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Progress Report

TEX CREEK MULE DEER AND ELK COMPETITION

July 1, 2007 to June 30, 2008

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TEX CREEK MULE DEER AND ELK COMPETITION

Abstract

Over the last century, mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) have had to cope with extensive loss of winter habitat. It is likely that deer and elk used habitats differently than before humans settled significant portions of winter ranges. Such changes in habitats or population densities could alter competitive relationships. Mule deer have been declining across much of the western United States while elk populations have been increasing. These trends suggest that growing elk herds may be negatively affecting mule deer populations under some circumstances. We fitted 22 adult female elk and 42 adult female mule deer with GPS (global positioning system) radio collars and 58 six-month-old mule deer fawns with VHF (very high frequency) radio collars over two consecutive winters in 2007 and 2008. We will determine if mule deer and elk are competing on the winter range and, if so, investigate the population-level consequences of that competition for deer. Our major objectives are to test whether high elk concentrations result in habitat shifts by mule deer, changes in deer diets, increased rate of loss in body condition for deer, higher stress levels in deer, and lower survival of juvenile deer.

Introduction

Mule deer populations have undergone several population fluctuations in the last century (Connolly 1981). The early 1900s were marked with sharp declines of mule deer as human settlement, livestock grazing, loss of habitat, and unrestricted hunting took their toll (Lindzey et al. 1997, Mackie et al. 1998). Mule deer numbers rebounded in the mid 1900s to all-time highs; this peak has been attributed to restrictions on hunting, a widespread program to eliminate predators, and favorable weather patterns (Lindzey et al. 1997). Rangeland conditions also improved for mule deer; vegetation changes following years of intensive livestock grazing, logging, and burning provided increased habitat diversity and more palatable plants for mule deer (Mackie et al. 1998). Mule deer populations once again declined in the 1970s probably because of a combination of factors ranging from over-browsing by mule deer, over-grazing by livestock, unfavorable weather patterns, and vegetation succession that lead to less productive habitat (Lindzey et al. 1997, Mackie et al. 1998, Connolly 1981). However, the reasons behind the declines are poorly understood.

During this same period (1970s to present), the West also experienced the growth and expansion of elk populations. Elk populations are thought to have nearly doubled from 1975 to 1995 (Lindzey et al. 1997), probably due to more restrictive hunting seasons. The decline of the mule deer along with a corresponding rise in elk numbers has led some to wonder what effects a growing elk population has upon an already stressed mule deer population. Interspecific competition between deer and other large herbivores has been suggested as part of the mule deer decline (Lindzey et al. 1997). Elk appear to be able to out-compete mule deer in many circumstances (Mackie 1981). Advantages in thermodynamic range, energy costs for locomotion in snow, the ability to use grass-dominated habitats year-round, and less risk to shared predators may give elk the competitive advantage in areas where the two species are sympatric. One advantage that mule deer might have over elk is a better ability to habituate to human activities on winter ranges. Ward (1980) suggested that mule deer were more tolerant of pedestrian and vehicle (roads) traffic than elk. Further, substances in mule deer saliva enable them to handle higher tannin-rich diets than elk, which appears to give mule deer an advantage in consuming tannin-rich shrubs (Lindzey et al. 1997). This advantage is minimized, however, by shrubs having low tannin levels during winter, the time at which elk are most likely to browse shrubs (Lindzey et al. 1997).

There are three forms of interspecific competition: indirect, direct, and apparent (Caughley and Sinclair 1994). Indirect (exploitative) competition occurs when one species uses the resources of an area so that they are unavailable to another species. Direct (interference) competition is characterized by direct interactions or avoidance of one species by another. Apparent competition arises from two prey species that share a food-limited predator (Holt 1977). This form of competition will not be outlined due to our inability to test hypotheses related to apparent competition in this study.

Competitive exclusion is a long held ecological principle that states two species cannot occupy the same ecological niche (Gause 1934, Caughley and Sinclair 1994). Deer and elk are native sympatric herbivores; therefore, the competitive exclusion principle suggests that deer and elk, while coexisting in the same habitats, would have either shifted to separate ecological niches or one would have replaced the other.

