Elk pregnancy, production, and calf survival in the South Fork of the Flathead River, Montana

by Michele Ann Kastler

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
The purpose of this study was to determine elk pregnancy rates and calf survival before winter range habitat enhancement took effect. Habitat enhancement was completed in the Firefighter mountain area of the South Fork of the Flathead on elk winter range in the spring of 1996. I followed approximately 25 collared cow elk and their calves per year over a 2-year period to gather baseline data on pregnancy rates and calf survival. Pregnancy was determined mainly through fecal analysis, and calf survival through observations and capture. I hypothesized that pregnancy, production and calf survival rates for elk would be equal between treatment (habitat enhanced sites) and control (non-manipulated sites). 40-year harvest trends show a possible decline in elk populations in the South Fork of the Flathead river around Firefighter mountain, I speculated that there were lower pregnancy rates in the South Fork as compared to other Rocky Mountain ecosystems. I found pregnancy rates ranged from 95% in 1996 to 65% in 1997. This may be because of alternate year breeding, summer or winter habitat quality, and/or weather conditions. Calf survival and production were not significantly different between treatment and control elk between years.

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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.

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TABLE OF CONTENTS

TABLE OF CONTENTS – CONTINUED

LIST OF TABLES

LIST OF TABLES CONTINUED

LIST OF FIGURES

ABSTRACT

The purpose of this study was to determine elk pregnancy rates and calf survival before winter range habitat enhancement took effect. Habitat enhancement was completed in the Firefighter mountain area of the South Fork of the Flathead on elk winter range in the spring of 1996. I followed approximately 25 collared cow elk and their calves per year over a 2-year period to gather baseline data on pregnancy rates and calf survival. Pregnancy was determined mainly through fecal analysis, and calf survival through observations and capture. I hypothesized that pregnancy, production and calf survival rates for elk would be equal between treatment (habitat enhanced sites) and control (non-manipulated sites). 40-year harvest trends show a possible decline in elk populations in the South Fork of the Flathead river around Firefighter mountain. I speculated that there were lower pregnancy rates in the South Fork as compared to other Rocky Mountain ecosystems. I found pregnancy rates ranged from 95% in 1996 to 65% in 1997. This may be because of alternate year breeding, summer or winter habitat quality, and/or weather conditions. Calf survival and production were not significantly different between treatment and control elk between years.

INTRODUCTION

Manipulation of habitat for the benefit of wildlife is a common practice throughout the United States. Millions of dollars are spent each year by federal and state agencies, private wildlife organizations, utility companies, and many other groups to enhance or create suitable wildlife habitat. Often these activities are done to mitigate for habitat loss due to the construction of dams, highways, oil refineries, etc. Burning, logging, brush slashing, fertilization, and seeding are some of the methods used to try to enhance forage production, quality, and habitat (Hobbs and Spowart 1984, Crouch 1986, Canon et al. 1987, Happe et al. 1990, Morgantini and Woodward 1994). While many enhancement projects have shown positive responses by the habitat in terms of increased production, availability, and quality of forage (Leege 1979, Crouch 1986, Stussy 1993), few have determined real benefits to fish or wildlife in terms of increased fecundity or survival (Comer 1982). Without monitoring and evaluation of the habitat and populations after restoration, the goals for actual population improvement often are unknown (Madsen 1981, Hunter 1991, Kondolf et al. 1996).

Enhancement designed to mitigate for wildlife habitat loss following the construction of Hungry Horse Dam in northwestern Montana included habitat manipulation to increase carrying capacity for Rocky Mountain elk (*Cervus elaphus nelsoni*). Hungry Horse Dam was constructed on the South Fork of the Flathead River by the Bureau of Reclamation and is managed and maintained by Bonneville Power Administration (BPA). Subsequent flooding after the construction of the dam created Hungry Horse Reservoir in 1954. This resulted in the loss of 9,700 ha of elk winter range along 61.8 km of the South Fork of the Flathead River (Casey 1990) and decreased carrying capacity in elk by an estimated 175 animals (Vore 1994). Fire suppression and subsequent conifer encroachment in the area caused additional alteration of elk winter range from large open shrub fields and grassy hillsides to dense timber and small isolated shrub fields. The Columbia Basin Fish and Wildlife Program authorized BPA to fund winter range enhancement with the goal of increasing elk numbers by 133 in the South Fork (Casey et al. 1984). The Hungry Horse Mitigation Project, which was initiated in 1988 and completed habitat enhancement in 1997 (Hickle 1996), was designed to enhance forage availability and quality through logging and rejuvenation of existing shrub-dominated openings by prescribed burning and mechanical brush treatment.

A common assumption of winter forage enhancement is that because of increased forage production animal condition will improve, allowing for higher pregnancy rates, heavier birth weights, and higher calf survival rates (Thorne 1976, Leege 1979, Nelson and Leege 1982, Crouch 1986). Forage quality and abundance can influence elk productivity in 2 ways. First, nutrition of cow elk during rut (Clutton-Brock 1982, Trainer 1969, and Willard et al. 1994) and gestation (Banfield 1949, Thorne et al. 1976) can influence pregnancy rates by allowing or preventing elk to become pregnant and successfully carry a calf to term. Extreme weather conditions can cause resorption of fetuses (Banfield 1949), which may occur when elk have poor winter nutrition. Secondly, winter forage can influence viability of offspring (Thorne et al. 1976, Clutton-Brock et al. 1982, Nelson and Leege 1982). Breeding-age female elk, which lost more weight than other pregnant elk during the last half of pregnancy, produced lighter calves with reduced survival to 2 weeks of age (Thorne 1976, Clutton-Brock 1982). If mitigation were successful, winter habitat improvements done in the Hungry Horse area on Firefighter Mountain would be expected to manifest themselves in population increases through higher pregnancy rates, calf production, and/or survival.

This study was initiated to gather baseline data on pregnancy rates, calf production, and survival to help evaluate the long-term effects of habitat enhancement on demographic characteristics of elk in the South Fork of the Flathead. The objectives for this study were to: 1) determine survival and causes of mortality of elk calves in the South Fork of the Flathead River; 2) evaluate methods for the determination of pregnancy, parturition dates and location of calves, and calf survival; and 3) compare elk reproductive success on control and newly mitigated sites on Firefighter Mountain. I tested the null hypothesis that pregnancy rate, calf production, and survival would show no difference for elk occupying habitat-enhanced sites (treatment) and control areas.

STUDY AREA

The study area was located east of Kalispell, Montana in Flathead County (Figure 1). It was bordered by the Great Bear Wilderness to the east; Hungry Horse Reservoir to the west; Hungry Horse Dam to the northwest; Desert Mountain and Martin City to the northeast; and Hoke Creek to the south. Firefighter Mountain is located in the northern portion of the study area and was adjacent to the northeast shore of Hungry Horse Reservoir (Figure 1).

Geographic and elevation changes cause considerable climatic variations in areas surrounding Hungry Horse Reservoir. Average annual precipitation ranges from 76 cm along Hungry Horse Reservoir to ≥ 203 cm along the Continental Divide (Simmons 1974). Average maximum snow accumulation occurs in late March. Most areas are snow free by late May, although snow may persist until late August on north slopes at high elevations. The Western Regional Climate Center (WRCC) has a weather station at Hungry Horse Dam which provided means for monthly temperature (maximum and minimum.), precipitation, and snow depth based on a 50-year date base from 1948 to 1997. Snow depth in the study area was at average in 1996 and much higher than average in 1997 (Table 7, Appendix C). Daily averages were given for the months of January 1996 through September 1997. July and August were the

