Elk use of various sized cattle exclosures
by Jeffrey Alan Gross

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


Abstract:
Delineation of elk and cattle impacts on rangelands is necessary for proper management of forage resources in certain areas of the intermountain west. Cattle exclosures have been used as a tool for this delineation. By comparing the area inside the exclosure to the area adjacent to the exclosure, impacts of cattle on rangeland can be measured. Problems may arise using this technique in areas with elk when it is assumed that elk use the area inside an exclosure an equal amount to the area adjacent to the exclosure. Difference in elk use of the area inside, versus adjacent to an exclosure, may be caused by the size of the exclosure. The objectives of this study were to (1) determine if elk use is equal inside and adjacent to several different sized cattle exclosures; (2) determine if elk use is equal for all sizes of cattle exclosure tested; (3) determine if there is a correlation between exclosure size and elk use of the exclosure; (4) determine if data from this study can be used to predict a minimum exclosure size to be used in areas with elk. This study was conducted on the Blackfoot Clearwater Wildlife Management Area approximately 70 km northeast of Missoula, MT. Seven different sized cattle exclosures (4.00, 2.00, 1.00, 0.50, 0.25, 0.10, and 0.05 ha) were used in this study. Trackplots, 1 m2 areas cleared of vegetation, were used inside and adjacent to each exclosure to monitor elk use (presence) . Data was collected in the spring of 1996 and 1997, from snow melt (early to mid-April) through mid-June. Chi-square tests indicated elk use the area inside each exclosure less ($P<0.1$) than the area adjacent to each exclosure for all exclosure sizes tested. According to my ANOVA there was not a difference ($P<0.1$) in elk use of the exclosure sizes tested; however, my regression analysis indicated a significant correlation between exclosure size and elk use ($P<0.03$). Elk use increased ($P<0.03$) with increasing exclosure size. Assuming a linear relationship exists beyond my data set, my regression model predicted an exclosure would need to be considerably larger than 4.00 ha in size to facilitate equal elk use inside and adjacent to the exclosure. My results did not coincide with the recommended minimum exclosure size (0.4 ha), in the literature, to be used in areas with elk. Logistically, it may be impractical to build an exclosure large enough to account for the effect of exclosure size on elk use of the exclosure. Dropping the fence when cattle are not present, or using exclosures when elk numbers are low may reduce the effect of exclosure size. The effect of size should be considered when experimental cattle exclosures are being used in areas with elk.

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of the requirements for the degree

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APPROVAL

of a thesis submitted by

Jeffrey Alan Gross

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.

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**ABSTRACT**

Delineation of elk and cattle impacts on rangelands is necessary for proper management of forage resources in certain areas of the intermountain west. Cattle exclosures have been used as a tool for this delineation. By comparing the area inside the exclosure to the area adjacent to the exclosure, impacts of cattle on rangeland can be measured. Problems may arise using this technique in areas with elk when it is assumed that elk use the area inside an exclosure an equal amount to the area adjacent to the exclosure. Difference in elk use of the area inside, versus adjacent to an exclosure, may be caused by the size of the exclosure. The objectives of this study were to (1) determine if elk use is equal inside and adjacent to several different sized cattle exclosures; (2) determine if elk use is equal for all sizes of cattle exclosure tested; (3) determine if there is a correlation between exclosure size and elk use of the exclosure; (4) determine if data from this study can be used to predict a minimum exclosure size to be used in areas with elk. This study was conducted on the Blackfoot Clearwater Wildlife Management Area approximately 70 km northeast of Missoula, MT. Seven different sized cattle exclosures (4.00, 2.00, 1.00, 0.50, 0.25, 0.10, and 0.05 ha) were used in this study. Trackplots, 1 $m^2$ areas cleared of vegetation, were used inside and adjacent to each exclosure to monitor elk use (presence). Data was collected in the spring of 1996 and 1997, from snow melt (early to mid-April) through mid-June. Chi-square tests indicated elk use the area inside each exclosure less ($P<0.1$) than the area adjacent to each exclosure for all exclosure sizes tested. According to my ANOVA there was not a difference ($P<0.1$) in elk use of the exclosure sizes tested; however, my regression analysis indicated a significant correlation between exclosure size and elk use ($P<0.03$). Elk use increased ($P<0.03$) with increasing exclosure size. Assuming a linear relationship exists beyond my data set, my regression model predicted an exclosure would need to be considerably larger than 4.00 ha in size to facilitate equal elk use inside and adjacent to the exclosure. My results did not coincide with the recommended minimum exclosure size (0.4 ha), in the literature, to be used in areas with elk. Logistically, it may be impractical to build an exclosure large enough to account for the effect of exclosure size on elk use of the exclosure. Dropping the fence when cattle are not present, or using exclosures when elk numbers are low may reduce the effect of exclosure size. The effect of size should be considered when experimental cattle exclosures are being used in areas with elk.

# CHAPTER 1

## INTRODUCTION

Proper allocation of forage between livestock and wild ungulates on public and private rangelands has become an important issue in recent years. This is most evident in areas with considerable overlap of cattle (*Bos taurus*) and elk (*Cervus elaphus*) range. In Montana, land owned by the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), Montana Department of Fish, Wildlife and Parks (MFWP), and private ranches on or near elk winter ranges are of greatest concern. Spatial, temporal, and dietary overlap can occur between cattle and elk (Wisdom and Thomas 1996). It is important to delineate the impacts of cattle from the impacts of elk to make proper management decisions involving stocking rates and timing of use on cattle grazing allotments (Berg and Hudson 1982, Miller and Vavra 1982, Kasworm et al. 1984, Lyon 1985).

Livestock exclosures are used to separate the impacts of livestock and wild ungulates on rangelands (Cook and Stubbendieck 1986). Problems may arise using this technique in areas with elk when it is assumed that elk use the area inside an exclosure in the same proportion as adjacent areas. Difference in elk use of the area inside versus adjacent to an exclosure may be caused by the size of the exclosure. Several sources recommend using a minimum livestock exclosure size of 0.4 ha in areas populated with wild ungulates (Young 1958, Tueller and Tower 1979, Yoakum et al. 1980). Young (1958) conducted the only study which quantified this recommendation. Young concluded that a livestock exclosure should be a minimum of 0.4 ha in size to facilitate equal wild ungulate (elk) use inside and adjacent to the exclosure. However, this conclusion was inferred from the data and was not statistically tested.

The purpose of my study was to determine if elk use is equal inside and adjacent to several different sized cattle exclosures. I also wanted to determine if elk use is equal for all exclosure sizes tested and if there was a relationship between elk use inside the exclosures and exclosure size. Finally, I wanted to determine if data from this study could be used to predict how large a cattle exclosure needs to be to facilitate equal elk use inside and adjacent to the exclosure. The null hypotheses I tested were 1) elk use inside a cattle exclosure is equal to elk use adjacent to a cattle exclosure for all sizes of cattle exclosure tested, and 2) elk use of exclosures is proportionally equal for all exclosure sizes tested.