Schoener (1982) believed that lean times would result in intense, directional selection resulting from interspecific competition. This selection would lead to specialization to exploit resources that they did not share with their competitors (realized niche). Morphological and physiological differences between mule deer and elk should have allowed them to exploit habitats differently when forage or other needs were limited. Generally larger ruminants, such as elk, have larger rumens, which results in lower feeding frequencies and longer forage retention times. This enables them to use more lower-quality forage than mule deer (Kie et al. 2003). Conversely, mule deer need high-quality forage that is more digestible with higher protein concentrations (Kie et al. 2003). We predict that coevolved sympatric herbivores partition resources during times of limited forage enabling the species to coexist. Several investigators demonstrated that there was little or no simultaneous spatial and dietary overlap between these two species during winter when resources were most limited (Compton 1975, Mackie 1970, Baty et al. 1995, Wydeven 1985). Compton (1975) observed mule deer and elk had a very high dietary overlap in

Wyoming, but were spatially separated, whereas Baty et al. (1995) reported that elk and mule deer in western Montana overlapped spatially but had different diets. Hudson (1976) also noted spatial overlap of deer and elk on winter range, but suggested that the two species were eating different vegetation, although supportive data were not provided.

Changes in habitats or population densities could alter competitive relationships. North American ungulates have had to cope with extensive loss of habitat over the last century, and habitats that currently support mule deer and elk have changed to the extent that conditions are now much different from those that existed while mule deer and elk evolved (Lindzey et al. 1997). If one species occurs in large enough numbers, competition can also occur from over-exploitation of habitats (such as elk over-browsing trees to the extent that deer cannot reach forage), although both species would likely suffer in such an example.

Indirect Competition

Large ungulates in temperate regions must accumulate fat stores during summer and fall to maintain them through winter when forage quality and quantity is limited (Mautz 1978). While there is evidence that summer range quality is a crucial part of ungulate over-winter survival and subsequent fitness (Pederson and Harper 1978, Stewart et al. 2005), mule deer and elk cannot successfully meet their nutritional requirements during winter because of low-quality forage (Mautz 1978, Stewart et al. 2005). This life-history trait of mule deer and elk makes the winter season a logical starting point for investigation of competition between mule deer and elk.

Fall and Winter Competition-- Collins and Urness (1983) observed that mule deer used more browse than elk and elk used more grass than mule deer but also noted an increase in browsing for elk during winter. The authors argued that the wider feeding niche of elk meant that there was considerable potential for exploitative competition in lodgepole and aspen communities. Mower and Smith (1989) noted that resource overlap was most prominent during winter in a study of mule deer and elk in Utah. Those authors noted that deep snow covered grasses, which forced elk to rely on browse that wintering mule deer populations also used.

Stewart et al. (2002) reported that changes in forage quality during autumn coincided with mule deer moving into areas used by elk. Spatial overlap would not necessarily result in dietary overlap but high spatial overlap in autumn, when resources were most limited on their study area, led the authors to believe that exploitative competition was likely taking place between mule deer and elk. Schwartz and Ellis (1981) also reported that as forage became more limited, dietary overlap increased in sympatric grassland herbivores and that forage quality may be more important than forage quantity in competition between selective feeders. Further evidence was provided in a study of resource partitioning of white-tailed deer (*Odocoileus virginianus*), elk, and moose (*Alces alces*) in northwest Montana. Jenkins and Wright (1988) noted that increasing snow levels increased the ecological overlap and had strong potential for interspecific competition. The greatest overlap was between elk and white-tailed deer use of browse. Evidence of limited forage leading to higher dietary overlap is available for mule deer and elk (Mower and Smith 1989, Stewart et al. 2002) and mule deer and cattle (Bowyer and Bleich 1984).

Spring and Summer Competition-- Beck and Peek (2005) reported that although elk focused on graminoids in the spring, they shifted to a greater concentration of forbs (59-78%) in summer. Those authors also noted that the amount of graminoids used by elk varied from 18-60%. Mule deer diets, however, remained relatively stable over the three-year period with summer use of browse at 30%, forbs at 64-72%, and graminoids at 2-5%. Overall, mule deer and elk diets overlapped 59%, 45%, and 50%, respectively, during the three-year study. The authors believed that the greatest potential for competition was selection of forbs in aspen communities. What seems evident is that elk can and do use forbs and browse that are critical to deer, whereas deer do not widely utilize grasses that elk often use (Lindzey et al. 1997).