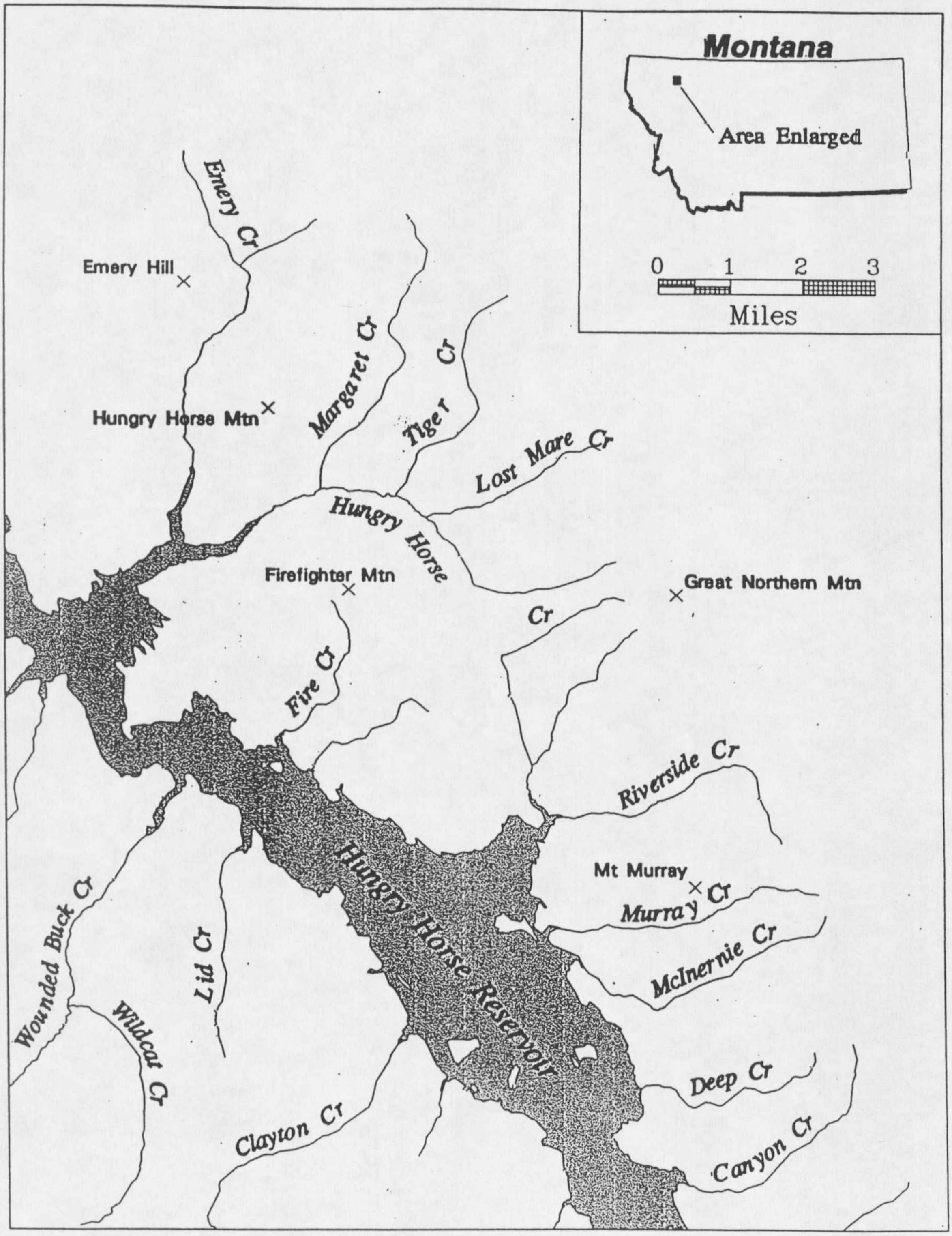

Figure 1. Map of the Firefighter Mountain project area adjacent to Hungry Horse Reservoir, northwest Montana.

hottest months with mean monthly maximum temperatures of 29.5 and 28.3 C, respectively (Table 8, Appendix C). January was the coldest month with a mean minimum temperature of –10.9 C (Table 9, Appendix C).

Terrain on the eastern side of the study area was moderately steep to steep. Glacial deposition has affected the entire area, leaving rounded topographic forms. Soils around the Betty Creek and Paint Creek area are derived from pre-Wisconsin material and are highly productive, compactible, and erosive (Forest Plan 1985).

Primary tree species found on the study area were western larch (*Larix occidentalis*), Douglas-fir (*Pseudotsuga menziesii)*, Englemann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa)*, western white pine (*Pinus monticola*), and lodgepole pine (*Pinus contorta*). Understory browse species that had the highest use by ungulates in 1990-1991, were rose (*Rosa* spp.), willow (*Salix* spp.), western serviceberry (*Amelanchier alnifoloa*), and redstem ceanothus (*Ceanothus sanguinus*) (Vore 1994).

The large mammal fauna in the study area contained most of the species native to the area. Large herbivores included elk, mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), and moose (*Alces alces*). Predator species included coyote (*Canis latrans*), mountain lion (*Felis concolor*), black bear (*Ursus americanus*), grizzly bear (*U. arctos*), bobcat (*Lynx rufus*), wolverine (*Gulo gulo*), Canada lynx (*L. canadensis*), and occasional sightings of wolf (*Canis lupus* (Mace 1997).

The winter range on Firefighter Mountain comprised nearly 11,330 ha. Habitat manipulation was confined to an area of approximately 2,830 ha in the core of the winter range (Casey and Malta 1990). Habitat enhancement of Firefighter Mountain created approximately 400 ha of potential foraging habitat. In all, 66 enhancement units at Firefighter Mountain were created. Nine units were mechanically treated and burned to reduce shrub cover, and 57 units of closed canopy forest stands were opened or thinned through logging. Habitat alteration projects were completed in the spring of 1997 (Hickle 1996).

METHODS

Field work was conducted from January through September 1996 and 1997. Firefighter Mountain was chosen as the study area because most of the habitat enhancement units were completed by the start of the project. In addition, the geographical size of the study area in comparison to many elk project areas (Pengelly 1960, Knight 1970, Vore 1990) was small (winter range is <100 km^2), making the study logistically efficient. This area was also home to a stable resident elk herd of about 100 individuals (Vore and Schmidt 1997), increasing the chance that a population response to habitat improvement could be measured. Baseline data on elk and their distribution were available and there were numerous accessible points for ground telemetry.

Montana Fish, Wildlife and Parks (MFWP) developed initial data on impacts on wildlife (Casey et al. 1984) and the design of the wildlife mitigation plan. The U.S. Forest Service (USFS) carried out the treatment activities outlined in the wildlife mitigation plan.

Sampling

Trapping

A trapping program was started in 1988 and continued through this project. Elk caught prior to December 1993 were trapped in corral or Clover traps. Beginning in December 1993, trapping was conducted by Helicopter Wildlife Management (Salt Lake City, Utah) using aerial net gunning with a Hughes 500 helicopter. This supplemented previously trapped animals and provided a sample of 19 to 33 adult elk (≥2 years old) per year. Thirteen elk were trapped during 1996 and 5 in 1997. The elk were fitted with a 10-cm vinyl-covered leather band and an Advanced Telemetry Systems (Isanti, MN) transmitter, powered by lithium batteries with an expected life of 1,100 days. All collars were individually identifiable at ranges up to 200 m. There were 27 elk in the study area with operating collars at the start of my research and 19 remaining in September of 1997. Age, animal condition, biological samples, and pregnancy were collected and determined from trapped animals. Age was determined by tooth eruption, replacement and wear using a technique described by Quimby and Gaab (1957). Elk pregnancy was determined through fecal progestagin concentrations (Garrott et al. 1998), blood serum assay (Sasser et al. 1985, Willard 1994), and rectal palpation (Greer 1967). Elk determined pregnant by rectal palpation during trapping were fitted with vaginal implants that were used to monitor calving dates and locations.

Pregnant collared cows were located daily during the calving period of May 15 to June 30, and attempts to capture calves occurred during this time span. If a cow showed restriction in movements, site fidelity, and isolation for 3 days or greater (Langley and Pletscher 1994, Vore 1996), we would attempt to obtain visual confirmation of calving. If a cow looked gaunt, had a full udder, or had expelled a vaginal implant, we conducted grid searches of the area where we thought calving had taken place in an attempt to locate and capture a calf. If a calf was observed, it was approached slowly and indirectly. Attempts to catch calves occurred without the use of nets or tranquilizers. Upon capture of a calf a hood was immediately placed over its eyes to calm it (Beringer et al. 1996). Self-adjusting radio-collars (Keister 1988) were placed on calves and standard measurements were taken (Appendix A). Metal ear tags were placed in both ears, in the event the collars were lost but the calf survived.

Telemetry

Radio-telemetry was used to determine home ranges, classify treatment versus control elk, track gross movements during calving season, and monitor vaginal implants and calf collars. Aerial locations were used to determine home ranges in cow elk. An H-antennae was placed on each wing of a Cessna 185 and operated by a directional box within the plane. Flights were made every two weeks during the winter and summer, and every 4 days during calving season. Winter flight locations of elk determined treatment and control animals. Elk were classified as belonging to the treatment or control groups depending on the amount of time they spent in the enhancement sites or within 400 m of these sites (Figure 3) during the winter. I included the 400 m buffer zone as an approximation of the average daily distance an elk will move during the winter, especially when deep snows are common (Craighead 1973, Canfield 1984). Elk with 2 or more winter locations and ≥ 50% relocations within the enhancement zones during the winter were deemed treatment elk. Winter use dates were December 15 through March 31 since elk of the South Fork move onto winter range after the first heavy snowfall (which usually occurs at the end of November) and move off at the start of spring green-up (Vore Pers. Comm. 1997).