# CHAPTER 2

# LITERATURE REVIEW

## Introduction

This literature review will begin with an overview of livestock/wild ungulate interactions and how researchers and resource managers addressed them in the past. The review will then focus on cattle and elk impacts on rangelands of the west and management of cattle and elk under multiple-use objectives. Efforts to manage Montana rangelands for cattle and elk will be reviewed next followed by the reasons for monitoring rangelands. The definition of an exclosure will be given followed by an explanation of how exclosures can be used to delineate the effects of cattle and elk on rangelands. Past and present use of exclosures by researchers and resource managers will then be reviewed. Finally, the influence of exclosure size on elk use of livestock exclosures will be reviewed.

## Livestock/Wild Ungulate Interactions

Livestock/wild ungulate interactions on rangelands have been an important issue since the beginning of this century (Laycock 1994). Previous studies of livestock/wild ungulate interactions have focused on competition for resources, most often forage (Smith 1950, Grumbles 1964, Julander and Jeffrey 1964, Morris 1956, McMahn 1964, Willms et al. 1979, McLean and Willms 1982, Vavra et al. 1982). Early studies generally addressed the issue of competition by dealing with the impacts of livestock separately from the impacts of wild ungulates (Holloran 1943, Morris 1956, Julander and Jeffrey 1964, McMahn and Ramsey 1965). Effects of livestock and wild ungulates on rangelands include the influences of grazing, trampling, and defecation on vegetation, soils, watershed and landform. Management recommendations resulting from these studies usually involved reduction or elimination of the impacts of livestock or wild ungulates in favor of the other (Halloran 1943, Julander 1962, Jensen et al. 1972).

In the past few decades researchers and agency personnel have revised the way they approach livestock/wild ungulate interactions. In the 1960's and 1970's several laws and planning acts were created, including Public Law 86-517, June 12, 1960, Public Law 88-607, September 19, 1964, the 1974 Forest and Rangelands Renewable Resources Planning Act (RPA), the 1976 National Forest Management Act (NFMA), and the 1976 Federal Land Policy and Management Act (FLPMA), that required the implementation of multiple use and sustained yield policies on most public lands (Hormay 1970). These influences led researchers and public resource managers to conduct research and design management plans aimed at multiple use of resources.

Since the 1960's, research has illustrated that livestock and wild ungulates can coexist on rangelands with proper management (Jensen et al. 1972, Smith et al. 1979, Fulgham et al. 1982, Austin et al. 1983, Austin and Urness 1986, Frisina and Morin 1991, Alt et al. 1992, Frisina 1992). Research has demonstrated that livestock grazing can be used as a tool to improve rangeland for wild ungulates (Mueggler 1950, Anderson and Scherzinger 1975, Willms et al. 1979, Willms et al. 1981, Longhurst et al. 1982, Neal 1982, Reiner and Urness 1982, Urness 1982, Jourdannais and Bedunah 1985, Jourdannais and Bedunah 1990, Rhodes and Sharrow 1990, Urness 1990, Yeo et al. 1993, Vavra and Sheehy 1996).

## Managing Range for Elk and Livestock

Because of their spatial, temporal, and dietary overlap in many areas of the west, cattle and elk are among the most likely of competitors on rangelands of North America (Wisdom and Thomas 1996). With demands for affordable cattle forage in a depressed cattle market, wildlife management practices aimed at sustaining or increasing elk numbers to meet hunter demands, and the proliferation of subdivision on prime rangeland and elk winter range, demand on range forage in certain areas of the intermountain west is at an all time high (Lyon 1985, Vavra and Sheehy 1996).

Westoby et al. (1989) suggests plant species composition can be influenced by the effects of herbivory. This idea is supported by numerous studies showing livestock and wild ungulates can effect forage species composition and production on rangelands (Mueggler 1950, Julander 1962, Jones 1965, Yeo et al. 1990, Wikeem and Pitt 1991). Over utilization of range forage by cattle and elk, caused by improper forage allocation, can have a cumulative effect resulting in undesirable impacts on rangeland vegetation (Friedel 1991, Westoby et al. 1989). Smith and Doell (1968) stated interspecific competition among plants is affected markedly by animal influences. Significant animal-vegetation interactions have been observed on foothill ranges in the intermountain areas that are grazed by elk and cattle. Therefore, it appears necessary to balance elk and cattle pressures on range plants in order to maintain plant communities which are productive for both kinds of animals (Smith and Doell 1968). This is a desirable objective under multiple use.

## Efforts in Montana

In recent years, state and federal agencies, in Montana, have cooperated with private ranchers to develop coordinated management programs to properly allocate resources to livestock and elk on elk winter ranges. The Sun River, Fleecer, Wall Creek, Mount Haggin, and Blackfoot Clearwater Wildlife Management Areas have all developed coordinated management programs (Jourdonnais and Bedunah 1990, Frisina and Morin 1991, Frisina 1992, Alt et al. 1992). These management programs utilize rest-rotation grazing principles, under multiple-use land management, as described by Hormay (1970). The programs have improved the quality and quantity of forage for cattle and elk on and around these winter ranges (Jourdonnais and Bedunah 1990, Frisina and Morin 1991, Frisina 1992, Alt et al. 1992).

## Need for Monitoring

Although these coordinated management programs demonstrate a balance can exist between elk and cattle use of range vegetation, an accurate means of monitoring the effects of elk and cattle on rangelands is necessary to perpetuate proper allocation of resources between elk and cattle. Anderson and Currier (1973) emphasized that timely management checks provide guidelines for determining needed adjustments and additional treatments in range resource management. Therefore, if species composition and production of rangeland vegetation is being driven in an undesirable direction, in areas utilized by both cattle and elk, it is important to distinguish the effects of cattle from the effects of elk to make proper management decisions. This delineation of livestock and wild ungulate impacts on rangeland vegetation is one of the most difficult problems facing today's multiple use resource managers. Wisdom and Thomas (1996) stated without question, the most confounding and frustrating process facing resource managers today is that of stocking allocation between wild and domestic ungulates. The most widely used technique to delineate livestock and wild ungulate impacts on range vegetation is the use of livestock exclosures (Cook and Stubbendieck 1986, Laycock 1994).

## Definition of an Exclosure

Daubenmire (1940) defines an exclosure as..."any experimental area which is protected from the activities of a particular class of animal by a barrier such as a fence." Exclosures have been used in studies conducted on grasslands, shrublands, in forests, and along riparian areas to exclude insects, rodents, rabbits, wild ungulates, and livestock (Daubinmire 1940, Young 1958, Bryant 1982). For the purposes of this review I will focus on experimental livestock and big game exclosures used on rangelands.