Torstenson et al. (2006) observed dietary selections of elk, mule deer, and cattle in northwestern Wyoming on foothill and mountain rangelands. Dietary overlap of mule deer and elk was 55% in summer, 60% in autumn, 48% in winter, and 63% during spring. The authors point out that potential for competition would be the greatest when species consume similar diets while foraging within similar habitat types, which they defined as foraging niche overlap. The percent foraging niche overlap for mule deer and elk was 26% in summer, 21% in autumn, 29% in winter, and 45% during spring. The authors concluded that foothill sagebrush grasslands, especially those with southern facing aspects, were most likely to be sites of competition between elk and mule deer in spring.

Direct Competition

Waldrip and Shaw (1979) reported that white-tailed deer avoided elk and were not usually seen in areas with high elk populations. That study also indicated that interference competition may have been responsible for elk displacing deer to less desirable fawning and bedding sites. White-tailed deer fawns were forced to bed in open habitats with little concealment cover and therefore experienced high mortality from predation.

Avoidance of elk by mule deer has been reported during spring and summer at the U.S. Forest Service Starkey Experimental Forest and Range (Johnson et al. 2000, Stewart et al. 2002). The Starkey studies showed mule deer resource selection was inversely related to elk resource selection, whereas elk resource selection was independent of mule deer resource selection. Mule deer and elk differed in how they selected slope, distance to roads, and aspect. Elk tended to be on gentler slopes, further from roads and occur on westerly aspects. Mule deer occurred on steeper slopes, closer to roads, and on easterly aspects. The authors determined that mule deer were avoiding elk (Johnson et al. 2000).

Coe et al. (2001) reported the avoidance of cattle by elk, and a later study by Stewart et al. (2002) indicated that when cattle were introduced onto the range in spring, elk moved to higher elevations and mule deer shifted to lower elevations. The authors concluded that there was likely a competitive displacement of elk by cattle and a subsequent response to elk movements by mule deer. Stewart et al. (2002) also provided evidence that mule deer were strongly affected by the movements of elk, and mule deer movements did not affect elk.

Tex Creek Historical Background

Tex Creek Wildlife Management Area (WMA) and surrounding areas were no different than most of the West during the 1970s in experiencing low deer densities. The population was estimated <400 animals during winter 1973-1974. Deer populations rebounded on the WMA to an estimate of over 3,000 animals during winter 1985-1986 (Kuck et al. 1992a). The number of mule deer wintering at Tex Creek remained relatively high until sometime between 1997 and 1999, when the herd went from almost 6,000 animals to 3,500 (Kuck et al. 2000a). Despite the tightening of hunting restrictions, the mule deer populations have not rebounded. The 2005 estimate for the Tex Creek area was 1,532 mule deer (Compton et al. 2005b) (Figure 1).

Available population estimates and hunter-harvest data point to a steadily rising elk population over the last 25 years. The Tex Creek area had 1,715 elk in 1980, 2,986 in 1991, and 4,196 in 2005; and that was after a record level elk harvest during the 2004 hunting season (Compton et al 2005a, Kuck et al. 1992b, Kuck et al. 2000b) (Figure 2).

The slow and steady rise of elk populations coinciding with a decline in deer populations has led many to suggest that large elk concentrations are impeding a recovery of deer to their former levels.

Possible Effects of Interspecific Competition

Effects of interspecific competition would most likely be similar to intraspecific competition effects. Those effects might include body condition of adults, age at first reproduction for females, percentage of females pregnant, number of young, and survivorship of young age classes (McCullough 1979, 1999; Kie et al. 2003). Mortality due to environmental stochasticity and density dependence will affect the youngest age classes first (Eberhardt 1977). Large ungulates tend to have high and stable adult survival rates while juvenile survival and fecundity varies widely (Gaillard et al. 1997, 2000). Therefore, most of the population regulation would take place at the youngest age classes (Gaillard et al. 1997).

Objective

The objective of this study is to determine if mule deer and elk are engaged in either direct or indirect interspecific competition, or any combination of the two. To do so, we will test whether high elk density on winter range will:

1. Result in avoidance of large groups of elk by mule deer (direct competition),
2. High elk density on winter range will result in less favorable diets in mule deer (indirect competition),
3. High elk density on winter range will result in lower body condition scores (Riney 1955) of adult does over winter when controlled for pregnancy,
4. High elk density on winter range will result in high stress levels, determined by fecal glucocorticoid concentrations,
5. High elk density on winter range will negatively affect survival rates of mule deer.

