Density and Feeding Habits of Elk and Deer in Relation to Livestock Disturbance

Kenneth Clegg
Utah State University

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DENSITY AND FEEDING HABITS OF ELK AND DEER
IN RELATION TO LIVESTOCK DISTURBANCE

By
Kenneth Clegg

A thesis submitted in partial fulfillment
of the requirements for the degree
of
MASTER OF SCIENCE
in
Fisheries and Wildlife

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UTAH STATE UNIVERSITY
Logan, Utah
1994
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Finally thanks to my wife, Heather. Her assistance scholastically, emotionally, and financially permitted me to accomplish this task. Her tolerance for countless days and nights in the field and away from her was amazing. I respect and love her very much.

Ken Clegg
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ABSTRACT

Density and Feeding Habits of Elk and Deer
in Relation to Livestock Disturbance

by

Kenneth Clegg, Master of Science
Utah State University, 1994

Major Professor: Dr. Michael L. Wolfe
Department: Fisheries and Wildlife

Elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) density and foraging behavior were monitored in conjunction with disturbance by livestock (cattle and sheep) from 1991 to 1993 at Deseret Land and Livestock property near Woodruff, Utah. Elk and deer densities declined by as much as 92% in response to introduction of livestock, while associated areas where livestock were absent did not show this response. Biting rates and bite sizes were estimated and used to determine instantaneous intake rate. These measures were similar between pastures with cattle present or absent in 1992 but differed in 1993 for bite rate and marginally so for instantaneous intake rate. Bite rate and bite size but not instantaneous intake rate showed significant differences among years when the data for both treatments were combined. My results indicated that livestock locally displaced wild ungulates but displacement occurred only while the livestock
were present. Differences in elk foraging behavior were greater between years than between treatments, and instantaneous intake rate alone was viewed as an inaccurate indicator of potential reductions in fitness.
Grazing Conflicts

The controversy over grazing on public lands and potential competition between domestic livestock and native ungulates on western rangelands is a long-standing issue. The relationship between livestock and wildlife is viewed differently by various groups or individuals. Smith (1977:p. 117) stated: "Livestock grazing is the single most important factor limiting wildlife populations in the West: it has been and continues to be administered without adequate consideration for wildlife, especially on federally owned lands." Anderson and Scherzinger (1975) and Alt et al. (1992) found that elk benefitted from the managed use of cattle. Populations of elk in the Anderson and Scherzinger (1975) study increased nearly 10-fold in 15-25 years. The authors noted that cattle grazing was only a part of the overall management plan designed to increase elk numbers, but the reality remains that wildlife and cattle were maintained in the same area and wildlife seemed to prosper under the managed conditions. Wuerthner (1992) contended that the results of the Alt et al. (1992) study were misleading, because the study lacked a control area that had no cattle but still received the benefits of the rest of the management plan.

Recent research findings have fueled the fire. McNaughton (1979, 1985, and 1993) and Dyer et al. (1991) suggested that grazing can increase above-ground primary production under certain conditions. Other authors (Painter
and Belsky 1993, Bartolome 1993, and Patten 1993) contended that the popular press has used these results to justify high levels of grazing on public lands. Lonner and Mackie (1983) noted that the majority of research, while implicating competition, actually provides evidence of co-existence. Competition implies that two species mutually reduce each other’s fitness, but demonstrating a reduction in fitness as the result of an interaction is extremely difficult. This controversy concerning allocation of public resources has led to an emotionally charged debate among managers, a more informed public, and users of western rangelands.

Previous Work

Researchers investigating interactions between wild and domestic ungulates have employed various indices to measure potential competition, namely: (1) dietary overlap, (2) spatial displacement; and (3) foraging changes (efficiency and behavior). A key issue is whether there is a decrease in fitness associated with the interaction. These indices have been used to indicate potential reductions in fitness. Much of the research addresses interactions between cattle and elk, perhaps because these species have a high degree of dietary similarity. Extrapolation of other interspecific interactions may require validation.
Dietary Overlap

Dietary overlap is probably the most studied aspect of potential competition among livestock and wildlife. An exhaustive compilation of this information is not the purpose of this paper. The following is a partial listing of studies relating to dietary similarity between elk and cattle and elk diets alone from a variety of geographical areas and is intended to show the variability among different studies.