Ground telemetry was used throughout the year to locate elk, observe gross movements during calving, and monitor vaginal implants and calf collars. Equipment used included an H-antennae, Telonics (Mesa, AZ) receiver, 7.5 minute U.S. Geographical Survey topographical map, and Silva compass. Attempts were made to use telemetry equipment to assist in sightings of elk or to get 3 bearings from points along mapped roads. Since error in bearing angles tends to be high in ground telemetry (Harris et al. 1990, White and Garrott 1990, Arjo pers. Comm. 1998, Kasworm pers. comm. 1998), our goal was to use telemetry primarily as a tool in obtaining visual observations and to determine gross movements of female elk during calving. During calving season, ground telemetry locations were made daily and supplemented by flight locations. Vore (1996), working with elk, and Langley and Pletscher (1994), working with moose, reported that cows restrict movements to ≤300 m a day when calving. I used

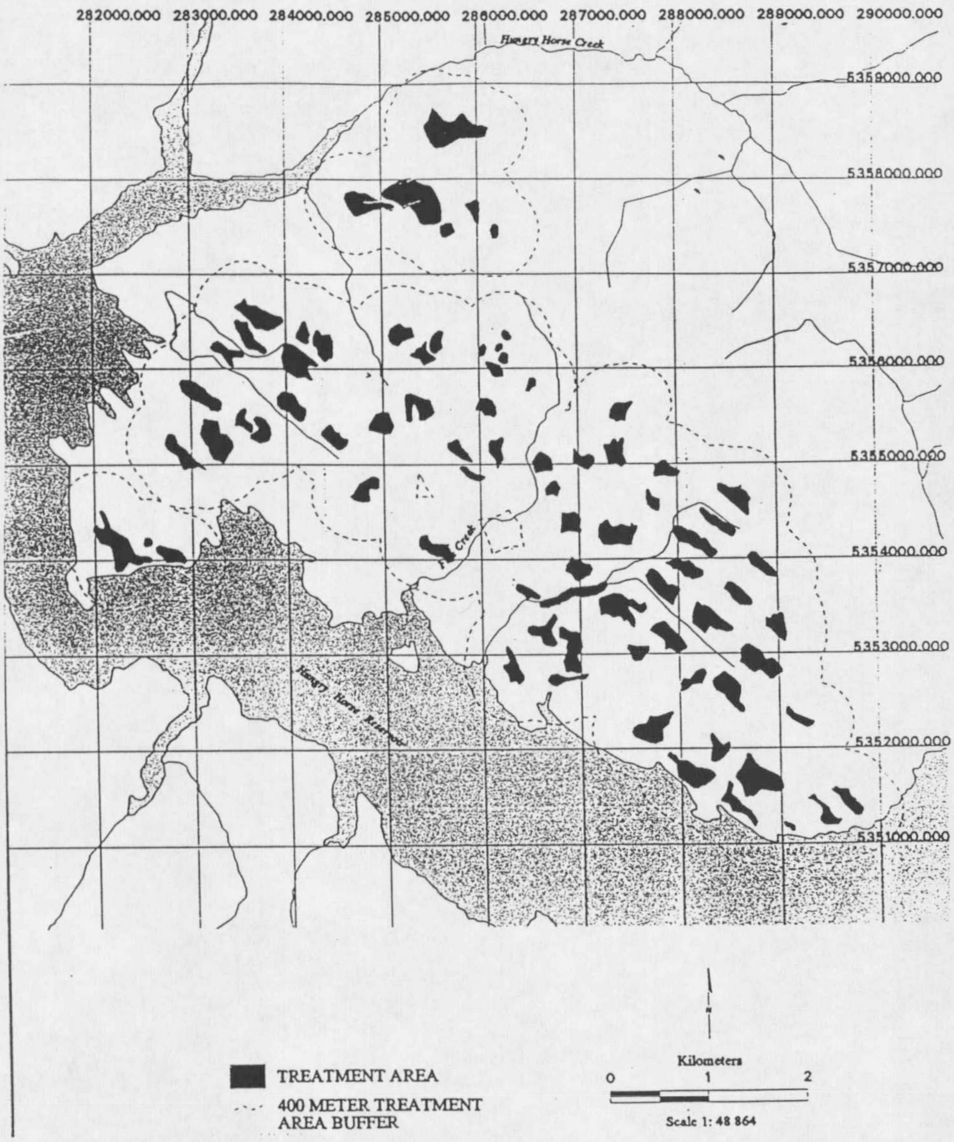

Figure 2. Map of treatment areas and 400-m buffer zones located on Firefighter Mountain, Montana. UTM coordinates are listed on the X and Y axis.

restriction of movements to ≤300 m for ≥3 consecutive days as a potential indicator of time and location of parturition. Telemetry was also used to monitor vaginal implants and determine survival of calves.

Pregnancy

Pregnancy was determined during January through April using fecal steroid assay, necropsy, blood serum assay, and rectal palpation. Fecal samples used in steroid assays were from elk observed defecating, elk rising from beds with fresh feces, or feces procured by back-tracking a known elk. Fecal samples were collected from radio-marked and unmarked adult female elk and taken directly from the colon or rectum of dead and trapped elk to supplement this sample. Pregnancy was determined through fecal radio-immunoassay (RIA) by testing for progestagins (P_4) (Garrott et al 1998). Lab work was done by the Smithsonian Institution in Front Royal, Virginia. Fecal samples were assigned to categories (pregnant, non-pregnant, unknown (Garrott et al. 1998)) based on fecal progestagin levels. This information was used to calculate a pregnancy rate for the South Fork elk herd. Samples classified as pregnant had a concentration of $\geq 1.1 \mu g$ of P_4 per gram of dry fecal matter. Non-pregnant samples had concentrations of $\leq 0.90\ \mu g$ of P_4 per gram of dry fecal matter.

In addition to fecal samples, pregnancy was determined in elk by examination of uteri (Morrison 1960), which were collected from hunter kills and natural mortalities. Trapped elk had blood drawn and were rectally palpated to determine pregnancy. Blood was assayed for pregnancy specific protein B (PSPB) (Sasser et al. 1985, Willard 1994) at Biotracking Inc., Moscow, ID. Rectal palpation (Greer 1967) was used to obtain an immediate assessment of pregnancy.

Production

I defined calf production as a cow bringing a calf to term. Failure to produce would mean that in utero loss of the fetus occurred (the fetus was aborted or resorbed). Calf production was determined using a combination of results from vaginal implants, observation of movements, and observations of calves with female elk known to be pregnant. Females that expelled vaginal implants before May 15, did not exhibit restriction of movements, and were not observed with a calf, were listed as failing to produce a calf.

I tested vaginal implants as a tool for use in determining calving dates and locations. These were adapted from a progesterone implant originally designed by Dr. Harry Jacobson and Jacob Bowman (Mississippi State University) for domestic swine and used on white-tailed deer. John Vore (Kalispell, MT) adapted the size and transmitter package to fit elk. These modified implants were made by Advanced Telemetry Systems. A radio transmitter was fitted to the end of the implant and covered with soft plastic. The battery had a 175-day life span. The implants were approximately 32 cm in total length and 14 mm in diameter. All transmitters were equipped with a 4-hour mortality switch. Range of the transmitter was 0.4 km using ground telemetry and 0.8 km using aerial tracking, when the implant was in the elk. We were able to get 0.4 - 0.8 km range from both ground and aerial telemetry when the transmitter was out of the elk. In 1996, 5 implants were placed in pregnant elk, and an additional 3 were inserted in 1997. The implant was placed into the vagina with the use of a PVC tube marked with the average distance to an adult elk's cervix. After the implant reached the cervix, it was drawn out approximately 1 cm to prevent irritation and allow a centimeter of the antennae to remain outside of the elk, preventing puncturing of the vaginal wall by the antenna. Equipment was sprayed with Betadine to minimize infection.

Calf Survival

The first day that restricted movements in adult females were observed was designated as the birth date for a calf. Birth date for elk with vaginal implants was designated as the date the implant was expelled and emitted a mortality pulse (120 beeps per minute).

Calves that were captured and collared were monitored daily to determine movements and survival. When the calf collar emitted a mortality signal I attempted to locate the collar to determine cause of death. Fate date was designated on calves fitted with radio-collars as the date the collar emitted a mortality signal.