## Delineation of Livestock/Wild Ungulate Impacts Using Exclosures

Two types of exclosures are generally used to delineate livestock and wild ungulate impacts on rangelands. The first is a livestock exclosure, which is generally constructed of woven wire or 3 to 4-strand barbwire fence 0.8 to 1.0 m in height (Yoakum et al. 1980, Willms et al. 1981, Rhodes and Sharrow 1990). The livestock exclosure is designed to exclude livestock from a given area while allowing wild ungulates to enter by jumping over or crawling through the fence (Young 1956, Jones 1965, Julander 1958, Tueller and Tower 1979, Austin et al. 1983, Austin and Urness 1986, Rhodes and Sharrow 1990). The second type of exclosure is a big game exclosure constructed of 1.8 to 2.5 m tall woven wire fence (Young 1956, Austin et al. 1983, Austin and Urness 1986). The big game exclosure is designed to restrict access to livestock and wild ungulates. By excluding livestock and/or wild ungulates from a given area, comparisons can be made between areas accessible to livestock and wild ungulates (generally located adjacent to an exclosure), wild ungulates only, and areas to which neither have access. This information is used to delineate the effects of livestock from the effects of wild ungulates on rangeland.

## Use of Exclosures

Use of experimental big game and livestock exclosures began in the 1930's. Early studies utilizing exclosures were initiated in response to competition between livestock and wild ungulates for forage resources on public lands. Exclosures were used in 1932 in southern Utah when public land agencies' policies concerning resource allocation between increasing deer numbers and livestock conflicted with the interests of stockmen and sportsmen (Young 1956). The stockmen, threatened with grazing allotment reductions, believed the increasing deer populations, not livestock, were mainly responsible for the deterioration of range conditions in southern Utah. The sportsmen contended the deer population was not a problem and resisted proposals to increase the deer harvest. To address this problem, exclosures were built to delineate the effects of livestock and wild ungulates on rangelands.

Since 1932, exclosures have been used by researchers and resource managers to study factors associated with grazing. These factors include, level of forage utilization, effects on forage productivity and species composition, selectivity of range forage, impacts to big game habitats, and influence on livestock and big game distribution (Young 1956, Young 1958, Julander 1958, Jones 1965, Smith et al. 1979, Tueller and Tower 1979, Willms et al. 1981, Bryant 1982, Austin et al. 1983, Kosco and Bartolone 1983, Austin and Urness 1986, Brand and Goetz 1986, Hironaka 1986, Rhodes and Sharrow 1990, Schulz and Leininger 1990).

Young's (1956) survey of exclosures in Utah looked at 36 different exclosures with 10 smaller than 0.2 ha, 10 from 0.2 to 0.4 ha, and 16 from 0.4 to 1.7 ha. Thirty of these exclosures were divided in half with one side designed to exclude livestock, but allow access to wild ungulates (livestock exclosure), and the other side to exclude livestock and wild ungulates (big game exclosure). The remaining 6 exclosures were designed to exclude livestock (livestock exclosure) while allowing access to wild ungulates. Thirty-four of the exclosures were on Forest Service property, 1 was on Utah State Department of Fish and Game property, and 1 was on U.S. Bureau of Land Management property. All 36 exclosures were located in areas populated by mule deer (*Odocioleus hemionus*), 3 were in areas with elk, 24 were in areas with cattle, and 2 were in areas with domestic sheep (*Ovis aries*). Agency personnel and researchers used these exclosures to determine livestock and wild ungulate effects on vegetative species composition, density and growth forms of range plants, litter, and soil.

Julander (1958) used 30.5 X 30.5 m livestock exclosures, both alone and paired with big game exclosures, to look at diet and area overlap of deer and livestock. Livestock exclosures were designed to allow access by deer. This study was conducted in Fishlake National Forest in Utah.

Jones (1965) used 24 big game exclosures and nine livestock exclosures to delineate the effects of grazing by elk and cattle on range vegetation in Northwest Wyoming. The livestock exclosures were designed to allow elk to enter while excluding cattle. By examining the exclosures pictured in the article and assuming there was 4.5-6.0 m between posts, I concluded the exclosures were approximately 0.4 ha in size.

Tueller and Tower (1979) utilized 0.4 ha big game and livestock exclosures to delineate the effects of livestock and deer grazing on annual forage production and to determine levels of forage utilization. The livestock exclosures were designed to allow access by deer. This study was conducted on four Nevada deer ranges.

Willms et al. (1981) used 0.67 ha cattle exclosures to determine forage selection by mule deer on control, previously burned, and previously grazed plots. The exclosures were designed to allow access of free-ranging deer. This study was conducted in British Columbia.

Rhodes and Sharrow (1990) used 900 $m^2$ livestock exclosures to exclude sheep grazing from a portion of Oregon coastal range populated by black-tailed deer (*Odocoileus hemionus columbianus*) and Roosevelt elk (*Cervus elaphus roosevelti*). Forage inside the exclosure was compared to sheep-grazed forage adjacent to the exclosure to evaluate the effects of sheep grazing on quality and quantity of forage for big game animals. The exclosures were designed to exclude sheep while allowing access to deer and elk.

Austin and Urness (1986) utilized 0.1 ha livestock exclosures to exclude livestock grazing on an area of mule deer winter range in southern Utah. Area and diet selection of deer was compared on grazed and ungrazed areas. Exclosures were designed to allow access by mule deer prior to and during cattle grazing. This study used the same techniques Austin et al. used in a similar study in 1983.

The BLM and the USFS use livestock and big game exclosures to monitor effects of livestock and wild ungulates on federal rangelands. The BLM and USFS exclosure construction guidelines parallel the design described by Young (1956). BLM guidelines recommend exclosure sizes range from 6.7 to 13.5 ha in size and USFS guidelines recommend exclosures 0.4 to 2.0 ha in size. Guidelines of both agencies describe cattle exclosures designed to allow access by big game animals.

## Influence of Exclosure Size

To delineate effects of wild ungulates and livestock on rangelands, using cattle excosures, wild ungulate use must be equal inside and adjacent to the exclosure. Young (1958) suggested that wild ungulate use of livestock exclosures could be inhibited if the exclosure encompasses too small of an area. Several sources address the effects of livestock exclosure size on wild ungulate use of the area inside the exclosure (Young 1956, Julander 1958, Tueller and Tower 1979, Yoakum et al. 1980, Cook and Stubbendieck 1986, Laycock 1994). These sources suggest experimental livestock exclosures should be a minimum of 0.4 ha in size in areas populated by wild ungulates. Julander (1958), Tueller and Tower (1979), and Young (1956) are the only sources that scientifically tested wild ungulate use of livestock exclosures.

Julander (1958) found deer use of 30.5 X 30.5 m cattle exclosures varied. Some exclosures had greater deer use inside than outside, some had more use outside than inside, and some had equal use inside and outside. Deer use was monitored by pellet group counts. Differences in deer use inside and adjacent to exclosures were determined with a test of differences; however, specific statistical methods were not explained.

Tueller and Tower (1979) found that mule deer use of 0.405 ha livestock exclosures was not significantly different ($P<0.05$) from deer use of an adjacent 0.405 ha unfenced area using a t-test for paired plots. Comparisons were made by counting pellet groups in ten 0.004 ha plots inside and adjacent to each exclosure, converting these numbers into deer-days and calculating use per acre.

Young's (1956) study is the only previous study, I was able to find, testing wild ungulate use of more than one size of livestock exclosure. Young looked at exclosures from < 0.2 to 1.7 ha in size. Young showed evidence that there were differences in wild ungulate use of various sized exclosures. He concluded the minimum exclosure size in areas populated with wild ungulates should be 0.4 ha in size; however, his conclusions were inferred from the data and not statistically proven. Young discussed the effects of exclosure size on elk use; however, only three of Young's exclosures were in areas with elk, and elk use was never measured.