In southern Colorado, Hansen and Reid (1975) found a range of overlap in summer diets of elk and cattle from 30-51%. Vavra et al. (1989) also noted the variability associated with seasonal differences in their 55-76% range of dietary overlap values found in eastern Oregon. In the Red Desert of Wyoming, Olsen and Hansen (1977) examined diets of elk and cattle for each season and determined a 25-85% range of overlap. The consensus from these studies is that cattle diets comprise a high fraction (90-95%) of grasses and forbs while the browse component is small. Another way to determine the potential for dietary overlap is to look at elk diets from a given area and determine what percent of grasses and forbs comprise elk diets. In the Bighorn Mountains of Wyoming, Long and Irwin (1982) found that grasses and sedges comprised 48% of elk diets. Grasses and forbs combined constituted 71-77% and 78-81% of elk diets in Washington (Korfhage et al. 1980) and Colorado (Baker and Hobbs 1982). While these values establish that overlap is likely, the degree varies by area.
and among seasons. The more important question of a population response due to this overlap is difficult to ascertain.

The issue is likely more complex than simple dietary overlap. Vavra et al. (1989) discussed specific differences involved with grazing during a single season and subsequent impacts based on the timing of the grazing event. They also pointed out the potential for carry-over effects or differences in the current year's primary production based on the previous year's associated activities. Collins and Urness (1983) found that elk preferred the highly productive meadow bottoms while deer preferred clearcuts. Elk used a more diverse array of plant species than deer. The areas preferred by elk matched those of cattle. Similar work by Loft et al. (1991) indicated a shift in the use of habitat type by mule deer in response to cattle grazing. The sharing of some resource is requisite for competition to occur, although the actual sharing of resources may have negligible effects if the shared resources are not limiting.

**Spatial Displacement**

The importance of displacement of wildlife species as a result of livestock introduction varies among studies. Although there are conflicting points of view, the general consensus regarding spatial displacement is that wild ungulates will move in response to livestock presence, depending on livestock density and the availability of
alternative habitats (Painter 1981). In central Arizona, Wallace and Krausman (1987) noticed a decrease in elk density from 0.75 to 0.12 elk/km² following the introduction of cattle. Elk remained at the depressed level until the cattle were removed. They also found that significantly fewer deer occurred on grazed versus ungrazed areas. In northern Arizona, McIntosh and Krausman (1982) found no significant differences in elk numbers before and after introduction of cattle between treated and control areas. In Wyoming, Long and Irwin (1982) also found that elk did not leave following the introduction of cattle. These results were reportedly due to the limited availability of alternative feeding sites in the study area. These studies may not reflect competitive effects among cattle and elk given that Lonner and Mackie (1983) argue that it is conjectural to assume negative fitness responses of wild ungulates resulting from spatial displacement or the lack thereof.

Other important aspects of spatial displacement deserve mention. Roberts and Becker (1982) and Knowles and Campbell (1982) both showed that elk selected for the rested pasture if a rest-rotation grazing system was in use. This could have important economic implications since a rested pasture is not truly rested if it is utilized by elk. Ward et al. (1973) described social compatibility between elk and cattle and a tendency for the two species to use similar areas. McIntosh and Krausman (1982) also observed elk in close proximity to
feeding cattle. Although construed as evidence of social tolerance, these situations could similarly indicate sharing of resources and potential competition.

Foraging Behavior

Responses in foraging to the presence of other herbivores may provide evidence for potential reductions in fitness due to competition. Hudson and Nietfeld (1985) examined forage depletion by four tame elk in an enclosure over a 7-day feeding trial, where the available biomass decreased nearly three-fold (from 2367 to 823 kg/ha). During this time the intake rate decreased significantly from 12.6 to 5.0 g/min and the cropping rate (bites taken per unit of time) increased from 35 to 45 bites/min. This suggests that bite rate might be increased to partially compensate for a reduction in forage biomass. Bite size necessarily decreased significantly from 0.36 to 0.11 grams. Wickstrom et al. (1984) used esophageal fistulation to measure changes in foraging of mule deer and elk. Use of this method requires a surgical procedure to allow diversion of food into a container outside the esophagus for later analysis. The diverted forage is dried and weighed to obtain an estimate of intake rate and then divided by the number of bites per unit of time (obtained through visual observation) to yield estimates of the average bite size. Wickstrom et al. (1984) found a similar trend namely that bite size for both deer and elk increased as the overall biomass increased. It was also pointed out that bite rate and bite
size are inversely correlated. The relationship of available forage and subsequent consumption may not always be so obvious. Spalinger and Hobbs (1992) found that foraging classes (i.e., grazers vs. browsers) may behave differently in response to forage reduction. This could mean that a browser may increase bite size under low forage availability while a grazer may take smaller bites. This adds difficulty in interpretation of results since a generalist herbivore like elk can behave as a browser or a grazer under differing circumstances.