Tex Creek mule deer and elk competition study, hypotheses, and tests were as follows:

1) High elk density on winter range will result in avoidance of large groups of elk by mule deer (direct competition).
    a. Tested by kreiging and/or kernel analysis techniques using mule deer and elk GPS collar locations (Stewart et al. 2005).
    b. Analyzing relationship of mule deer and elk GPS collar locations in temporal windows (six hour and seven day) with multiple regression models (Stewart et al. 2002).
    c. Analysis of deer locations on winter range and observations of large groups of elk on winter range.
        i. Size and composition of elk encountered while observing mule deer will be counted and recorded. Proximity to radio-collared mule deer will also be recorded.
2) High elk density on winter range will result in less favorable diets in mule deer (indirect competition).
    a. Analysis of mule deer diets in areas of high and low elk densities.
        i. Fecal nitrogen, neutral detergent fiber, and nitrogen content of neutral detergent fiber.
        ii. Microhistological analysis of mule deer and elk fecal material to genus level.
3) High elk density on winter range will result in lower body condition scores of adult does over winter.
    a. Radio-collared individuals will be observed two times a month and be given a body condition score (Riney 1955). This will enable us to put the individuals into classifications at the beginning of winter (good, average, bad) and the end of winter so that data will control for confounding factors, such as lactation, and represent what happened to the individual over the winter.
        i. Taking pictures of radio-collared adult mule deer through spotting scopes with digital cameras (digiscoping) will enable the pictures to be compared later and control for observer bias.
4) High elk density on winter range will result in high stress levels.
    a. Determined by fecal glucocorticoid analysis of deer as a function of elk density.
5) High elk density on winter range will negatively affect survival rates of mule deer.
    a. Determined by cause-specific mortality of mule deer as a function of elk density.

Study Areas

The study area consists of Tex Creek WMA, including over 32,000 acres of public land and the corresponding portions of GMU 69. Tex Creek WMA consists of most of the Tex Creek drainage and parts of Willow Creek and Meadow Creek drainages. Willow Creek is a deep canyon complex that stretches from Ririe Reservoir in the north, southward to Kepps Crossing. The main canyon is 44 km long with 71 km of tributary canyons (Thomas 1987). Tex Creek and Meadow Creek flow north and east from the Caribou National Forest boundary into the larger Willow Creek system. Large plateaus make up the areas in-between canyons and creek bottoms, many of which were originally farmed and now are part of the Conservation Reserve Program.

Elevations on Tex Creek vary from 1,550 to 2,250 meters; temperatures vary from –34° C to 37° C, and mean annual temperature is 6° C. Mean precipitation varies from 12 to 18 inches and occurs mostly in the form of snow. Common habitat types include Conservation Reserve Program grasslands with introduced grasses and alfalfa, sagebrush steppe, pinion juniper, aspen, mixed deciduous conifer forest, and conifer forest (Thomas 1999).

Methods

Trapping and Telemetry

We trapped adult female mule deer, six-month-old mule deer, and adult female elk using drive netting and net gunning techniques (Barrett et al. 1982, Thomas and Novak 1991). Telemetry from a fixed-wing aircraft was used to locate all radio-collared individuals on winter range (Feb) and on summer range (Jun), and will be used to locate them on transitional range (Nov). All trapping and telemetry objectives for 2007 and 2008 were completed.

Trapping and telemetry objectives for Tex Creek mule deer and elk competition study included the following:

- Trap and radio-collar 20 female adult mule deer with GPS collars in 2007 and 2008.
- Trap and radio-collar 18 female adult elk with GPS collars in 2007 (four additional collars put out in 2008).
- Trap and radio-collar 30 six-month-old mule deer with VHF collars in 2007.
- Trap and radio-collar 26 six-month-old mule deer with VHF collars in 2008.
- Locate radio-collared animals once a month from January-April with fixed-wing aircraft.
- Locate radio-collared animals during the first part of June for fawning and calving locations with fixed-wing aircraft.
- Locate radio-collared animals during mid-November for hunting season locations with fixed-wing aircraft.
- Determine survival of radio-collared adult and juvenile mule deer by checking mortality versus live signals of radio-collars bi-weekly.
- Determine recruitment of radio-collared mule deer by using June aerial locations and telemetry techniques to obtain visual observations of radio-collared adult females with or without juveniles in summer.