After a review of the scientific literature I was unable to locate any scientific evidence to support a recommendation of a minimum cattle exclosure size to be used in areas populated with elk. Therefore, it appears there is a need for scientific information concerning the effect of livestock exclosure size on elk use of the area inside experimental livestock exclosures.

# CHAPTER 3

# METHODS

## Study Site

### General Description and Climate

Livestock exclosures were constructed in 2 pastures (A and B) on the Blackfoot Clearwater Wildlife Management Area approximately 70 km northeast of Missoula, MT. Pasture A is approximately 450 ha in size and pasture B is approximately 250 ha in size. Temperatures range from a mean of -8.4 degrees C in January to 16.8 degrees C in July (Steele 1981). Mean annual precipitation is 45 cm and ranges from 30-75 cm (Steele 1981). Over 66% of the annual precipitation often falls from December through June (Steele 1978). Winter snow accumulations in the area can be substantial, with accumulations of > 100 cm in the surrounding areas above 1,800 m (Baty 1995).

### Vegetation

Vegetation in study pasture A is dominated by timothy (*Phleum pratense*) and is surrounded by stands of Douglas-fir (*Pseudosuga menziessii*). Additional species of range vegetation include rough fescue (*Festuca scabrella*), western wheatgrass (*Agropyron smithii*), bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria cristata*), bluegrass (*Poa* spp.), spotted knapweed (*Centaurea maculosa*), arrowleaf balsamroot (*Balsamorhiza sagittata*), lupine (*Lupinus* spp.), and sticky geranium (*Geranium viscosissimum*).

Vegetation in study pasture B is dominated by rough fescue. Additional species of range vegetation include western wheatgrass, bluebunch wheatgrass, Idaho fescue, prairie junegrass, bluegrass, spotted knapweed, arrowleaf balsamroot, lupine, and sticky geranium.

Ungulate Use

Wild ungulates that use the pastures include elk, white-tailed deer (*Ococoileus virginianus*), and mule deer. These pastures are part of an elk winter range, but due to snow pack from January through April the pastures are not used by elk and mule deer until spring. White-tailed deer utilize the pastures and surrounding area throughout the year. Prior to 1995, pasture A was excluded from livestock grazing since 1948 (Personnel Commun. Mike Thompson, MFWP). Pasture A supplied forage to 120 cow/calf pairs for six weeks in the fall of 1995 and six weeks in the spring of 1996. Pasture B has been excluded from livestock grazing since 1948. For the purposes of this study, elk use was defined as the presence of an elk inside or adjacent to a cattle exclosure and was quantified using a monitoring index.

Exclosure Design

Exclosures were constructed of 3 strands of barbwire with the top strand 1.0 m above the ground. Wood posts were used at the corners of the exclosures and metal t-posts, spaced 6.0 m apart, were used to support the wire between the corner posts. Exclosures were constructed in the shape of a square.

## Study Design and Exclosure Layout

The parameters to be estimated by this study, included elk use inside and adjacent to the exclosure sizes tested. A randomized block design was used in this study. In pasture A, two sets (transects 1 and 2) of seven different sized exclosures were randomly located along a line (exclosure line) with a minimum of 50.0 m between each exclosure (Fig. 1). Exclosures were 0.05, 0.10, 0.25, 0.50, 1.00, 2.00, and 4.00 ha in size. In pasture B, two sets (transects 3 and 4) of three different sized exclosures were randomly located along a line with a minimum of 50.0 m between each exclosure (Fig. 1). Exclosures were 0.05, 0.50, and 2.00 ha in size.

Each transect in the two pastures represented a block for a total of four blocks. Each exclosure size represented one treatment for a total of seven treatments. The experimental unit was defined as an individual cattle exclosure with two replicates of the 0.10, 0.25, 1.00 and 4.00 ha exclosure sizes, and four replicates of the 0.05, 0.50 and 2.00 ha exclosure sizes. Exclosure sizes tested were chosen to reflect sizes equal to, above, and below those recommended in the literature.

Vegetative type, slope, and exposure were kept as similar as possible inside and adjacent to each exclosure to ensure similar conditions when comparing elk use inside and adjacent to each exclosure (Young 1958). The fence was dropped during the 6-week periods when cattle were present to allow grazing inside and adjacent to exclosures. Grazing adjacent to, but not inside an exclosure, could have influenced elk use due to differences in vegetation associated with grazing.