Estimation of time and effort spent in various activities can change with differential forage availability (Green and Bear 1990). Kie et al. (1991) placed radio collars equipped with tip switches on individual mule deer to determine changes in their foraging efficiency as a result of cattle grazing in the Sierra Nevada of California. They claimed that using wild deer simulated the realistic situation of predator avoidance during feeding times. They found that the portion of the day spent feeding by deer increased from 24% to 31% and 44% among treatments of no, medium, and high cattle grazing, respectively. The underlying assumption was that time spent feeding increases predation risk. Therefore, cattle grazing may increase the risk of predation by forcing wild ungulates to spend more time in a risky activity. Other research not directly related to the question of determining competition may be useful in evaluating potential competition between
domestic livestock and wild ungulates. McCorquodale (1993) found that the number of changes in direction per 100 paces traveled by elk on Washington winter range (an indicator of difficulty in searching for food) increased with an index of diet diversity.

Spatial displacement and foraging behavior have most often been studied separately and often in artificial environments. Kie et al. (1991) argued that research on these two aspects needed to be conducted concurrently in settings applicable to natural conditions in the western United States if typical responses are to be expected. The lack of combined information concerning both spatial displacement and foraging behavior gathered on a typical rangeland setting justifies further experimentation. While complex study areas pose experimental difficulties, they may be necessary to determine actual responses of wild ungulates to the introduction of domestics.
OBJECTIVES

The primary objectives of this study were to determine whether (1) the presence of livestock displaces native ungulates; and (2) measures of foraging behavior such as biting rates and bite sizes differ between areas with livestock present or absent. Densities were measured for three time periods and the changes between periods were assessed. The null hypothesis for the first objective was that changes in deer and elk densities did not differ between pastures with livestock present or absent. The alternative hypothesis was that changes in deer and elk densities differed between pastures with livestock present or absent.

The second objective pertained only to foraging behavior of elk in response to cattle. Measurements of biting rate and bite size and their product (instantaneous intake rate) were taken in pastures with cattle either present or absent. The null hypotheses were that bite rate, bite size, and/or instantaneous intake rate of elk did not differ between pastures with cattle present or absent. The alternative hypotheses were that bite rate, bite size, and/or instantaneous intake rate differed between pastures with cattle present or absent.
METHODS

Study Area

This study was conducted on the Deseret Land and Livestock property located in northeastern Utah near Woodruff, Utah. This is a 775-km² privately owned cattle ranch. Elevation on the ranch ranges from 1830 m to 2740 m. Ten-year average precipitation is 21.6 cm in Woodruff. The area of interest was the summer range, which comprises 50% of the ranch and is utilized by native ungulates from May through November and grazed by about 1,400 cattle and 2,000 sheep from June to September. Estimates of wild ungulate populations using summer range in 1992 were 4,500 deer, 2,200 elk, and 100 moose (Alces alces). A severe winter in 1992-93 caused a 40-45% reduction in the deer herd. No significant reduction in elk or moose numbers occurred.

The summer range is divided into a series of pastures by fences and natural barriers that limit movement only of domestic animals. A rest-rotation grazing system is used for the cattle, which are distributed by herders on horseback with trained dogs. Movements from one pasture to the next occur over several days of gathering and herding to the new pasture. The use of salt blocks with protein mineral supplements helps to distribute cattle away from water sources and riparian areas. The grazing strategy employed by the ranch ensured that the same pasture was not grazed at the same time in subsequent years. Pastures were also rested on a regular
basis so that no grazing by domestic ungulates took place for an entire season. Sheep were herded by a herder and trained dogs and followed a season-long grazing plan designed to utilize forage in a manner to distribute use evenly over the range and match timing of use to plant phenology. Guard dogs were also employed to reduce predation loss. These dogs can impact wildlife as discussed by Timm and Schmidt (1990).