We captured 68 mule deer and elk in January 2007. Of the 18 GPS-collared elk, two drop-off mechanisms executed early so collars were put out again in January 2008. Three collars are still active on live animals because of drop-off mechanism malfunction, and 13 collars dropped off correctly and have been retrieved. Of the 20 GPS-collared deer, three collars malfunctioned and cannot be located, and 17 have been located and retrieved despite several collar malfunctions. Of the 30 VHF-collared mule deer fawns, there were six mortalities, and 24 VHF collars were carried back to summer range in 2007 where the collars fell off and were retrieved.

We captured 48 mule deer and four elk in January 2008. Of the four GPS-collared elk, one collar is still active on a live animal because of drop-off mechanism malfunction, and three collars dropped off correctly and have been retrieved. Of the 22 GPS-collared deer, five collars are scheduled to fall off in September, five collars are scheduled to fall off in December, 10 collars dropped and were retrieved, one collar is currently missing, and one collar is still on a live animal due to malfunction of drop off mechanism. Of the 26 VHF-collared mule deer fawns, 22 collars have been retrieved from mortalities, one collar is missing, and two collars are on live animals and should fall off during fall 2008.

Trapping Protocol

Protocol for the capture of adult female mule deer and adult female elk included:

- Record hind foot length (cm)
- Record chest girth measurement (cm)
- Ear tag in each ear
- Collect fecal sample
- Collect blood sample
- Record body condition score
- Fit with GPS radio-collar

Protocol for the capture of six-month-old mule deer include:

- Record hind foot length (cm)
- Record chest girth measurement (cm)
- Ear tag in each ear
- Record body weight
- Fit with VHF radio-collar

Distribution of Radio Collars

Collars were distributed over a 25-mile square area that included contrasting areas with high and low elk density units, based upon previous population estimates of the area.

Collection of Fecal Material

Fresh fecal masses were collected and frozen for DNA analysis to determine sex and species, fecal glucocorticoid analysis to determine stress levels of animals, and microhistological analysis to determine diet composition.

The protocol for monthly fecal collections (Jan-Apr) for deer included:

- 20 samples/month
- Fecal nitrogen, neutral detergent fiber, nitrogen content of neutral detergent fiber
- Sex determination
- Fecal glucocorticoids

The protocol for monthly fecal collections (Jan-Apr) for elk included:

- 10 samples/month
- Microhistological diets to genus level

During 2007, we collected 80 separate fecal samples; 10 per month for elk in January and February, and 20 per month for mule deer in January, February, and March. Fecal collections for elk during March and April were cancelled because of mild winter conditions that resulted in elk leaving the winter range. Fecal collections for mule deer in April were cancelled for the same reason.

During 2008, we collected 120 separate fecal samples; 10 per month for elk January through April, and 20 per month for mule deer January through April.

Observational Activities

During 2007, we located and observed 195 adult mule deer in January, February, and March. All individuals were assigned a body condition score (Riney 1955); 52 on GPS-collared mule deer, 28 on VHF-collared mule deer, and 115 on uncollared mule deer. Size and composition of groups of elk and their proximity to mule deer were recorded. Radio-collared elk were observed 2-4 times a month to determine the number of individuals in the group with the radio-collared animal.

During 2008, we located and visually observed 427 adult female mule deer January through April. All individuals were assigned a body condition score (Riney 1955); 51 on GPS-collared mule deer, 12 on VHF-collared mule deer, and 364 on uncollared mule deer. Size and composition of groups of elk and their proximity to mule deer were recorded.

Statistical Analysis

Most of the hypotheses will be tested using mixed model analysis. We will use Proc Mixed (SAS Institute 1999) for the analysis because of its ability to handle fixed and random factors and unbalanced data. The independent variables are elk density, month, sex, year, and all interactions to analyze fecal glucocorticoid levels, fecal nitrogen, neutral detergent fiber, deer survival, and deer recruitment. We will use the repeated measures design in Proc Mixed (SAS Institute 1999) to analyze the body condition of adult deer using the same independent variables. Because we will have three dependent variables in the diet composition analysis, we will use Proc Glm (SAS Institute 1999) procedure in SAS. This will enable us to use a manova approach to analyze diet composition for mule deer with respect to our independent variables.

Results

Mule Deer Avoidance of Elk

The drop off mechanisms on the GPS collars have executed and the collars have dropped on all but four animals (which are still currently alive and carrying those collars). Those GPS collars that have dropped have been collected and data analysis of GPS locations is currently underway.

Dietary Changes for Mule Deer

We received the laboratory results for the diet samples from the 2007 field season and we are currently analyzing those results. We are awaiting laboratory results for the 2008 diet samples.