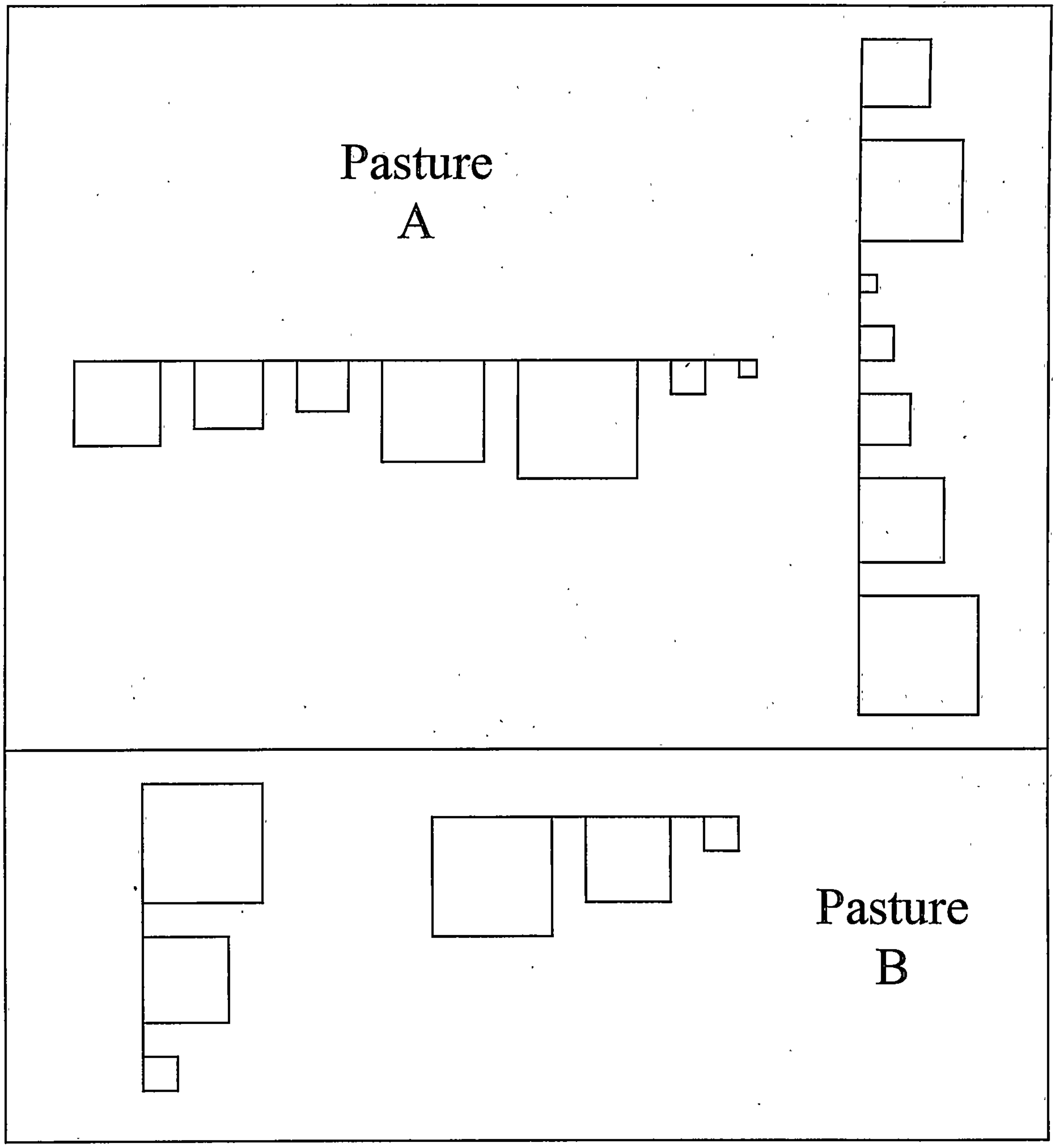


Figure 1. Exclosure layout.

## Monitoring Index

Elk use inside and adjacent to each exclosure was monitored through the use of trackplots. One meter square trackplots (areas cleared of vegetation to expose bare soil) were evenly spaced along the centerline of each exclosure parallel to the exclosure line (Fig. 2). Three track plots were located in the 0.05, 0.10, 0.25, 0.50, and 1.00 ha exclosures, 5 in the 2.00 ha exclosures, and 7 in the 4.00 ha exclosures. An equal number of trackplots were located 25 m outside each exclosure, spaced equally to those inside the exclosure, parallel to the exclosure line (Fig. 2). Trackplots were monitored every 2-4 days when the ground was free from snow, and when there were elk in the study area (mid-April to mid-June). Data was collected on 13 different days in 1996 and 20 different days in 1997.

When one or more elk hoof prints were found in a trackplot the trackplot was considered hit. Total numbers of hit trackplots inside and adjacent to each exclosure were recorded on each day data was collected. Elk hoof prints were cleared from trackplots each day data was collected to assure that the same hoof prints were not counted twice. Total numbers of trackplots hit inside each exclosure were pooled at the end of each year. Total numbers of trackplots hit adjacent to each exclosure were pooled at the end of each year. Total numbers of trackplots hit inside and adjacent to an exclosure during one year equaled one observation. If there were no trackplots hit during an observation the observation was dropped from the final data set. Mean number of trackplots hit inside and adjacent to each exclosure size tested was used to quantify elk use.

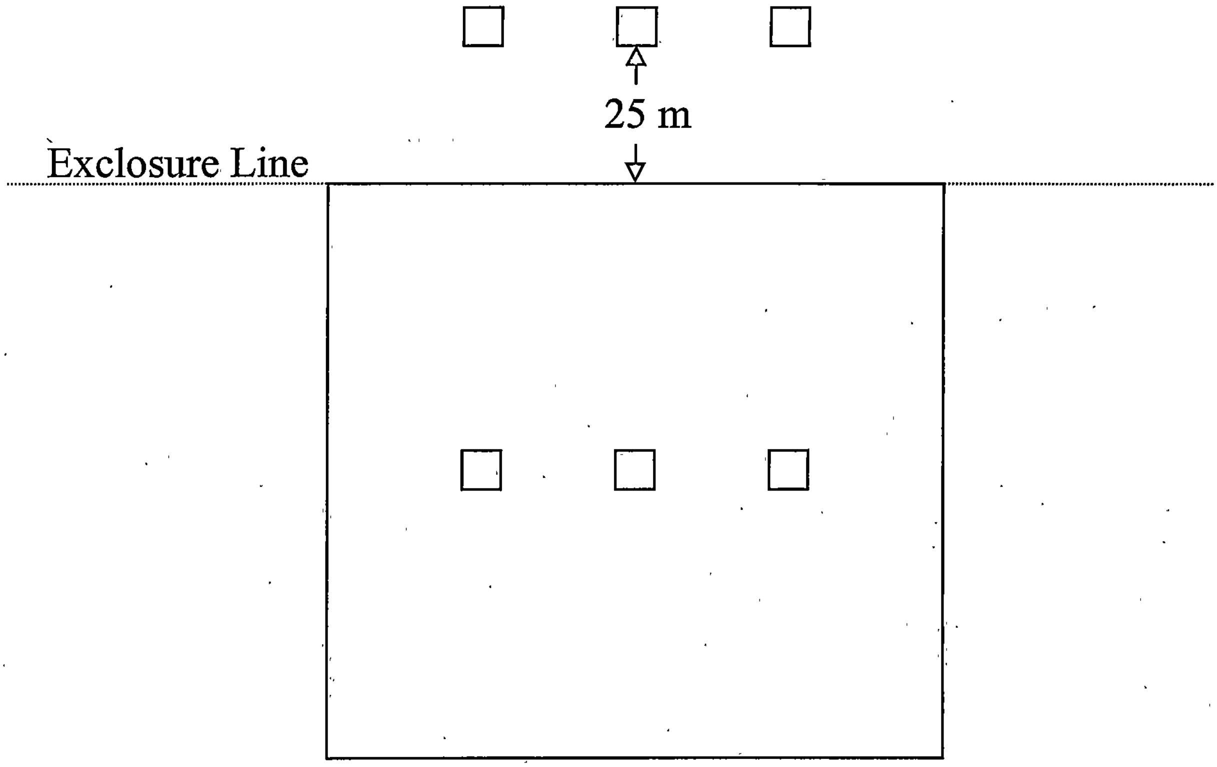


Figure 2. Example of trackplot layout.

## Statistical Analysis

Chi-square tests were used to test for significant differences ($P<0.1$) in elk use inside and adjacent to each size of cattle exclosure tested. Mean number of trackplots hit inside and adjacent to each exclosure size was used in this test.

An analysis of variance (ANOVA) was conducted, using the general linear model in SAS, to test for differences in elk use of the exclosure sizes tested (SAS 1985). Elk use was converted to a proportion (total elk use = proportion of elk use inside an exclosure + proportion of elk use adjacent to an exclosure) to account for the variability of the relative area sampled by the trackplots for the exclosure sizes tested. Treatment effect, block effect, year effect, all interactions, and random error were included in the initial model. Interactions that were not significant ($P<0.1$) were dropped from the final model. All main effects were kept in the final model, even if they did not have a significant p-value ($P<0.1$), to account for variability associated with these factors.

Regression analysis was conducted, using the general linear model of SAS (1985) to determine the correlation between elk use and exclosure size ($P<0.1$). Elk use was converted to a proportion (total elk use = proportion of elk use inside an exclosure + proportion of elk use outside an exclosure) to account for the variability of the relative area sampled by the trackplots for the exclosure sizes tested. Treatment effect, block effect, year effect, all interactions, and random error were included in the initial model. Interactions that were not significant ($P<0.1$) were dropped from the final model. All main effects were kept in the final model, even if they did not have a significant p-value ($P<0.1$), to account for variability associated with these factors.