No phytomass estimates on summer range were made in any year of the study. However, the transitional and winter range portions of the ranch were sampled intensively. Aboveground productivity increased from 100 to 190 g/m² dry mass between 1992 and 1993 (M. E. Ritchie, pers. commun.) and likely reflected differences in productivity between years on summer range.

Density Indices

Densities of elk and deer were monitored in pastures with livestock present (treatment) or absent (control) in three consecutive summers (1991-1993). Density was assessed using methods similar to those described by Long and Irwin (1982). Pastures were organized into as many smaller units (plots) as possible with each plot center being a minimum of 1.6 km from an adjacent plot center. These plots contained sidehills or canyons that could be observed from a prominent ridge or peak. A sample of plots was randomly selected from each pasture to determine ungulate densities within the pasture. Pastures were sampled according to the sequence established
for rest and rotation.

Each plot was searched for ungulates and the area of sampling estimated. A selected ridge or peak was visited and a minimum of 2 hours was allowed to scan the plot with 7-10 power binoculars. Each observer used a spotting scope capable of at least 20 power magnification to locate and determine species and sex of all adult animals within each plot. To estimate density, the number of animals sighted within a pasture was divided by the sample area visible. Animals entering the plot from areas not visible were included. This could have effectively increased plot size but was assumed to be negligible and not important since change in density over time was the critical issue. Other information was recorded but not used directly in the analysis (see appendix).

Pastures served as replicates in the analysis. Each pasture was sampled during three periods (pre-treatment, treatment, and post-treatment). These three phases represented the application of livestock within a treated pasture while corresponding phases in control (i.e., ungrazed) pastures were also sampled. Pastures were paired geographically within time period. The first year of the study was intended to determine levels of variability and test potential methodology, so only a single pasture was sampled. In 1992 and 1993 a number of pastures with livestock present or absent were sampled (see Table 1). A minimum of 2 weeks separated each phase to insure that animals would have time to
Table 1. Number of pastures, number of plots and area sampled for wildlife density estimates in all conditions of cattle or sheep, present or absent at Deseret Land and Livestock, 1991-93.

<table>
<thead>
<tr>
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<th>Plots*</th>
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<tr>
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<td>Cattle Present</td>
<td>1</td>
<td>5</td>
<td>5.7</td>
</tr>
<tr>
<td>1991</td>
<td>Cattle Absent</td>
<td>1</td>
<td>3</td>
<td>6.9</td>
</tr>
<tr>
<td>1991</td>
<td>Sheep Present</td>
<td>1</td>
<td>3</td>
<td>4.9</td>
</tr>
<tr>
<td>1991</td>
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<td>Cattle Absent</td>
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<td>11</td>
<td>12.8</td>
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<td>12.6</td>
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<tr>
<td>1993</td>
<td>Sheep Absent</td>
<td>3</td>
<td>9</td>
<td>13.2</td>
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</tbody>
</table>

* All plots within each pasture were sampled a minimum of three time periods or phases i.e., pre-treatment, treatment and post-treatment both in areas with livestock present and absent.
adjust to differences between treatments and to insure statistical independence. Where possible the original observer visited a given plot for all sampling phases. Each plot was visited at the same time of day during each subsequent phase.

Some problems occurred in defining the appropriate spatial and temporal scale of plots in sheep-grazed pastures because sheep were tightly herded and moved rapidly. Plots recently grazed (less than one week) were considered part of the treatment phase even if no sheep were encountered. This created some subjectivity since the level of grazing was difficult to ascertain without visual observation of the sheep. Generally wild ungulates remaining within a sheep-grazed pasture were found in small areas that had been either missed or skirted by the band of sheep. This differed from the cattle-grazed pastures in that cattle were more visible and tended to disperse more evenly throughout the pasture. Standardization of these spatial and temporal scale problems would have required exclusion of all but a few plots that displayed obvious high sheep use. These plots typically held few or no wild ungulates and would likely over-estimate the influence of sheep on deer and elk.