Survival of uncollared calves was determined through repeat observations of radio-marked cows known to have produced a calf. If the cow was observed on 3 consecutive occasions without a calf, the calf was listed as deceased (presumed dead), and the first day the cow was observed without the calf minus the birth date was designated as the age of calf at mortality. Mortality date for calves was then recorded as the day the cow was first observed without a calf. A second method of calf survival used observations of a cow with calf, regardless of the number of observations made previously without a calf. This calf was then assumed to be that of the cow, and survival length was recalculated. Survival rates were calculated to 14, 30, 60, and >120 days using both approaches. Causes of calf mortality were determined by examining the carcass. Observations of hoof wear (Banfield 1949), body condition, consumption patterns (if preyed upon), predator sign (hair or scat), or direct observation of a predator near the area of mortality assisted in determining if mortality was due to stillbirth, malnutrition, or predation.

Analysis

Efficiency of the methods I used was assessed descriptively. A Poisson rate (Munholland pers. comm. 1995) and a g^2 test using SAS (1988) compared estimates of pregnancy rates, production, and calf survival between treatment and control areas for the years of 1996 and 1997 separately, both years pooled, and comparison of overall rates (treatment and control combined) between years. In addition, I compared pregnancy rates for marked elk versus unmarked elk in 1996 and 1997 separately and between years. An alpha error threshold of 0.05 was considered indicative of significant difference (Sokal and Rohlf 1981) and used for all statistic tests. Calf production was analyzed using the data from elk known to have live births through use of vaginal implants, observation of movements, or location of calves. Calf survival was analyzed using 2 different methods of survival mentioned previously. Calf survival was graphed for 2 weeks, 30 days, 60 days, and $\geq$120 days.

RESULTS

I monitored movements of 33 elk in 1996 and 19 elk in 1997. Radio-collared elk were relocated an average of 40 times during my study, with a range of 4-74 locations per animal. In 1996, a mean number of locations during calving season were 11.6, with a range of 1 to 22 locations. In 1997, I had a mean of 13.5 locations during calving season, with a range of 1 to 28. In 1996, 5 elk were designated as treatment animals and 23 as control animals. In 1997, I had 2 elk designated as treatment and 15 as control.

Efficacy of Methods

Trapping

In 1996, I utilized 27 adult female elk captured before my study began. I continued to monitor 16 of these 27 elk in 1997. The other 11 had either died or their collars failed before the start of the 1997 field season. Trapping was conducted during March 20 and 21, 1996, and March 11 to 13, 1997. During the trapping season of 1996, we caught 13 cows. Of these 13, 3 died during trapping, and 5 were fitted with vaginal implants. In 1997, we caught 5 cow elk and 3 had vaginal implants placed in them. One elk broke through the ice on Hungry Horse Reservoir after release, was pulled out with the aid of the helicopter, but died a few days later. Four of the 5 elk trapped in 1997 died before June 1. There was a 23% mortality for trapped elk in 1996, and 80% mortality in 1997, for a total of 39% mortality of trapped elk. Four of these mortalities can be directly associated with trapping giving a direct trapping mortality rate of 22%.

Pregnancy

Twenty-nine fecal samples were collected in 1996, and 30 were collected in 1997 to determine pregnancy. Twenty-one samples were from marked elk and 8 from uncollared elk in 1996. In 1997, 18 were from marked elk and 12 from unmarked elk. In 1996, I had 13 elk with both fecal and blood serum samples which were assayed for pregnancy. In 1997, 5 elk had both blood serum and fecal samples collected and assayed. Pregnancy results were identical between these two tests during both years. However, there was 1 instance in both years where calf fecal samples were classified as pregnant.

Production

In 1996, 5 vaginal implants were placed in 5 known pregnant elk during trapping. During the 1997 trapping session, an additional 3 were placed in known pregnant elk. In 1996, all the implants continued transmitting until expelled and switched to a mortality signal after being expelled. Of these 5 implants, only 1 came out early (May 1), from a cow that was classified as aborting her fetus (failure to produce). In 1997, all the implants had battery failure. Two of the 3 elk fitted with the implant died from starvation or predation and the implant was found securely in place in the vagina. Out of the 8 implants placed in elk during the study, 3 had batter failure and 1 was expelled early (although this was probably due to an abortion). This gave a success rate of 62.5%. However, I know that at least 7 out of 8 stayed in place in the vagina until parturition or death, and possibly all, giving a retention rate of at least 88.5% and possibly as great as 100%.

Calf Survival

In 1996, 1 calf was caught on June 5 and fitted with an expandable collar. This collar dropped off the calf after 33 days (on July 8), although the calf survived. In 1997, 3 calves were caught and fitted with expandable collars. Two collars remained on calves until they died (at age 4 days and 28 days). And 1 collar broke off a calf after 29 days, although the calf survived through the fall. Success of the collars was 50% (Table 1).

Table 1. Fate of calf collars during 1996 and 1997 with days of deployment until mortality signal was emitted.

Collar identification	Days	Fate
164.120-1	33	Failed[1]
165.406	28	OK[2]
164.120-2	29	Failed[1]
164.020	4	OK[2]

[1]Collars slipped or broke off of calf, even though calf survived

[2]Collars remained on calves until mortality of calf occurred

Analysis of Reproductive Indices

Pregnancy

I compared pregnancy rates based on fecal progesterone, movements, and observations for 23 control elk vs. 5 treatment elk in 1996, and 17 control vs. 3 treatment elk in 1997. I failed to reject the null hypothesis. There was no difference between pregnancy rate in treatment and control animals in 1996, 1997, and 1996 to1997 (Table 3). In comparison, all elk in 1996 versus all elk in 1997 had a significantly higher pregnancy rate ($p = 0.003$) in 1996 (Table 4). I also compared pregnancy rates for marked (collared) adult cow elk versus unmarked adult cow elk in 1996, 1997 and between years to determine if pregnancy rates in marked elk were representative of pregnancy rates in the South Fork elk herd. Comparing marked versus unmarked elk in 1996 showed no significant difference ($p = 0.31$), nor was there any in 1997 ($p = 0.64$). However, there was a significant difference in pregnancy between years for marked elk ($p=0.006$) but not for unmarked elk ($p=0.28$) (Table 2).

Table 2. A comparison of pregnancy rates between marked (collared) and unmarked (uncollared) elk in 1996 and 1997. P-values are given for pregnancy differences between years for marked and unmarked elk. A p-value of 0.05 showed significant difference.

	Pregnancy		
	1996	1997	1996 vs.97
Marked	0.97 (29)[1]	0.74 (18)	P<0.01
Unmarked	0.88 (8)	0.67 (12)	P=0.28
P-value	0.31	0.64	

[1] Number in parenthesis is sample sizes in elk years.

Production

I was able to determine whether 26 elk in 1996 and 11 elk in 1997 did or did not produce calves (using a combination of movement data, implants, and classified observations). Twenty-one elk in 1996 were classified as control elk and 5 as treatment elk. In 1997, I had determined calf production status for 9 control animals and 2 treatment animals. I failed to reject the null hypothesis. There was no difference in calf production between control and treatment animals in 1996, 1997, and 1996 to 1997 (Table 4). There was no calculable p-value for 1997 since both populations had production rates of 100%. There was no significant difference (p = 0.40) between the years of 1996 and 1997, (Table 3).

Table 3. Pregnancy and production rates for control and treatment elk in 1996, 1997 and 1996-1997. P-value given is for a significant difference between control and treatment rates using SAS and a g^2-test. There is no P-value for production in 1997 as both control and treatment had a rate of 100%. P-value is tested against an alpha of 0.05.

	Pregnancy			Production		
	1996	1997	1996-97	1996	1997	1996-97
Control	0.96 (23)[1]	0.65(17)	0.83 (40)	0.95 (21)	1.0 (9)	0.97 (30)
Treatment	1.0 (5)	0.67 (3)	0.88 (8)	1.0 (5)	1.0 (2)	1.0 (7)
P-value	0.53	0.95	0.72	0.51		0.51

[1]The number in parenthesis is sample sizes in elk years.

Table 4. Pregnancy and production rate for elk sampled in 1996 and 1997. This is a comparison between years to test for significance. P-value is tested against an alpha of 0.05

	Pregnancy	Production
1996	0.96 (29)[1]	0.96 (26)
1997	0.65 (30)	1.0 (11)
P-value	>0.01	0.407

[1]The number in parenthesis is sample sizes in elk years.

