2 1/2+ y.o.)
CALVES PER 100 COWS: 43/100
BULLS PER 100 COWS: 16/100

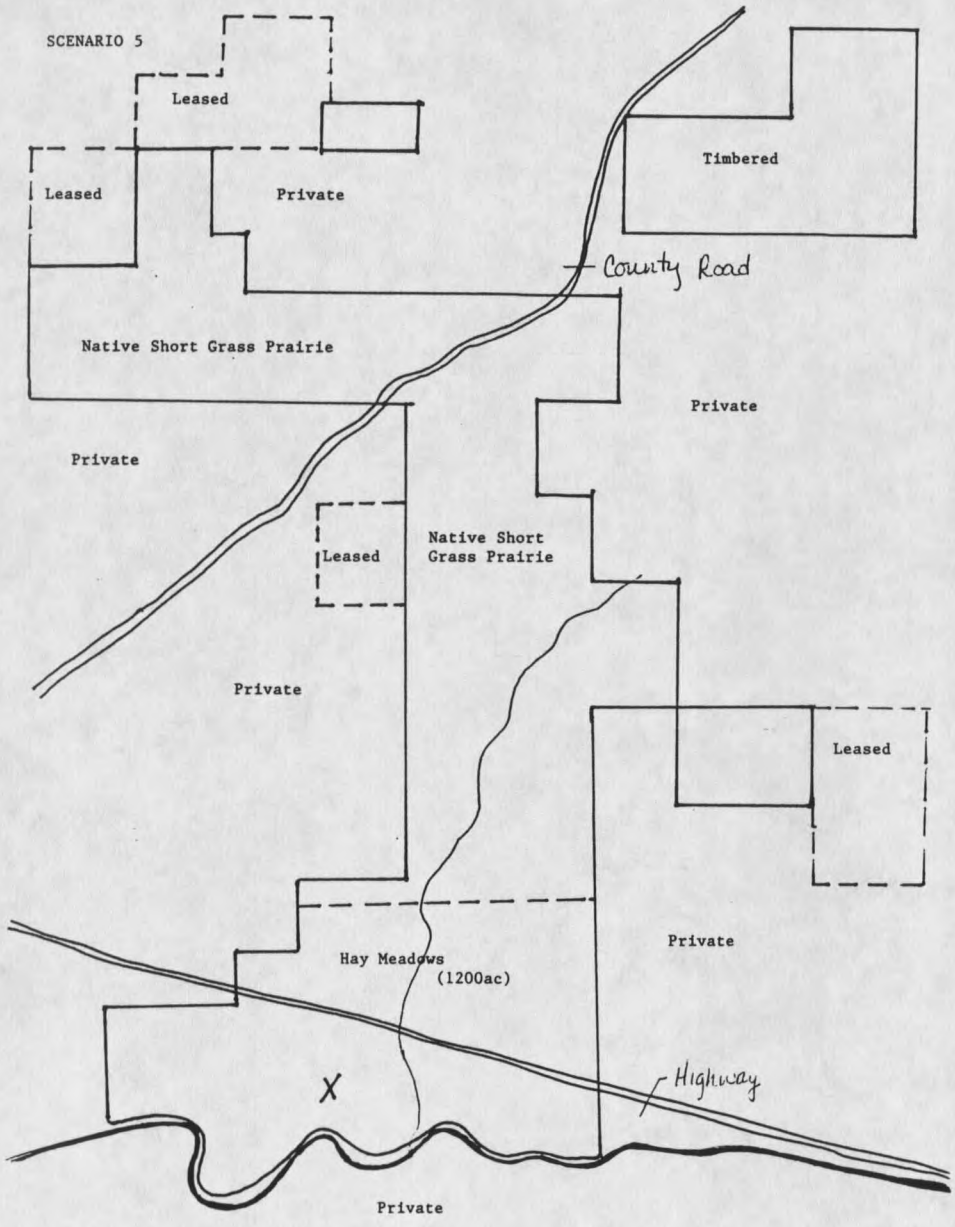
HABITAT PROVIDED TO ELK: very little security cover, most of the habitat is open, short grass prairie type.

ACCESS AND FACILITIES AVAILABLE TO OUTFITTER AND CLIENTS: Outfitter may use any and all of the roads on the ranch. All roads are open to motorized vehicles. A one-room cabin is available for use by the outfitter and clients. The outfitter also controls the number of hunters coming on to hunt.

Only the deeded land is available to the outfitter, and public hunting is allowed on the leased sections of land, although those are open to horse and foot travel only. Also, the hay meadows (1200 ac) are closed to the outfitter and open to the public to hunt cow elk during the hunting season.

OTHER: * Family members hunt in hay meadows for cow elk; outfitter controls the rest.
* Ranch is currently being outfitted with a 90% success rate for cow elk and a 70% success rate for brow-tined bulls.

MONETARY VALUE FOR A SEASONAL LEASE:_____
PLEASE COMMENT ON ANY OTHER FACTORS THAT WOULD MAKE THIS LAND MORE OR LESS VALUABLE TO YOU AS AN OUTFITTER.


SCENARIO 5
Leased
Leased
Private
Timbered
County Road
Native Short Grass Prairie
Private
Private
Leased
Native Short
Grass Prairie
Private
Leased
Private
Hay Meadows
(1200ac)
X
Highway
Private