Foraging Parameters

Foraging behavior of elk was determined in pastures with cattle present or absent. Two measurements, namely: (1) biting rate (bites taken per minute) and (2) bite size
(grams) were estimated. The product of these two
(instantaneous intake rate in g/min.) was also calculated.
Observations or samples of biting rate and bite size were
collected for each pasture during the treatment phase only
(see Table 2) by a single observer. At least 2 weeks of
grazing had occurred in each pasture before foraging data were
collected. The ungrazed pasture was sampled within a week of
the paired grazed pasture to insure that changes in plant
phenology were minimal.

The estimates of bite rate and bite size were determined
by observing feeding elk. A 30x spotting scope was used to
determine both number of bites per minute and the specific
plant utilized. Observations were confined to <400 m between
animal and observer. The exact feeding site was then visited
to estimate the length of the portion of the plant used.
Saliva on the utilized plant or obvious recent defoliation
insured the accurate relocation of the specific spot. A
similar portion of either the same plant or a nearby plant of
the same species was clipped to determine average bite size.
The plant samples were dried later at 60°C for 24 hours and
weighed to the nearest 0.1 gram.

Foraging samples reflected the demographic composition of
elk occupying each pasture. Age and sex composition of the
elk within the pasture were noted and the percentages of cows
with calves, yearling cows, spike bulls and mature bulls were
sampled randomly at the approximate proportion at which they
Table 2. Number of estimates within each pasture of both bite size and biting rate both in areas with cattle present and absent at Deseret Land and Livestock, 1992-93.

<table>
<thead>
<tr>
<th>Year</th>
<th>Pasture</th>
<th>Bite Size estimates</th>
<th>Biting rate estimates</th>
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<tr>
<td></td>
<td></td>
<td>cattle present</td>
<td>cattle absent</td>
</tr>
<tr>
<td></td>
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<td>cattle</td>
</tr>
<tr>
<td>1992</td>
<td>#1</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>1992</td>
<td>#2</td>
<td>35</td>
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<tr>
<td>1992</td>
<td>#3</td>
<td>33</td>
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<tr>
<td>1993</td>
<td>#1</td>
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<td>1993</td>
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</tr>
<tr>
<td>1993</td>
<td>#3</td>
<td>35</td>
<td>27</td>
</tr>
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</table>
occurred in both grazed and ungrazed paired pastures. If 30 bite samples were taken for bulls and cows in the grazed pasture, then 30 bite samples were taken for bulls and cows in the paired ungrazed pasture.

Data Analysis

Differences in wild ungulate densities between treatment and control pastures for each year were assessed by an analysis of variance (ANOVA) with pastures as replicates. Additional analyses using the means for each year as the replicate provided a comparison over time. The figure used in the ANOVA was the difference between phases, so pre-treatment densities were subtracted from treatment densities for treated and control pastures. Pre-treatment densities were also subtracted from the post-treatment density counts to determine if the disturbance continued after domestic stock were removed. Densities were log-transformed before subtraction to obtain normal distributions.

Biting rate, bite size, and the associated instantaneous intake rate as well as determination of potential differences between group size and time visible were compared between treatments using paired t-tests. The alpha level for analysis of the instantaneous intake rate was shifted from 0.05 to 0.025 using a Bonferroni method described by Zolman (1993). The shift was justified since the bite size is correlated to the instantaneous intake rate (P=0.001) but not to bite rate. This shift was inconsequential since either value provided the
same outcome. A regression between cattle and elk density was used to determine the predictability in time of site-specific cattle and elk interactions. Data were analyzed using the Number Cruncher Statistical System (Hintz 1986).
RESULTS

Density Interspecific Interactions

Cattle and Elk

The change in elk density (pre-treatment minus treatment) was significantly different between pastures with cattle present or absent in both 1992 and 1993 (P=0.04 and P<0.001, respectively; Figure 1). A single, paired pasture precluded statistical analysis in 1991. The same analysis using the means for each year as the replicate was significantly different between treatments (P=0.02, Figure 2). The trend of much lower elk densities in cattle-grazed pastures during the treatment phase was observed in all pastures each year. A measure of the duration of displacement, which was determined by subtracting pre-treatment from post-treatment densities, showed no significant differences between pastures with cattle present or absent in any year of the study or when using the yearly means as replicates.