Calf Survival

Calf survival was based on 16 calves in the control group in 1996, and 5 in the treatment group in 1996, 10 with the control group in 1997, and 2 in the treatment group in 1997. Using calf survival rates based on 3 observations of the cow without a calf as the criterion for calf death. I failed to reject the null hypothesis for control vs. treatment areas in 1996, 1997, and 1996 to1997 (Table 5). Using calf survival rates calculated from all observations of a cow with a calf (regardless of the number of times the cow was seen without her calf), I also failed to reject the null hypothesis for control vs. treatment areas in 1996, 1997, and 1996 to1997 (Table 6). Calf survival between years, 1996 versus 1997, (Table 6) were also not significantly different (p = 0.29). Calf mortality was highest in the first 2 weeks in 1996 and first 4 weeks in 1997 (Figure 4, 5).

Table 5. Rate for calf survival in 1996, 1997 and 1996-1997. A comparison of treatment vs. control elk using 2 different values for calf survival. First, if a cow was observed for 3 consecutive times without a calf, the calf was recorded as deceased (3 cow locations). Second, a cow observed with a calf, regardless of number of observations made previously without a calf, the calf was assumed to be that of the cow (all cow locations). P-value given was determined using SAS and a g^2-test. P-value is tested against an alpha of 0.05.

	3 cow locations			All cow locations		
	1996	1997	1996-1997	1996	1997	1996-1997
Control	0.5 (16)[1]	0.3 (10)	0.42 (26)	0.63 (16)	0.3(10)	0.5 (26)
Treatment	0.6 (5)	0.5 (2)	0.60 (7)	0.6 (5)	0.5 (2)	0.57 (7)
P-value	0.70	0.59	0.49	0.92	0.59	0.74

[1] number in parenthesis is sample sizes in elk years.

Table 6. Rate for calf survival in 1996 and 1997 using 2 different survival values. First, if a cow was observed for 3 consecutive times without a calf, calf was recorded as deceased (3 cow locations). Second, a cow observed with a calf, regardless of number of observations made previously without a calf, the calf was assumed to be that of the cow (all cow locations). This is a comparison between years to test for significance. The p-value is tested against an alpha of 0.05.

	3 Cow Locations	All Locations
1996	0.52 (21)[1]	0.62 (21)
1997	0.33 (12)	0.33 (12)
p-value	0.287	0.234

[1] number in parenthesis is sample size in elk years.

DISCUSSION

Efficacy of Methods

Trapping

Capture via net gunning animals from helicopter has been used on many projects (Langley and Pletscher 1989, Ostovar pers. comm. 1997, Burchum pers. comm. 1998) with good success and low trap mortality (Carpenter 1996). Helicopter Wildlife Management conducted the trapping program for this study during 1996 and 1997. They reported a 2.4% trapping mortality, with 29 mortalities out of 1,219 elk marked during 1993-1995. During my capture efforts I had a 22.0% trapping mortality. However, other studies done on the effects of trapping mortality have shown similar numbers. Beringer et al. (1996) showed mortality in white-tailed deer to range from <1% to 23.5%. Beringer also discussed that deer may die within a few hours or days after trapping from predation, exposure or renal damage, however, these can be directly related to trap stress. Causes of mortality during trapping in 1996 were due to snow-free slopes. Elk were able to run rapidly across slopes so that when they were hit with the net, they often tumbled downhill, causing broken bones and internal injuries. In 1997 elk were unwilling to leave the cover of timber because of deep snow. This made getting a clear shot at an elk with the net gun difficult. When elk were in openings, they tried to leap through belly deep snow, causing added stress to already severely winter-stressed animals. Beringer et al. (1996) stated that the use of rocket nets caused deer to be disoriented upon release and run into obstacles. One elk in 1997 walked out onto thin ice and broke through immediately upon release after being trapped with a net gun fired from a helicopter. Although this elk was pulled free of the reservoir through use of the helicopter, she died within 3 days. Overall, in 1997, 4 out of 5 elk (80%) did not survive 60 days post-trapping. This could be attributed to the stress of trapping during a severe winter.

Telemetry

Arjo (pers. comm. 1998) found that bearing error in terrain similar to that of the South Fork averaged 12 degrees using ground telemetry. Pinpointing elk locations precisely enough to detect movements of ≤300 m was not feasible with the telemetry equipment, habitat, and experience of the field crews with which I worked. Studies have shown that error is inherent with radio-tracking animals (Schmutz and White 1990), some to the extent that telemetry locations will not be used fi the animal is >1/4 km (Kasworm pers. comm. 1997). Therefore, I only used ground telemetry locations as a tool for obtaining general information on distribution and obtaining visual locations of collared animals on this study. Aerial locations were more effective.

Pregnancy

The use of fecal steroid assay to determine pregnancy in free ranging animals (Messier et al. 1990), especially elk, is a new method that has had good success (Garrott et al. 1998). However, since it is a new method, not all the problems have been addressed. I had significantly different pregnancy rates between years. These differences could be caused by alternate year breeding, abortion or resorption of fetuses when elk were in starvation condition (as was the case in 997), error in collection from reproductive age cows, or dilution of steroids in fecal matter when elk consume large quantities of low quality food. The latter is unlikely though, since there was agreement in pregnancy results from both the pregnancy specific protein B in blood samples and progestagin concentrations in fecal samples, for the 13 elk sampled in 1996 and the 5 elk sampled in.

Another complication of using fecal steroids as indicators of pregnancy is in collecting samples produced by known age and sex classes. Elk were difficult to locate in the dense timber stands of the study area. Those that were eventually located were often only observed for a few minutes, running, or in large groups. Observing defecation and then locating the fecal sample for specific elk was often difficult because elk in groups defecated consecutively, defecated while walking in line, or were not observed long enough to separate out collared elk and their tracks and fecal samples from uncollared elk. Despite the problems, determining pregnancy in adult female elk using fecal samples was less expensive and intrusive than the collection of biological samples through trapping or sacrificing of the animal. Further research may identify hormone profiles that will identify calves and males unambiguously and eliminate the need to observe which elk defecated.

Necropsies were an effective way to determine pregnancy on elk, but sample sizes were limited. I was unable to reach many dead elk before scavengers had consumed the carcass. A high percentage of females dying in 1997 from starvation and predation (Vore pers. comm. 1998) yielded little additional information on pregnancy.

Pregnancy information gathered from trapping included PSPB from blood serum and rectal palpation. Both techniques require expensive and intrusive capture efforts but are a well-established method of pregnancy testing in elk (Sasser et al. 1985, Willard et al. 1994, Noyes et al. 1997). The information we were able to get from PSPB gave us a good guideline to compare the pregnancy results we got from fecal steroid assays. Rectal palpation was used only as an immediate determination of pregnancy. This technique requires experienced personnel (Thompson et al. 1994), such as a veterinarian and can be associated with incorrect diagnosis (Dawson 1975). Since a veterinarian was not available during my trapping efforts, vaginal implants were only placed in animals that we were positive on the pregnancy status. It is also wondered if palpation increases pregnancy complications, Thompson et al. (1994) stated that this is not the case.

Production

We defined production as a pregnant elk carrying a calf to term. Problems with determining this rate included the untested performance of vaginal implants on elk, difficulty mapping movements because of radio-telemetry error (Arjo pers. comm. 1998) and difficulty locating calves after parturition (Altmann 1951, Clutton-Brock et al. 1982). Only one of the 41 pregnant elk we identified did not produce a calf. Based on her loss of the vaginal implant, lack of restriction in movements during calving season, and repeat observations without a calf, I assumed this cow aborted her fetus 30 days prematurely.

Vaginal implants have the potential as a means of determining calf production, but need additional field trials. I was only able to put out 8 implants and 3 of them failed in 1997 because of battery failure. In the past, the use of implants has had low success (Garrott and Bartmann 1984), but this was due to poor retention rates, not equipment failure. By examining our retention rates, we had at least an 87.5% success and possibly 100%. However, one elk had its implant stop transmitting after 46 days but lived (2 out of 3 elk fitted with implants in 1997 died from starvation or predation before calving), so I was unable to determine if the implant remained in this elk until parturition. However, the elk did successfully calve (she was observed throughout the summer with a calf). The batteries were to have a minimum life of 175 days, but of the three that failed none lasted greater than 131 days. Although this method is expensive and intrusive, it gave good information on calving dates and locations.

Identifying parturition via movement patterns (Vore 1996, Langley and Pletscher 1994) requires repeat locations through telemetry. Ground telemetry was not accurate enough to unambiguously identify restricted movements associated with parturition in elk of the South Fork. In addition, I did not have sufficient funding, nor were weather conditions such that I could conduct daily aerial locations. With elk already known to be pregnant, ground telemetry did allow us to determine approximate calving dates and locations, but I do not think this method could stand alone in determining pregnancy conclusively.