# CHAPTER 4

# RESULTS

## Elk Use Inside and Adjacent to Exclosures

Chi-square tests showed that the area inside each exclosure size was used less than the area adjacent to each exclosure size (Table 1, Fig. 3). Degrees of freedom for each exclosure size varied due to unequal numbers of observations. Numbers of observations for each exclosure size varied due to different numbers of replications for the exclosure sizes tested and observations dropped due to lack of trackplot hits (Appendix A).

Table 1. Chi-square values for elk use of exclosures.

| Exclosure Size (ha) | $\chi^2$ | Degrees of Freedom | P-value |
|---|---|---|---|
| 0.05 | 16.0 | 5[1] | 0.007 |
| 0.10 | 6.6 | 3[2] | 0.085 |
| 0.25 | 2.7 | 1[3] | 0.100 |
| 0.50 | 13.3 | 3 | 0.004 |
| 1.00 | 9.6 | 3 | 0.022 |
| 2.00 | 18.3 | 3 | 0.003 |
| 4.00 | 11.6 | 3 | 0.009 |

[1] $\chi^2_{0.1}$ with 5 d.f.=9.2
[2] $\chi^2_{0.1}$ with 3 d.f.=6.3
[3] $\chi^2_{0.1}$ with 1 d.f.=2.7

## Elk Use of Different Sized Exclosures

There were no interactions between any of the main effects in the ANOVA test (Appendix B, Table 4). Therefore, interactions were removed from the final model. The ANOVA test did not indicate a difference in elk use of the exclosure sizes tested (Table 2). There was no difference between transects and there was a difference between years (Table 2).

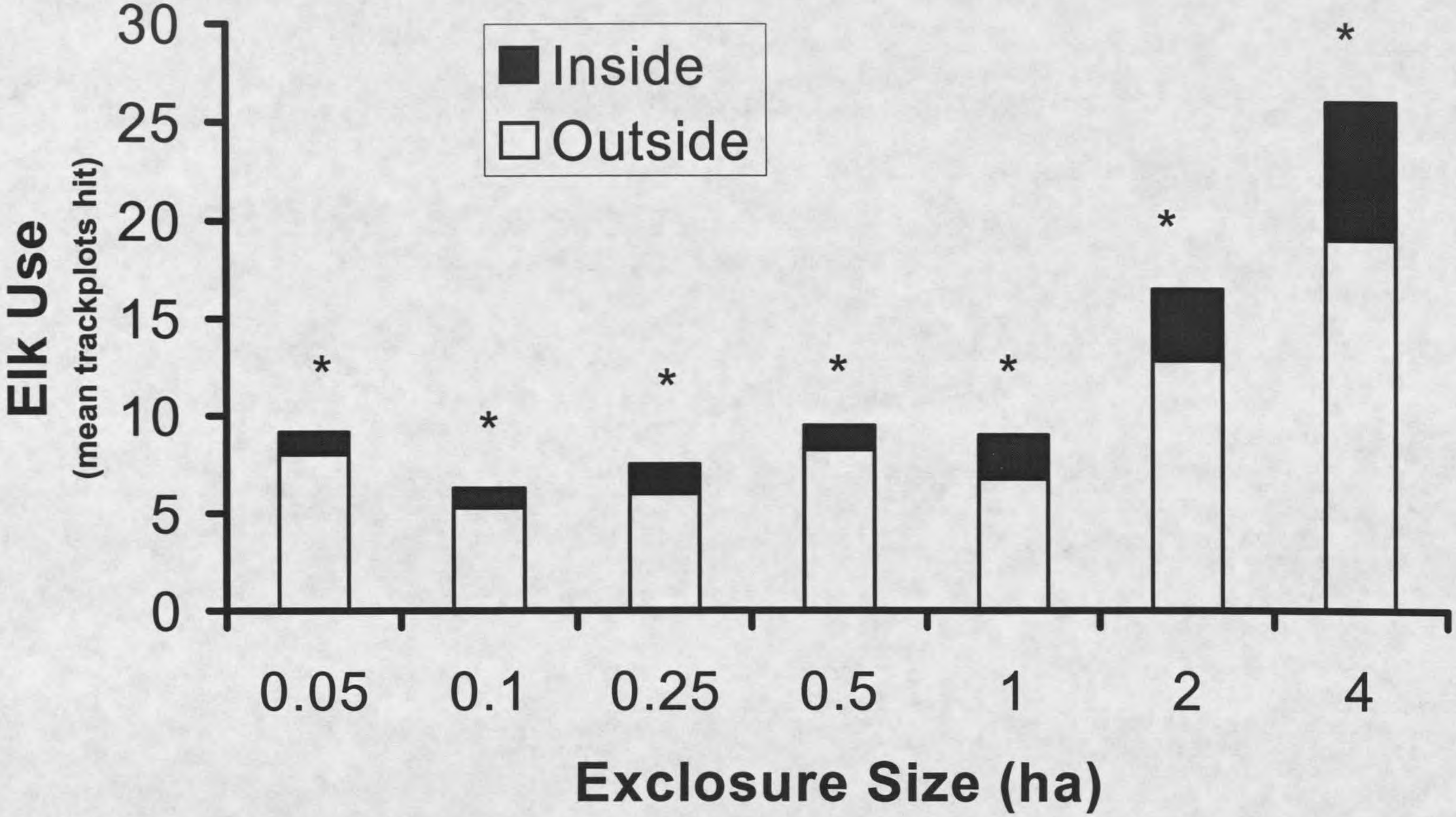


Figure 3. Elk use of the area inside and adjacent to exclosures. Asterisk * indicates a significant chi-square value, P<0.1.

Table 2. Reduced ANOVA model.

| Source | DF | SS | MS | F-value | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 0.0508 | 0.0508 | 3.86 | 0.0644 |
| Transect | 3 | 0.0152 | 0.0051 | 0.38 | 0.7656 |
| Treatment | 6 | 0.1004 | 0.0167 | 1.27 | 0.3167 |

There were no interactions between any of the main effects in the regression analysis (Appendix B, Table 5). Therefore, interactions were removed from the final model. Regression analysis indicated there was a relationship between elk use inside the exclosure and exclosure size (Fig. 4, Table 3). The linear regression indicated an increase in elk use inside the exclosure with increasing exclosure size. There was no difference between transects, and there was a difference between years.