Cattle also appeared to affect group size of elk. Mean group size (pre-treatment) compared with mean group size (treatment) combining all years of the study differed significantly (P=0.02) from 4.8 to 2.6 animals per group in areas with cattle present. Mean group size was determined by dividing total elk by the numbers of groups cited for each treatment (see appendix). Similar analyses where cattle were absent showed no significant difference between pre-treatment
Elk density with cattle present

Elk density with cattle absent

Figure 1. Elk densities (elk/km²) in pasture(s) with cattle present or absent at Deseret Land and Livestock, 1991-1993. Each bar represents an individual pasture and phase denotes treatment timing (i.e., 1=pre-treatment; 2=treatment; 3=post-treatment).
Figure 2. Elk densities (elk/km²) at Deseret Land and Livestock, 1991-1993. Each bar represents a three year average and the associated standard error line in pastures with livestock present or absent and phases representing treatment timing (i.e., 1=pre-treatment; 2=treatment; 3=post-treatment).
and treatment estimates of mean group size (4.0 and 4.7 animals per group, respectively). Average time visible (determined by averaging the visible time for each treatment) combining all three years was not different between pastures with cattle present or absent during any phase of the study.

The cattle-grazed pastures were analyzed to determine if site-specific cattle density affected the remaining elk density in the pasture. A single data point was omitted from the regression analysis after using the Cook's D test (used to predict outliers) found in the Number Cruncher Statistical System (Hintz 1986). No significant relationship was found in either 1992 or 1993 (P=0.11 or 0.99, respectively). Analysis of covariance, however, showed significant difference in slopes between 1992 and 1993 (P=0.04).

**Cattle and Deer**

Changes in deer densities (pre-treatment minus treatment) differed significantly (P=0.05) between pastures with cattle present or absent in 1993 (Fig. 3). The magnitude of reduction in deer density due to cattle grazing was smaller than that for elk. Figure 3 shows that deer densities were less impacted than elk densities but were lower in the grazed pasture during the treatment phase in both 1992 and 1993 than in the pre-treatment phase. No significant differences between pastures with cattle present or absent occurred when pre-treatment densities were subtracted from post-treatment densities in any year. Figure 4 shows an insignificant change
Figure 3. Deer densities (deer/km²) in pasture(s) with cattle present or absent at Deseret Land and Livestock, 1991-1993. Each bar represents an individual pasture and phase denotes treatment timing (i.e., 1=pre-treatment; 2=treatment; 3=post-treatment).
Figure 4. Deer densities (deer/km²) at Deseret Land and Livestock, 1991-1993. Each bar represents a three year average and the associated standard error line in pastures with livestock present or absent and phases representing treatment timing (i.e., 1=pre-treatment; 2=treatment; 3=post-treatment).
in deer density from the pre-treatment to treatment phase between pastures with cattle present or absent when using the means for all years.

Sheep and Elk

Changes in elk densities (pre-treatment minus treatment) were significantly different (P<0.001) between pastures with sheep present or absent in 1993 (Fig. 5). Insufficient replications precluded analyses for either 1992 or 1991. Similar analysis using means for each year also showed a significant difference (P<0.001) between areas with sheep present or absent (Fig. 2). Pre-treatment densities when subtracted from post-treatment densities were not significantly different in any year between areas with sheep present or absent although an insignificant decline was apparent.

Sheep and Deer

In 1993 the difference in deer density between pastures with sheep present or absent during the treatment phase was not significant (P=0.14) but is mentioned because the procedural problems described above likely affected the outcome of this analysis. In 1991 and 1992 insufficient replications precluded analysis. This is potentially misleading because Figure 6 shows that in two out of three years a high percentage of deer was apparently displaced. Post-treatment densities showed a similar trend to that of elk
Figure 5. Elk densities (elk/km²) in pasture(s) with sheep present or absent at Deseret Land and Livestock, 1991-1993. Each bar represents an individual pasture and phase denotes treatment timing (i.e., 1=pre-treatment; 2=treatment; 3=post-treatment).
Figure 6. Deer densities (deer/km²) in pasture(s) with sheep present or absent at Deseret Land and Livestock, 1991-1993. Each bar represents an individual pasture and phase denotes treatment timing (i.e., 1=pre-treatment; 2=treatment; 3=post-treatment).
in that deer densities were not significantly lower in the sheep-grazed pasture for at least 2 weeks after the disturbance. In every case the post-treatment densities were lower than the pre-treatment densities in pastures with sheep present but not with sheep absent, but, no significant differences were found. Using the means for each year as replicates revealed no significant differences in deer density between treatment and control pastures.