Calculating production using observations of elk with calves and calculating mortality through locating deceased calves were difficult. The terrain and vegetation in the South Fork made observation of and approaches to female elk with calves difficult, especially when elk with calves were more likely to be alert to disturbances than elk without calves (Clutton-Brock et al. 1982).

For a study conducted at moderate intensity, I believe fecal progestagins could be used as an index to calf production, as well as pregnancy. Elk rarely are reported to abort or resorb embryos (Clutton-Brock et al. 1989, Thorne 1976). Even under the severe conditions in 1997, I had no evidence of fetal loss in radio-collared elk that survived through June in the South Fork of the Flathead.

Calf Survival

Methods used to determine calf survival included using vaginal implants and cow movements to determine time and location of parturition, capturing and collaring calves, and repeat observations of cows with calves. Implants were marginally useful in locating newborn calves but did not greatly aid my efforts to capture calves. Of the 4 calves captured and fitted with collars, 2 remained on the calf until predation occurred. This did give us interesting anecdotal information. However, because of small sample sizes, I have no conclusive information on ages and causes of mortality of calves. Attempting to use ground locations of radio collared adult cows, as a means of determining calf survival for individual females in the South Fork is logistically inefficient. Calves with cows were difficult to observe, and calves often run to the nearest cow when startled or scared. These cows may not be their mothers (Altmann 1951, Geist 1982). The only alternatives I can conceive of that would facilitate this approach are better infrared scanners than those commercially available or trained dogs (for calves < 2 weeks old). Observation (aerial or remote camera stations) of marked cows with calves is expensive and likely to yield small sample sizes but is the most applicable technique for following survival of calves of individual females in the South Fork. The use of cameras or aerial surveys to obtain cow:calf ratios may be sufficient for assessing herd status. Surveys in late summer, early winter, and early spring could be used to assess differences in calf survival in treated versus control areas in the future.

Results

Pregnancy

Vore (pers. comm. 1996) hypothesized that the elk of the South Fork of the Flathead River may exhibit alternate year breeding driven by their success in raising calves in the previous year (Trainer 1969, Clutton-Brock and Albon 1989, Stussy 1993). My data did show a significant difference in pregnancy rates between 1996 and 1997; however, 1997 was one of the worst winters recorded by the National Weather Service (National Oceanographic and Atmospheric Administration 1997). Severe winters have been shown to affect calf survival by influencing birth weights, milk production and calving periods (Singer et al. 1997). The monthly average snow depth from November 1996 to March 1997 exceeded the 50-year average by approximately 235% per month (Figure 2). The deep snow caused greater winter stress. This was reflected in a high rate of adult mortality (Vore 1998), most of which could be attributed to starvation. The difference in pregnancy rates as determined by fecal steroids could indicate loss of fetuses due to nutritional stress, errors in classifying pregnant elk because of dilution of steroids in fecal matter, or alternate year reproduction. A long-term study would be required to resolve these questions.

Winter nutrition was also thought to affect pregnancy rates by causing resorption or loss of pregnant cows during gestation (Banfield 1949). Originally, Montana Fish, Wildlife and Parks thought pregnancy rates were around 60-70% yearly. This differs among breeding-age females in elk populations east of the Continental Divide in the United States and Canada range from 80-99% (Greer 1966, Flook 1970, Knight 1970). However, among Roosevelt elk (*C. e. roosevelti*), which are found in a patchy distribution along the Pacific coast from Northern California to British Columbia (Bryant 1982), pregnancy rates can range from 56 to 94% (Green 1995). Stussy (1993) found pregnancy rates in the Oregon Coast Range, where habitats are similar to those of the South Fork of the Flathead River, to be 83% (Stussy 1993). Since pregnancy rates during my study ranged from 66-96%, further research needs to be conducted to see if there is actually lower pregnancy rates in the South Fork or if the 66% pregnancy rate was due to the extreme weather conditions, sampling error, or alternate-year breeding hypothesis.

Comparison of pregnancy rates between treatment and control sites during 1996, 1997 and 1996 to 1997 showed no significant differences. This supported my original hypothesis, but it should be noted the sample size was very small. The treatment population for 1996 and 1997 were 5 and 3 respectively. The control groups were 23 and 17 for 1996 and 1997 respectively. Such small sample sizes result in very little statistical power.

Production

Of elk determined to be pregnant, all except 1 produced calves. There was no difference in elk associated with control versus treatment sites in 1996 or 1997. Elk rarely resorb or abort their fetus (Banfield 1949, Thorne 1976, Clutton-Brock 1989). Therefore, production in adults is unlikely to vary between control and mitigated sites. Monitoring yearling or 2-year old elk productivity might be more appropriate but would certainly be expensive and prone to small sample sizes.

Calf Survival

Results for calf survival also supported the null hypothesis of no difference between treatment and control animals. Trends in calf mortality were similar to elk calf mortality reported in Montana (Knight 1970) and with Red Deer (*Cervus elaphus*) in the Highlands of Scotland (Clutton-Brock and Albon 1989), showing a high mortality rate during the first 14 days and reduced rates thereafter. Overall, calf survival to fall was similar to that documented for the Sun River elk herd on the other side of the Bob Marshall wilderness (Knight 1970) and the Lochsa elk herd in Idaho (Schlegal 1986). It has been shown that extreme weather conditions can influence birth weights (Clutton-Brock and Albon 1989, Singer et al. 1996). The calves I captured suggested that the hard winter of 1997 caused lighter birth weights. Five calves, < 2 weeks of age, were found and weighed in 1997. They had a mean weight of 11.2 kg. The 3 that died in 1997 weighed 7.0, 8.0, and 18.6 kg at death. The only calf caught in 1996 weighed 16.0 kg at 2-4 days of age.

Research and management implications

This study was equivalent to a pre-treatment study in that the benefits of winter range enhancement were not yet available to elk. If enhancement is successful, elk that use enhancement areas could have increased pregnancy rates and greater calf survival. The proportion of the population using the enhanced areas should also increase. The lack of use of enhanced sites during the winter of 1997 suggests that enhancement may have no effects in extreme conditions. The highest amount of observed use of enhanced sites during this study occurred during spring when elk were seen feeding on early successional grasses and forbs. This would be expected on any recently burned or slashed units. I suggest that any post-enhancement monitoring concentrate on detecting distribution changes, fecal pregnancy indices, and summer and winter calf:cow ratios. The South Fork of the Flathead has a lot of logistical constraints; low elk densities, deep snows in the winter, washed out roads in the springtime, and dense forest habitat that made it difficult to implement intensive monitoring of individual elk. Emphasis should, therefore, be placed on herd/group indices rather than the individual.

Management implications will be more apparent after the follow-up study has been concluded. If significant positive changes in pregnancy and/or calf survival rates occur, additional habitat enhancement of the same types and scale can be implemented elsewhere. If there is no change or a decline in rates within the treatment areas, managers can devote resources to other approaches. Monitoring should be maintained whatever the outcome. Positive effects may be time or space limited, or ineffective under extreme weather conditions. If managers use only conclusions from short-term studies, opportunities for modifying ineffective management techniques would be lost and mitigation will fail.

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APPENDICES

APPENDIX A

CALF CAPTURE FORM

CALF CAPTURE FORM

Animal Identification

Capture Date _____ Radio Frequency _____ Personnel

Ear Tag Number ___ Symbol _____________ Sex

Age Class ________ Birth Date ___________

Cow Identification

Marked Cow Y / N Radio Frequency _____________

Symbol __________ Age Class __________________

Herd __________ Conception Date _____________

Miscellaneous

Weather __________________________ Predators in Area Y / N:

Other

____

____

____

____

____

Calf Capture Form Cont.

Physical Characteristics

Weight ___________ Height of Canines _____________ Odor Y / N

Total Length_______ Height of Incisor ________________ Coloration __

Right Hind Length __ Height of Cheek Teeth __________ Hair: Wet/Dry

Head Length ______ Navel Condition ________________ Blood Taken:

Hooves & Dew Claws: Hard / Soft / Smooth / Worn / Light / Dark

Animal Stature / Stability _____________ Overall Condition ____________

Attempted to Run When Approached: Y / N Vocalized: Y / N / Faintly

Prior To Capture Activities (nursing, hiding, grazing, etc.) ___________________

Capture Site Characteristics

Elevation _______ Aspect ____ Slope _________ Afterbirth Present : Y/N

UTMX _________ UTMY _____Habitat Type ______________

Timbered (>40% tree) / Open timber (10-40% tree) / Open (< 10% tree)

Xeric / mesic / Seasonally Inundated Distance to cover type edge _________

Flagged site: Y / N Location:

____

____

APPENDIX B

FIGURES

Figure 3. Monthly snow depth average for November 1996 – March 1997, plotted against a 50-year average. Measurements in centimeters.