Table 3. Reduced regression model.

| Source | DF | SS | MS | F-value | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 0.0508 | 0.0508 | 4.37 | 0.0474 |
| Transect | 3 | 0.0152 | 0.0051 | 0.44 | 0.7268 |
| Exclosure Size | 1 | 0.0716 | 0.0716 | 6.16 | 0.0204 |

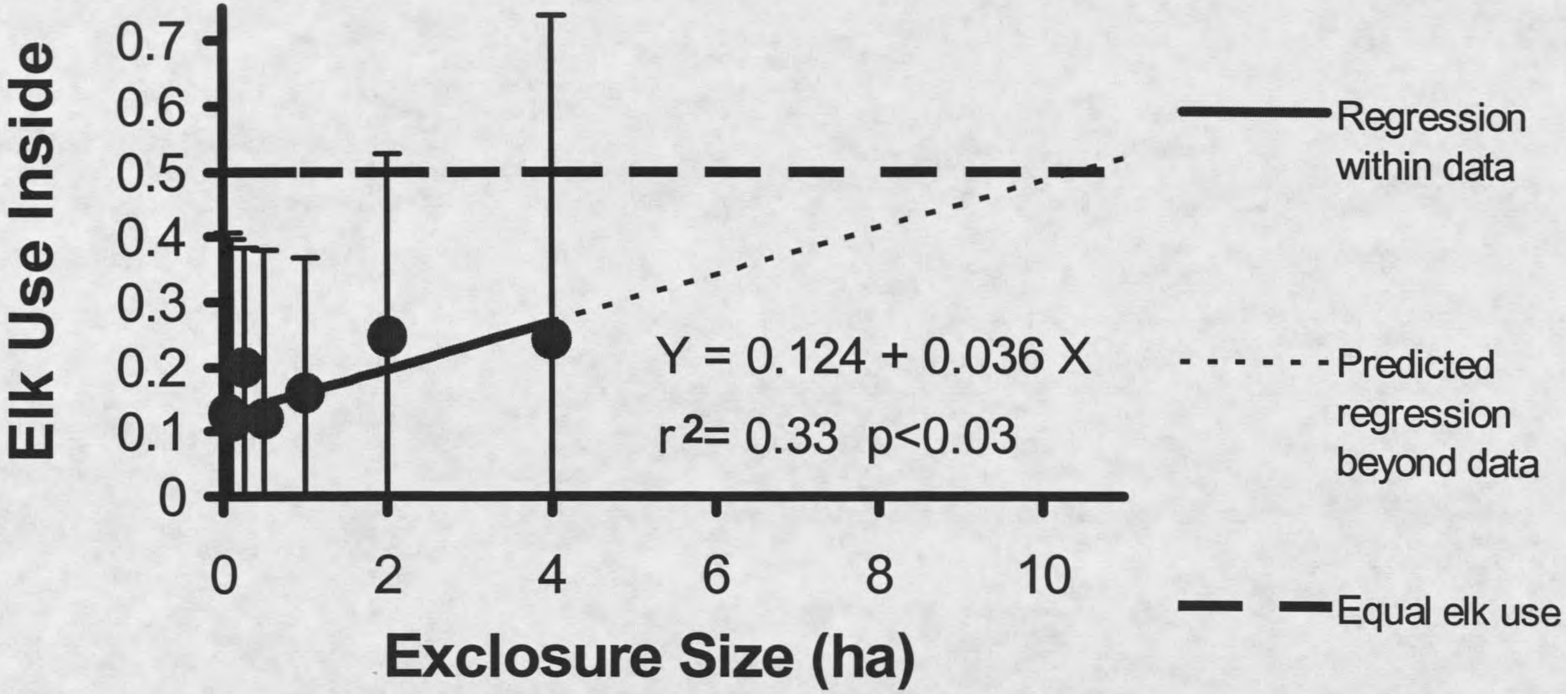


Figure 4. Proportion of elk use inside exclosures.

# CHAPTER 5

# DISCUSSION

## Elk Use Inside and Adjacent to Exclosures

Elk did not use the area inside any size exclosure tested as much as the area adjacent to the exclosure. Therefore, I rejected my first null hypothesis 1) elk use inside a cattle exclosure is equal to elk use adjacent to a cattle exclosure for all sizes of cattle exclosure tested.

I suggest two explanations why elk did not enter my exclosures. Elk may have been able to see the opposite side of the exclosure and realized they could walk around it. Also, observations by myself and others indicate that sometimes elk simply do not choose to cross fences. I have observed elk approach a fence and instead of jumping over it, parallel the fence in an apparent attempt to find a way around.

Julander's (1958) and Tueller and Tower's (1979) findings of equal deer presence inside and adjacent to 0.09 and 0.4 ha exclosures do not coincide with our findings. The applicability of their findings to elk may be confounded due to interspecific differences between deer and elk. They also may have lacked sufficient statistical power to detect a difference in deer use inside and adjacent to their exclosures (Steidl 1997). Lack of power in their study could be attributed to an inadequate sample size or an inappropriate alpha level for their design (Steidl 1997). Hayes (1987) points out that inappropriate management recommendations could be made if statistical power is not considered when a null hypothesis is not rejected.

Young's (1956) conclusions also differ from my findings. Although Young's study makes reference to elk use of exclosures, only deer use was measured. Young looked at 36 exclosures compared to 2 in Julander's (1958) and 4 in Tueller and Tower's (1979) studies; however, Young did not statistically analyze his data. Interspecific differences between elk and deer, and a lack of statistical analysis may confound the applicability of Young's study to elk.

## Elk Use of Different Sized Exclosures

My ANOVA test indicated that elk use was not proportionally different for the exclosure sizes tested. However, my regression analysis indicated there was a relationship between elk use inside an exclosure and exclosure size. Elk use inside an exclosure increased as exclosure size increased.

The contradiction between these two tests was probably due to "effect size" (Steidl et al. 1997). The effect size is the change in elk use associated with the change in exclosure size. The effect size was probably too small for the ANOVA test to detect a difference in elk use, with the sample size used, but large enough for the regression analysis to detect a difference. This indicates that elk use increases slowly with increasing exclosure size. Therefore, I reject my second null hypothesis 2) elk use of exclosures is proportionally equal for all exclosure sizes tested.

I conclude that the effect of exclosure size, on elk use inside the exclosure, decreases with increasing exclosure size. One explanation may be, the larger the exclosure the less likely the elk is able to see the opposite side, and the less likely the elk is to parallel the fence until it finds a way around.

The r-squared value for our regression is 0.33. The logistics of this experiment limited our sample size, which restricted the level of power. This may explain the low r-square value. The low r-square restricts the power of my regression model to predict how large a cattle exclosure needs to be to facilitate equal elk use inside and adjacent to the exclosure. However, with a significant correlation ($P<0.03$) between elk use and exclosure size, the model is a useful indicator that an exclosure needs to be larger than 4.00 ha in size to facilitate equal elk use inside and adjacent to the exclosure. If the relationship between elk use and exclosure size continued in a linear or near linear manner beyond my data, elk use would eventually become equal, or reach a level that was not significantly different from equal use. The regression line predicted by my regression model is a good indication that an exclosure may need to be considerable larger than 4.00 ha in size to facilitate equal elk use.

Although my ANOVA and regression analyses indicated there was a difference in elk use of exclosures between years (greater elk use in 1997 than in 1996), there were no interaction effects associated with this difference. Therefore, the difference in elk use between years was not a concern. Greater elk use in 1997 than in 1996 was probably due to higher concentrations of elk in pasture A caused by different snow conditions and the Wildlife Management Area being closed to human activity until June 1, in 1997, compared May 15, in 1996.