Measures of Foraging Behavior

Biting Rate

Elk bite rate differed significantly between treatments in 1993 (P=0.01), but not in 1992 (Figure 7). Differences between years in pastures with cattle present or absent were highly significant (P<0.001 and P<0.001, respectively), likely reflecting the differences in available forage.

Bite Size

Bite size of elk did not differ significantly between treatments in either year (Figure 7). The bite size in pastures with cattle present was different between years (P=0.02) but not different in pastures with cattle absent.

Instantaneous Intake Rate

Differences in instantaneous intake rate were not significant (P=0.09) in 1993 between treatment and control pastures (the significance level was adjusted to 0.025). No
Figure 7. Elk foraging parameters at Deseret Land and Livestock, 1992-1993. Each bar represents a pasture mean both in areas with cattle present (labeled 1 on x axis) or cattle absent (labeled 2 on x axis).
significant differences occurred in 1992 (Figure 7) even though the difference between treatment and control pastures was more apparent in 1993 than in 1992. When evaluating differences between years in pastures with cattle present, the relationship was significant \( (P=0.02) \), although in pastures with cattle absent there was no significant difference. Combining results from years was not attempted due to interannual variation.
DISCUSSION

The concept of competition has been extensively studied (Crowell and Pimm 1976, Schoener 1974 and 1985, Rosenzweig et al. 1985, Abramsky 1981 and Abramsky et al. 1986). Competition occurs in the broad sense if the welfare of one species is worsened by the presence of another species (Kie et al. 1991). Difficulties in applying the results of the above studies to large herbivores at the population level are expected due to the problems discussed previously. Schoener (1974, 1985) and Crowell and Pimm (1976) attempted to use census data to describe competition. Their results were questioned by Rosenzweig et al. (1985), Abramsky (1981), and Abramsky et al. (1986), who argued that the oversimplification often assumed by theoretical models may lead to inaccurate assessment. Their arguments notwithstanding, an attempt to describe potential competition between two large herbivores using measures of density and forage-related behavior has validity.

Density Implications

The results indicated that, in general, native ungulates were displaced during the grazing events by domestic livestock. This agrees with the findings of Wallace and Krausman (1987) in that elk were displaced by cattle. This displacement did not differ between 1992 and 1993 with respect to the magnitude of dispersal. The density
estimations (elk and deer) taken after removal of domestics were not different between treated and untreated pastures, although there was some tendency for densities to remain at insignificantly lower levels in the pastures that received livestock. This suggests that actual displacement only resulted from direct interaction of the species. The significant difference found for group size between treatments is an important corollary to the significant differences found between treatment densities. Hanley (1982) found that group size differed according to forage availability. However, no differences in group size were found between pastures with cattle present or absent between the pre-treatment and post-treatment phase.

Annual weather patterns may have impacted the reaction of animals to the grazing influence. In 1992, a drought year, elk selected grazed pastures several weeks after cattle had been removed. This was noted incidentally and was not properly replicated. Figure 8 shows the large increase observed in one of the grazed pastures as a presumed result of vegetation regrowth following cattle grazing. The regrowth was highly preferred and the pasture was selected by elk. In 1993 more moisture produced significantly greater biomass and elk did not select the grazed pasture after cattle were removed (Figure 8). This may have been due to an absence of early fall rains that would have stimulated a regreening in the grazed pastures.
Figure 8. Elk densities (elk/km²) at Deseret Land and Livestock, 1992-1993. Each bar is a single pasture (sampled through time) with cattle present or absent over the course of the respective year.
Foraging Implications

Foraging behavior is apparently impacted by the availability of forage. Intuitively, differences in available phytomass could occur due to either differential harvesting of the existing forage available (i.e., domestic grazing leading to less available forage) or differential growth (i.e., improved plant growth factors leading to increased primary production). Hudson and Nietfeld (1985) and Wickstrom et al. (1984) suggested that an increase in available phytomass would lead to decreases in the biting rate, increases in bite size, and an overall increase in the instantaneous intake rate. Comparison of their results with those of this study should be viewed cautiously, because available biomass in this study likely did not reach the artificially low levels they described.