During 2007, body condition scores were collected for three months instead of four because animals left the winter range early. We collected 195 body condition scores in January, February, and March. Of those locations, 52 were on GPS-collared mule deer, 28 on VHF-collared mule deer, and 115 on uncollared mule deer.

During 2008, body condition scores were collected for four months. We collected 427 body condition scores January through April. Of those locations, 51 were on GPS-collared mule deer, 12 on VHF-collared mule deer, and 364 on uncollared mule deer.

Stress Levels in Mule Deer

We received the laboratory results for the diet samples from the 2007 field season and we are currently analyzing those results. We are awaiting laboratory results for the 2008 diet samples.

Survival Rates of Mule Deer

Overall survival was 77% for mule deer captured as six-month-old fawns during 2007 and 18% for those captured in 2008.

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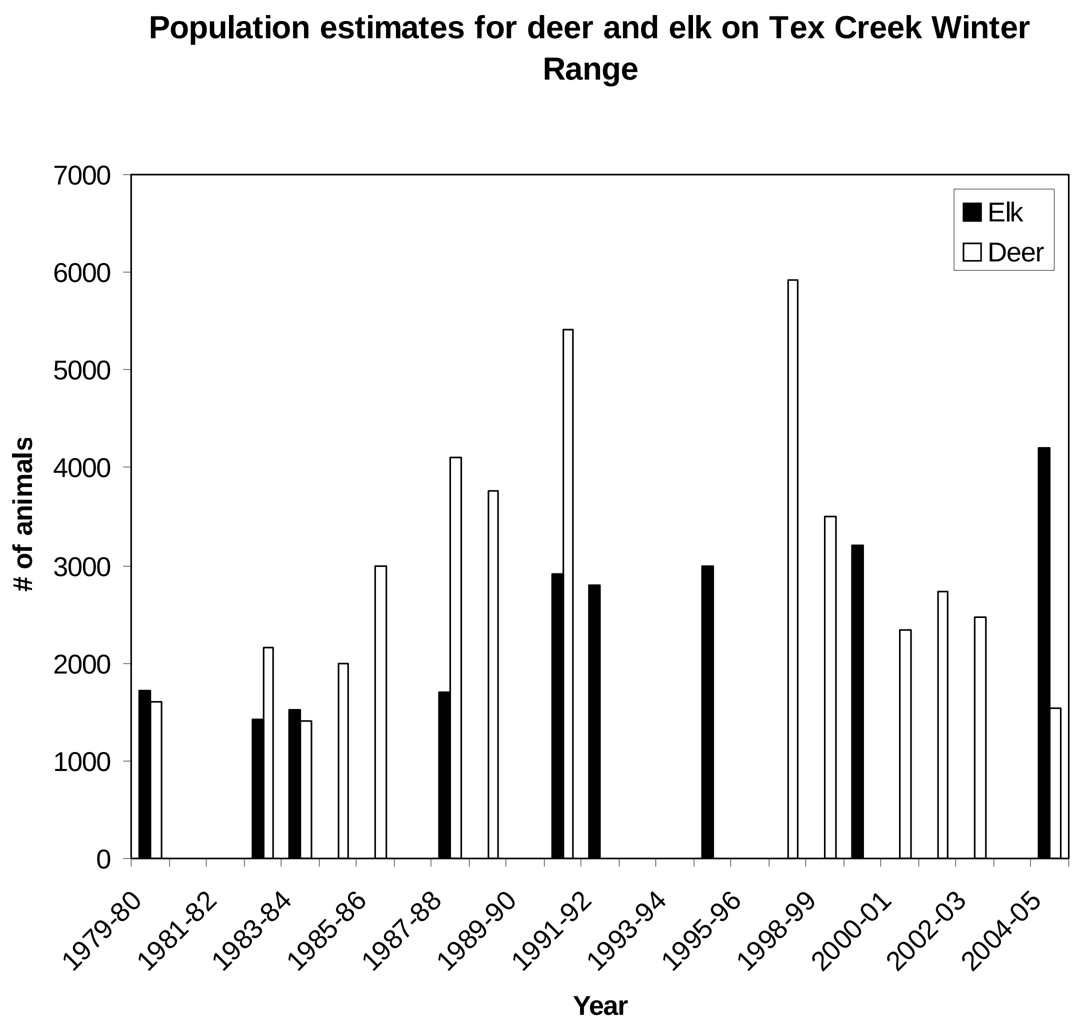

Figure 1. Population estimates gathered by helicopter for mule deer and elk on Tex Creek winter range over the years, 1980-2005.