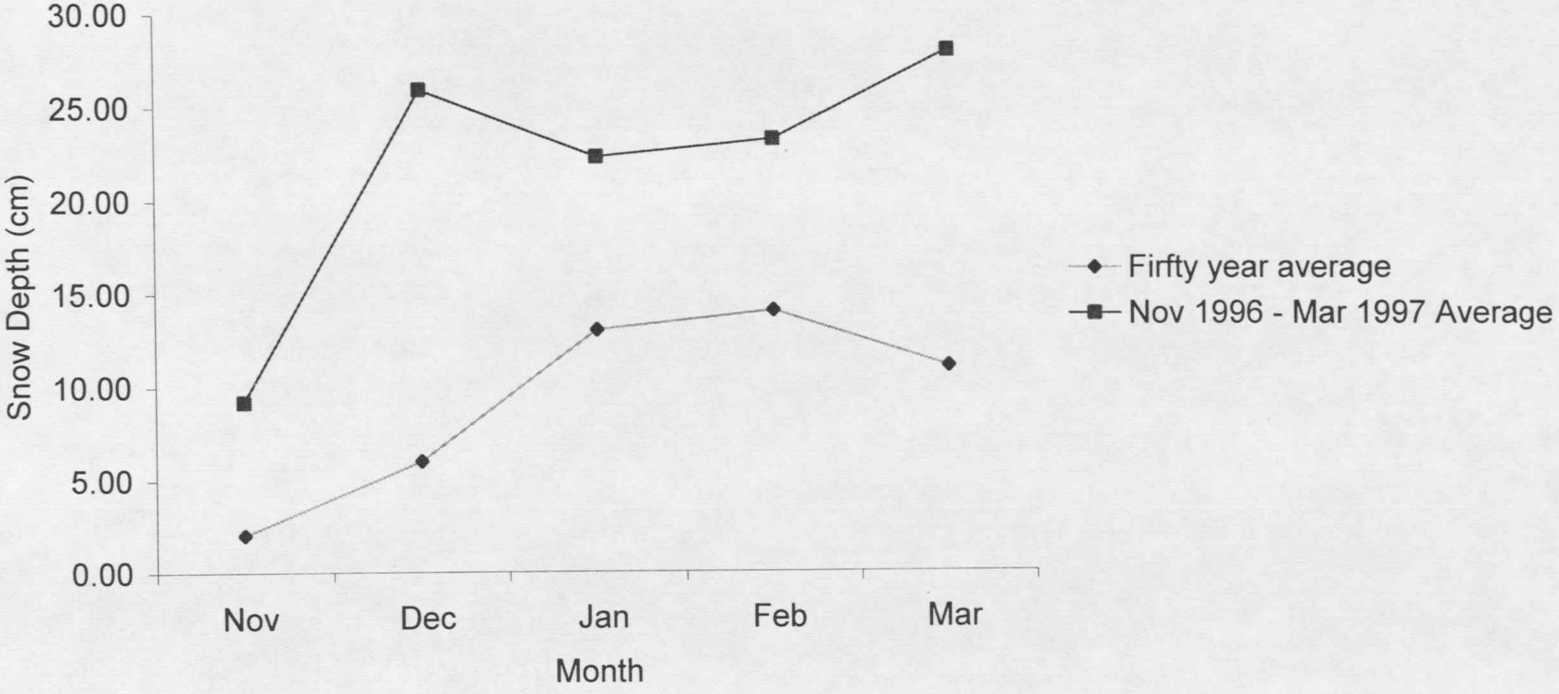


Figure 4. 1996 calf survival to 14, 30, 60 and > 120 days.

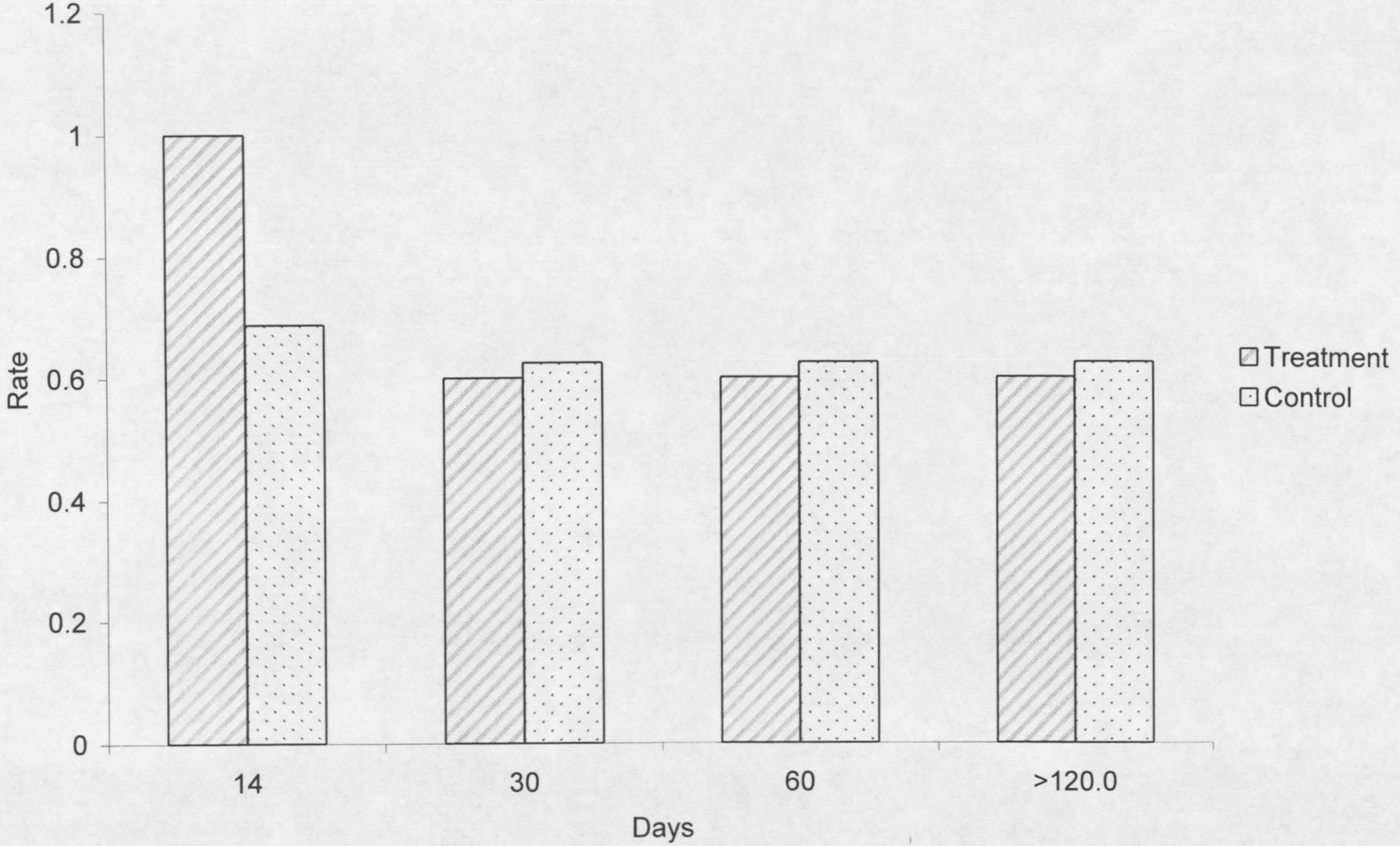
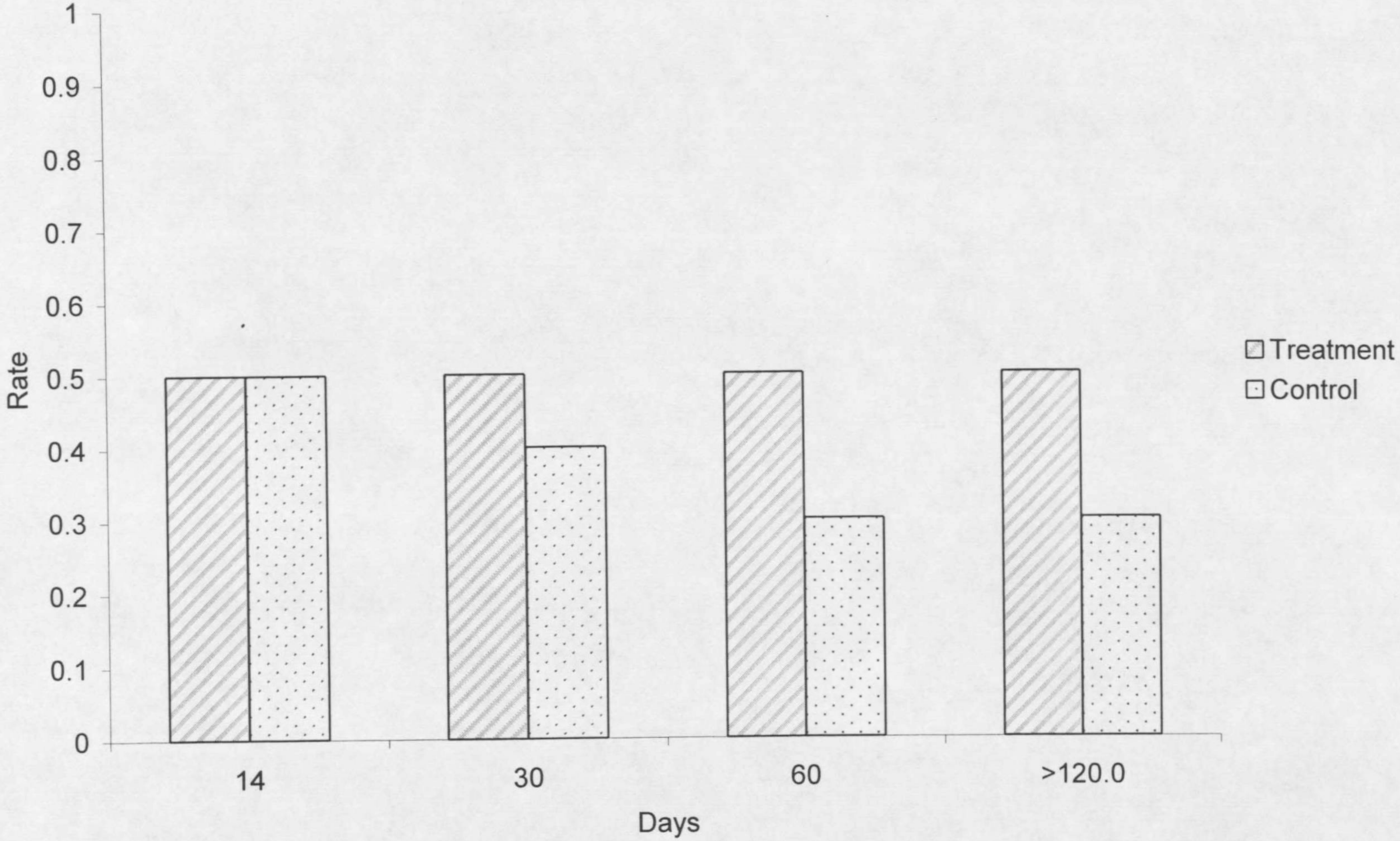