Bite size, bite rate, and instantaneous intake rate in 1992 did not differ between treatment and control areas, indicating cattle in this situation did not influence foraging behavior. The significant differences observed in biting rate between treatments could indicate that the response of elk to cattle grazing may vary based on differential primary production. The difference between years in pastures where cattle grazing occurred indicated that from 1992 to 1993, biting rates were higher, bite size was lower, and the instantaneous intake rate did not differ. This does not follow the expectations cited throughout the literature, but
may be explained by Spalinger and Hobb's (1992) description of a difference between browsers and grazers in the relationship of available biomass to intake rates and the trade-off between bite size and bite rate.

The estimates of instantaneous intake rate were not different for combined treatments (cattle present or absent) when compared between 1992 and 1993 (14.3 and 13.0 g/min. in 1992 and 1993, respectively; see Fig. 7). However, differences of bite size and bite rate between years indicated differential elk foraging behavior in spite of similarities in the instantaneous intake rate. The difference in forage availability between 1992 and 1993 apparently impacted some of the physical body measurements among harvested antlerless elk at Deseret Land and Livestock. The average weight of field-dressed calf elk in 1992 was 68.7 kg compared to 86.9 kg in 1993. Measurements of the depth of fat over the rump differed from 0.0 to 0.2 cm in 1992 and 1993, respectively. The adults fared similarly with average weights of elk 1.5 years and older being 144.5 kg in 1992 and 159.7 kg in 1993. Rump fat estimations were 0.9 cm in 1992 and 1.5 cm in 1993 (B. Wharff, Deseret Land and Livestock Biologist, pers. commun.), again indicating that the differences in forage production probably led to an average decrease in these measures. These estimates involved over 100 animals in both years and were collected ranchwide with no attempt to separate harvest sites into grazed and ungrazed areas. Thus, instantaneous intake rate
alone is likely a misleading indicator of fitness, and cattle effects on intake rate may not reflect competition.

Conclusions

Grazing by cattle and sheep influenced local densities of elk and to a lesser degree deer. Cattle effects on elk densities in both 1992 and 1993 were significant. No significant relationships occurred between treatment and control areas following removal of livestock, although somewhat depressed densities were observed. Foraging behavior showed greater variability between years than between treatments. The bite rate differed between pastures with cattle present or absent in 1993. Other measures of foraging behavior were not significantly different between treatments. Interannual differences in measures of foraging efficiency are judged to be more biologically significant than differences between areas with cattle present or absent. Instantaneous intake rate alone is likely an inadequate indicator of a reduction in fitness.

Management Recommendations

Based on this study of density and feeding habits, the following recommendations for minimizing conflict and maximizing benefit are made.

1. Building some type of rest into the grazing system is an important step in range management. This is already practiced at Deseret Land and Livestock but
is emphasized here to insure that the labor-intensive process of controlling cattle distribution is continued. Based on the apparent decline in elk and deer densities in areas ungrazed by livestock over the course of a grazing season, consideration of resting pastures from continuous wild ungulate use or research into attempting this type of procedure is advisable.

2. The response of wild ungulates to grazing practices should be considered. Livestock grazing could potentially influence deer and elk densities by concentrating or depleting these ungulates in localized areas. This could have important economic impacts since commercial hunting opportunities are regulated by state agencies and limit the season and area involved in wild ungulate harvests. Improper timing of livestock grazing could reduce these opportunities.

3. Sheep grazing is more dramatic in the length of wild ungulate displacement. If sheep grazing were to increase at Deseret Land and Livestock, the importance of insuring the availability of alternative areas ungrazed by livestock would increase.
LITERATURE CITED


Schoener, T.W. 1985 On the degree of consistency expected when different methods are used to estimate competition coefficients from census data. Oecologia 67:591-592.


General Plot Information

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Individual group observation information

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