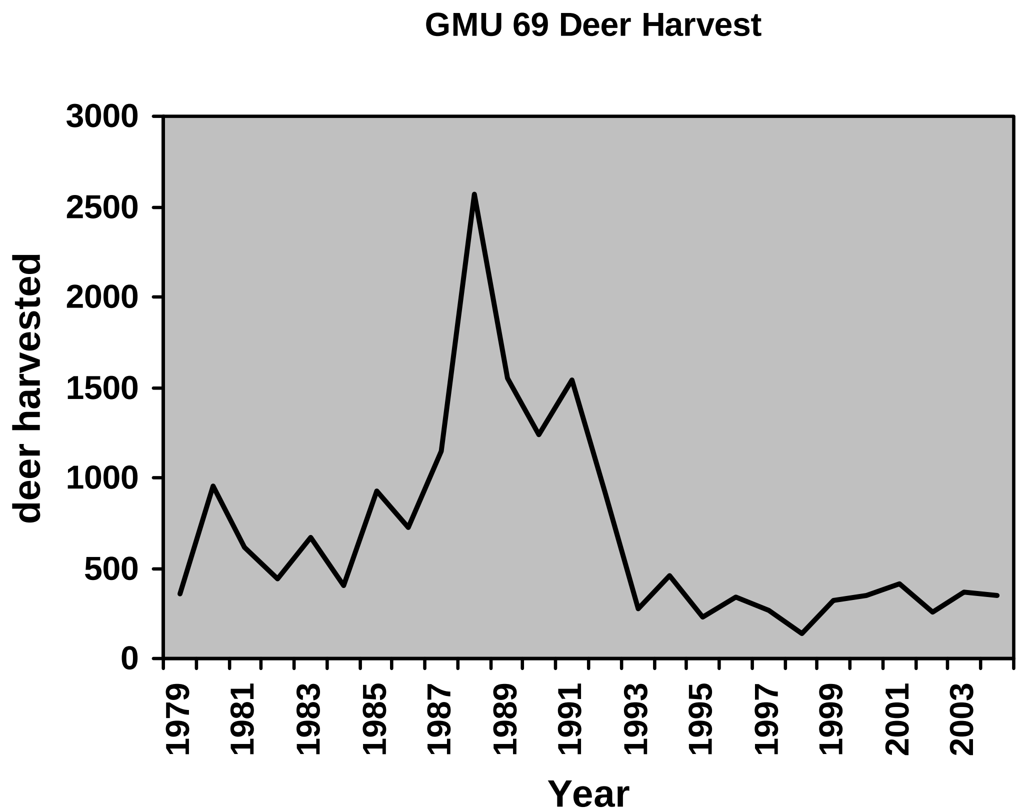

Figure 2. Hunting harvest for Idaho GMU 69 for mule deer, 1979-2004.

Appendix A. Fecal Glucocorticoids as a Measure of Stress Levels in Deer

Fecal glucocorticoid metabolite analyses are increasingly being used as a non-invasive method to measure animal stress (Millspaugh and Washburn 2004). Fecal glucocorticoid analyses are attractive because they can be obtained without disturbing the study subject. Millspaugh and Washburn (2004) warned that such analysis must be carried out carefully; fecal glucocorticoids must be adjusted for seasonal and daily fluctuations, body condition of animals, sex and reproductive status, sample storage, sample treatments, animal diets, assay selection, sample age and condition, and sample mass. Huber et al. (2003) found that neither sex nor fecal collection mode (known contributors versus anonymous contributions) affected mean fecal cortisol metabolite concentrations. Fecal glucocorticoids have been used to assess physiological effects of natural and human-induced disturbances in free-ranging elk, white-tailed deer, wolves (*Canis lupus*), and Pampas deer stags (*Ozotoceros bezoarticus bezoarticus*) (Creel et al. 2002; Millspaugh et al. 2001; Millspaugh and Washburn 2002; Pereira et al. 2006). Creel et al. (2002) found that day-to-day variation in fecal glucocorticoid levels paralleled the amount of human disturbance in Yellowstone National Park. For fecal glucocorticoid measures in deer and elk, Millspaugh and Washburn (2004) suggested collecting the entire fecal mass, freezing it as soon as possible, and using a 2% acetic acid treatment if sample had to be treated chemically. Care should be taken that samples are not subjected to thawing and refreezing which increases variability in the sample due to microbial effects (Millspaugh and Washburn 2004, Millspaugh et al. 2003).