Young's (1956) study was the only study I found that looked at the effect of more than one exclosure size on wild ungulates use of exclosures. Young's conclusions that elk use of the area inside exclosures increases with increasing exclosure size is supported by my results. However, Young's conclusions that a 0.4 ha exclosure has equal elk use inside and adjacent to it is not supported by my results. The lack of information on elk use of exclosures in Young's study indicates that his recommendation to use a 0.4 ha exclosure in areas populated with elk may be inappropriate.

## Management Implications

The results of this study have important management implications to federal, state, and private resource managers in areas with elk and cattle. With multiple use and ecosystem management becoming the norm in resource management, an accurate means of monitoring rangeland in areas with cattle and elk is important to make proper management decisions (Wisdom and Thomas 1996).

Previous management decisions, involving elk and cattle, based on information using cattle exclosures may have been confounded due to the size of the exclosure. The assumption that elk use is equal inside and adjacent to an experimental cattle exclosure may have resulted in inaccurate measurements of elk and cattle impacts on rangelands in the past. This may have resulted in inappropriate management decisions.

Logistically, it may be impractical to build an exclosure large enough to minimize the effects of size on elk use. A solution to this may be to drop the fence of the exclosure when cattle are not present. Elk could then enter an exclosure without having to jump a fence. This could be especially applicable to an elk wintering area that is being grazed by cattle at other times of the year. Elk are generally dispersed and in low numbers in these areas when cattle are present (during the growing season) and concentrated when cattle are absent (winter) (Lyon 1985). Another solution may be to erect the exclosure when elk are not present in high densities (growing season), collect vegetation data at the end of the growing season, and construct a new exclosure in a new location the following growing season. Exclosures can still be used as an effective management tool; however, precautions should be implemented to minimize the effects of exclosure size in areas populated by elk.

# CHAPTER 6

## CONCLUSIONS

In areas with overlap of cattle and elk range, cattle exclosures have been used to delineate the effects of cattle and elk on rangelands to make proper management decisions. Problems arise using cattle exclosures when elk use is not equal inside and adjacent to the exclosure, due to the size of the exclosure.

The literature suggests that experimental cattle exclosures should be a minimum of 0.4 ha in size to facilitate equal elk use inside and adjacent to the exclosure. These recommendations appear to be based on Julander's (1958), Tueller and Tower's (1979), and Young's (1956) studies. Each of these studies looked at deer use of exclosures only. Young's study is the only study to address elk use of exclosures; however, elk use of exclosures was not measured. Interspecific differences between elk and deer and lack of statistical power associated with these studies may confound their applicability to elk. Therefore, recommendations based on these studies for minimum exclosure size to be used in areas populated with elk may be inappropriate.

The results from this study indicate that elk did not use the area inside the exclosure sizes tested an equal amount to the area adjacent to the exclosures. It appears that elk do not use different sized exclosures equally. According to my results a relationship exists between elk use of an exclosure and exclosure size for the exclosure sizes tested. Elk use increased with increasing exclosure size. These results coincide with Young's (1956) conclusions that elk use of exclosures increases with increasing exclosure size. My ANOVA and regression analysis indicate that an exclosure large enough to facilitate equal elk use inside and adjacent to it is above the largest exclosure size (4.00 ha) I tested.

Logistically, it may be impractical to build an exclosure large enough to account for the effect of exclosure size on elk use of the exclosure. Dropping the fence when cattle are not present, or using exclosures when elk numbers are low may reduce the effect of exclosure size. Experimental cattle exclosures can still be used as an effective management tool; however, precautions should be used to account for possible effects of exclosure size in areas with elk.

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# APPENDICES

# APPENDIX A

# TRACKPLOT DATA

**0.05 ha Exclosure n = 6**

| | Transect 1 | | Transect 2 | | Transect 3 | | Transect 4 | |
|---|---|---|---|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 0 | 2 | 0 | 3 | | | | |
| 1997 | 2 | 9 | 2 | 5 | 2 | 8 | 1 | 10 |

**0.10 ha Exclosure n = 4**

| | Transect 1 | | Transect 2 | |
|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 0 | 3 | 1 | 5 |
| 1997 | 3 | 7 | 0 | 6 |

**0.25 ha Exclosure n = 2**

| | Transect 1 | | Transect 2 | |
|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 1 | 4 | 0* | 0* |
| 1997 | 2 | 8 | 0* | 0* |

**0.50 ha Exclosure n = 4**

| | Transect 1 | | Transect 2 | | Transect 3 | | Transect 4 | |
|---|---|---|---|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 0 | 10 | 0* | 0* | | | | |
| 1997 | 1 | 12 | 0* | 0* | 2 | 9 | 2 | 7 |

**1.00 ha Exclosure n = 4**

| | Transect 1 | | Transect 2 | |
|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 0 | 6 | 1 | 10 |
| 1997 | 3 | 8 | 5 | 13 |

**2.00 ha Exclosure n = 6**

| | Transect 1 | | Transect 2 | | Transect 3 | | Transect 4 | |
|---|---|---|---|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 5 | 7 | 2 | 16 | | | | |
| 1997 | 5 | 10 | 3 | 24 | 5 | 9 | 2 | 11 |

**4.00 ha Exclosure n = 4**

| | Transect 1 | | Transect 2 | |
|---|---|---|---|---|
| Year | Hits In | Hits Out | Hits In | Hits Out |
| 1996 | 1 | 6 | 14 | 30 |
| 1997 | 3 | 8 | 10 | 32 |

[1]

[1] * indicates observation was dropped

# APPENDIX B

# INITIAL ANALYSIS OF VARIANCE AND REGRESSION MODELS

Table 4. Initial ANOVA model.

| Source | DF | SS | MS | F-value | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 0.0230 | 0.0231 | 1.67 | 0.2658 |
| Transect | 3 | 0.0140 | 0.0047 | 0.34 | 0.7993 |
| Treatment | 6 | 0.1089 | 0.0181 | 1.31 | 0.4129 |
| Y*Trn | 1 | 0.0165 | 0.0165 | 1.20 | 0.3351 |
| Y*Trt | 6 | 0.0736 | 0.0123 | 0.89 | 0.5735 |
| Trn*Trt | 8 | 0.1199 | 0.0150 | 1.09 | 0.5028 |

Table 5. Initial regression model.

| Source | DF | SS | MS | F-value | Pr > F |
|---|---|---|---|---|---|
| Year | 1 | 0.0522 | 0.0522 | 3.77 | 0.0680 |
| Transect | 3 | 0.0036 | 0.0012 | 0.09 | 0.9665 |
| Y*T | 1 | 0.0016 | 0.0016 | 0.12 | 0.7348 |
| E*Y | 1 | 0.0125 | 0.0125 | 0.90 | 0.3554 |
| E*T | 3 | 0.0096 | 0.0032 | 0.23 | 0.8731 |
| E*Y*T | 1 | 0.0011 | 0.0011 | 0.08 | 0.7835 |
| Exclosure Size | 1 | 0.0467 | 0.0467 | 3.37 | 0.0829 |