Figure 5. 1997 calf survival to 14, 30, 60 and > 120 days.



APPENDIX C

TABLES

Table 7. Monthly snow depth average at Hungry Horse Dam, Montana for 1996, 1997, and a 50-year average. Measurements in centimeters.

	50-yr Ave.	1996	1997	Var. from 50-yr Ave., 1996	Var. from 50-yr. Ave, 1997
Jan.	33.02	27.69	56.64	-5.33	28.95
Feb	240.45	7.87	58.93	-27.69	51.06
March	27.94	1.27	70.86	-26.67	69.59
April	2.54	2.03	26.42	-0.51	24.39
May	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00
Aug.	0.00	0.00	0.00	0.00	0.00
Sept.	0.00	0.00	0.00	0.00	0.00
Oct.	0.00	0.00	No Data	0.00	No Data
Nov.	5.08	23.37	No Data	18.29	No Data
Dec.	15.24	65.79	No Data	50.55	No Data
Annual Ave.	9.95	10.67	23.65	0.72	12.98
Jan-Sept. Ave	11.01	4.32	23.65	-6.69	19.33

Table 8. Maximum monthly temperature average at Hungry Horse Dam, Montana for 1996, 1997 and a 50-year average. Degrees in Celsius.

	50-yr Ave.	1996	1997	Var.from 50 yr ave., 1996	Var.from 50 yr ave., 1997
Jan.	-1.89	-3.06	-1.72	-1.17	1.34
Feb.	1.56	-0.22	1.83	-1.78	2.05
March	5.56	3.94	5.67	-1.62	1.73
April	11.33	11.44	8.11	0.11	-3.33
May	17.61	14	19.17	-3.61	5.14
June	22.00	21.94	21.28	-0.06	-0.66
July	26.72	32.22	26.72	5.50	-5.50
Aug.	26.17	28.22	28.44	2.05	0.22
Sept.	19.17	16.83	19.94	-2.34	3.11
Oct.	11.28	10.78	No Data	-0.50	No Data
Nov.	3.17	0	No Data	-3.17	No Data
Dec.	-0.56	-2.17	No Data	-1.61	No Data
Annual	11.84	11.16	14.38	-0.68	3.22
Jan. - Sept. Ave.	14.25	13.92	14.38	-0.32	0.46

Table 9. Minimum monthly temperature average at Hungry Horse Dam, Montana for 1996, 1997 and a 50-year average. Degrees in Celsius.

	50-yr Ave.	1996	1997	Var.from 50 yr ave., 1996	Var.from 50 yr ave., 1997
Jan.	-9.56	-11.17	-10.67	-1.61	-1.11
Feb.	-7.44	-9.5	-6.44	-2.06	1.00
March	-5.00	-7.72	-4.56	-2.72	0.44
April	-0.33	-0.22	-3.11	0.11	-2.78
May	4.11	3.11	4.22	-1.00	0.11
June	7.67	7.28	8.22	-0.39	0.55
July	10.06	11.56	11.83	1.50	1.77
Aug.	9.50	11.06	11.11	1.56	1.61
Sept.	4.89	5.56	6.61	0.67	1.72
Oct.	0.61	1.39	No Data	0.78	No Data
Nov.	-3.72	-5.78	No Data	-2.06	No Data
Dec.	-7.17	-8.83	No Data	-1.66	No Data
Annual	0.30	-0.27	1.91	-0.57	1.61
Jan. - Sept. Ave.	1.54	1.11	1.91	-0.43	0.37

Table 10. Calf survival data for 1996 including: fate of calf (0 = died, 1 = lived, ? = not enough information), approximate birth date, fate date, last date that calf was monitored, and age of calf in days at fate.

Calf ID	Birthdate	Fate	Last Date Alive	First Date Not Seen	Fate Date	Treatment Elk	Age at Fate
4070-3	35217[1]	0		35306	35261.5		89
4130-2	35217	1				y	
4303-1	35217	0		35249	35233	y	16
4311-3	35218	1					
4750-1	35217	1	35403				
4776-1	35218	0		35229	35223.5		5.5
4910-1	35219	0		35264	35241.5		22.5
5042-1	35222	0	35376	35411	35393.5	y	189
5056-2	35209	0	35216	35217	35217		8
5087-2	35212	0		35229	35220.5		8.5
5098-1	35221	1					
5172-1	35219	1					
5242-5	35217	0	35221	35249	35235	y	18
5282-1	35218	1					
5293-2	35212	1				y	
5431-3	35243	0	35243	35264	35253.5		10.5
5467-2	35226	1					
5474-1	35217	0		35229	35223		6
5605-3	35214	1					
5652-2	35223	0		35249	35236		13
5735-2	35213	0		35403	35308		95

[1]All dates are given in a date value. This number is figured by Excel and is a computation of days starting at 0 with January 1, 1900.

Table 11. Calf survival data for 1997, including: fate of calf (0= died, 1 = lived, ? = not enough information), approximate birth date, fate date, last date calf was monitored, and age in days of calf at fate.

Calf ID	Birthdate	Fate	Last Date Alive	First Date Not Seen	Fate Date	Treatment Elk	Age at Fate
4070-3	35579[1]	0	35582		35583		4
4090-3	35578	0	35625	35636	35630.5		52.5
4150-3	35582	?					
4311-3	35586	1				y	
5056-2	35583	0		35640			
5125-2	35577	0	35604		35605		28
5242-5	35584	0		35587	35585.5	y	1.5
5431-3	35593	0			35595		2
5467-2	35601	0		35606	35603.5		2.5
5474-1	35585	1					
5605-3	35592	0	35594		35596		4
5898-2	35581	0		35584	35582.5		1.5

[1]All dates are given in a date value. This number is figured as a computation of days starting with 0 at January 1, 1900.