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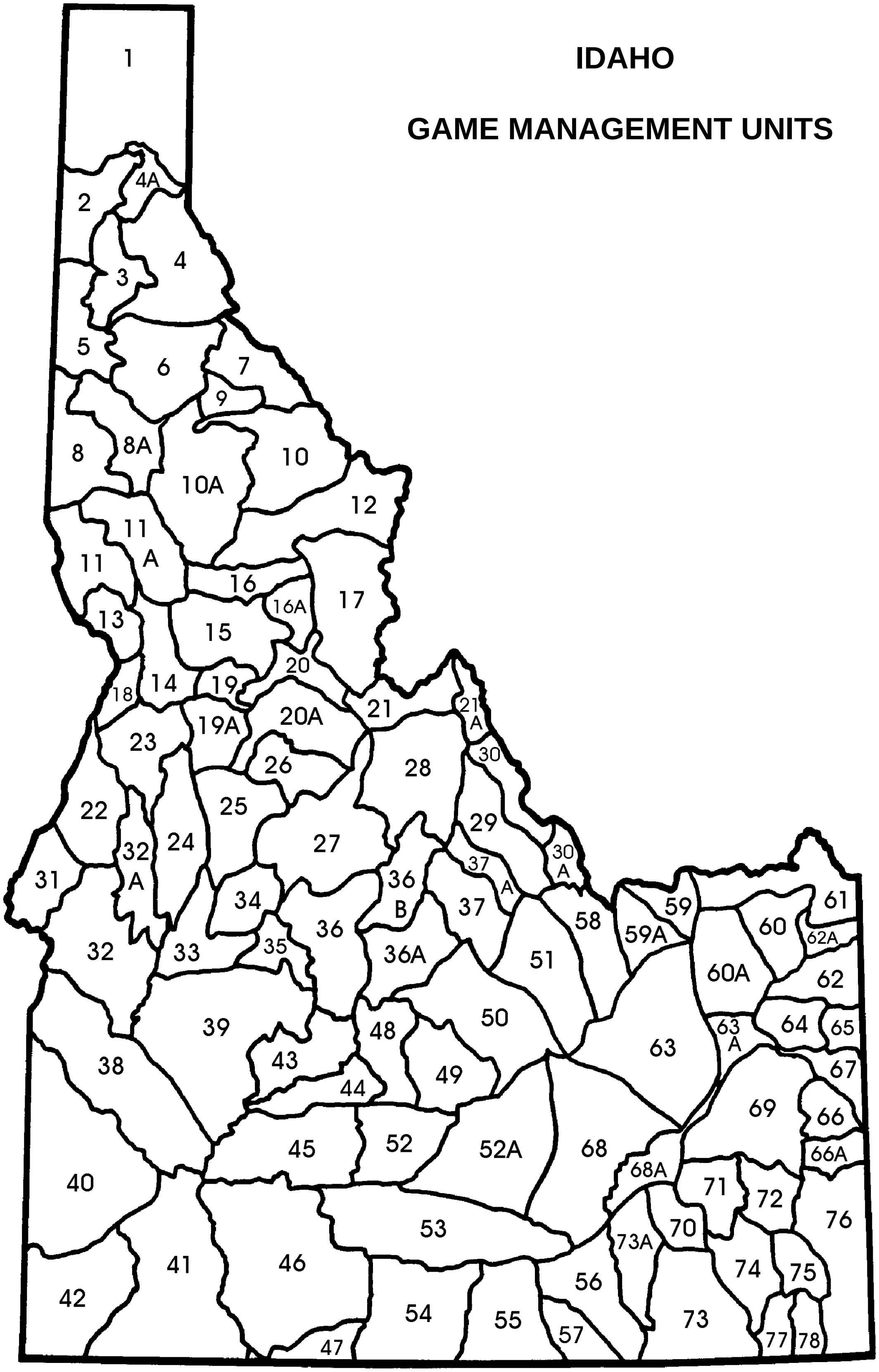
GAME MANAGEMENT UNITS



FEDERAL AID IN WILDLIFE RESTORATION

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sale of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. The Idaho Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be responsible, ethical hunters. Seventy-five percent of the funds for this project are from Federal Aid. The other 25% comes from license-generated funds.