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Overview of the Starkey Project: Mule Deer and Elk Research for Management Benefits

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Introduction

Managers have long been concerned about the welfare of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) on public lands in the western United States. These two species generate millions of dollars annually to state wildlife agencies from sales of hunting licenses, and elk viewing generates millions of additional dollars to local and regional economies (Bolon 1994, Bunnell et al. 2002). By contrast, the potential for elk and mule deer to compete with livestock, to damage agricultural crops and to modify plant succession make the two species obvious sources of controversy among private and public land managers.

In the 1980s, wildlife managers began to focus on the potential effects of timber management, livestock grazing, road use and ungulate harvest strategies on mule deer and elk. At the same time, land managers were concerned about constraints associated with these management activities, based on the perceived needs of the two species. In particular, timber harvest, livestock production, road construction and motorized traffic were dominant and pervasive uses of public lands during the 1980s and earlier decades, but their effects on deer and elk were uncertain and widely debated. In addition, the dichotomy of managing for productive habitats (i. e., high biomass and quality of forage) versus secure habitats (i. e, dense cover and minimal human disturbance) was highly debated, with management trade-offs that were unclear (Lyon and Christensen 2002). As an outgrowth of these concerns and the lack of empirical data, the Starkey Project was initiated in the mid-1980s at the U. S. Department of Agriculture, Forest Service's Starkey Experimental Forest and Range (Starkey) in northeastern Oregon (Figure 1). The project was designed to evaluate mule deer and elk responses to the most common management activities occurring on national forests in the western United States.

In this paper, we provide an overview of the Starkey Project as an introduction for the papers that follow. Additional details about the Starkey Project and Starkey are found in Rowland et al. (1997, 1998), Skovlin (1991) and at the Starkey Project's Website (http://www.fs.fed.us/pnw/starkey/).

Controversies of Ungulate Management: Beginning of the Starkey Project

The Starkey Project was born from contentious debate about how best to manage habitats and populations of mule deer and elk in the western United States and about the degree to which traditional management practices on public lands needed modification to accommodate the two species' needs. The most prominent issues of debate related to (1) road and traffic management, (2) intensive timber production and thermal cover, (3) competition between wild ungulates and cattle, and (4) breeding efficiency of male elk in relation to population productivity. These four issues became the foundation of the Starkey Project's original studies that began in 1989 and ended during the 1990s (Table 1).

The issue of road management revolved around the uncertainty of whether mule deer and elk avoided roads open to motorized traffic and whether the rate of motorized traffic influenced ungulate distribution (Rowland et al.

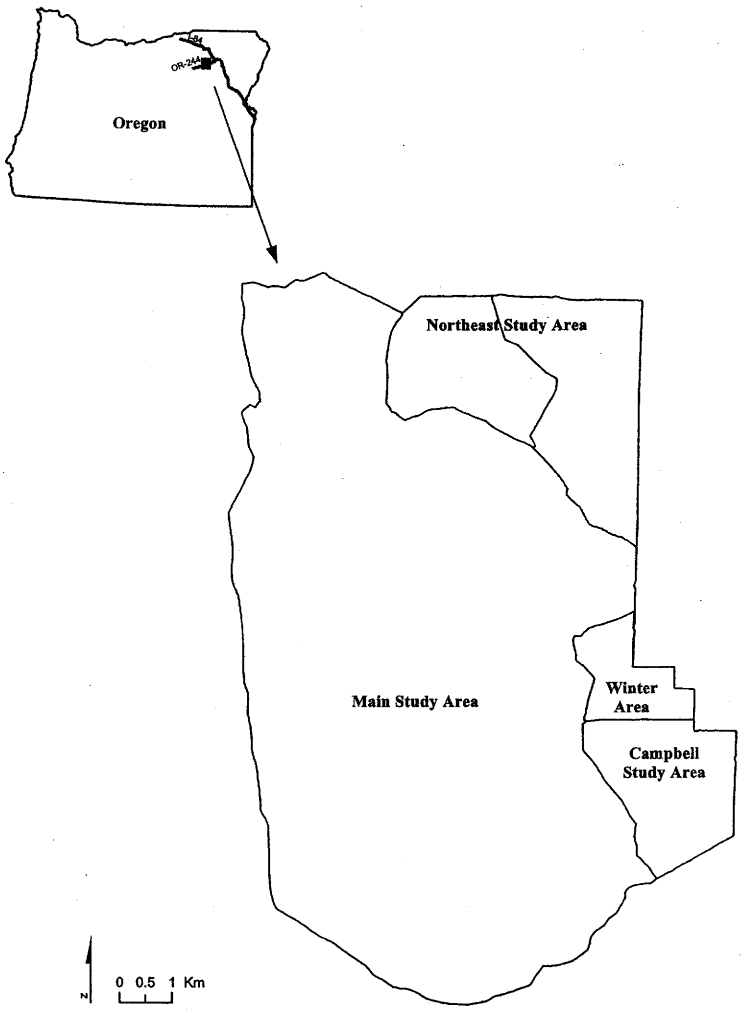

Figure 1. (Above) Location of Starkey Experimental Forest and Range in northeastern Oregon, 28 miles (45 km) southwest of La Grande. (At right) Boundaries of the ungulate-proof enclosure, internal ungulate fences and study areas. The 3,590-acre (1,453-ha) Northeast Study Area and the 19,180-acre (7,768-ha) Main Study Area are the two sites where research occurs from April through early December on free-ranging ungulates. The 655-acre (265-ha) Winter Area is the site of winter feeding and handling of deer and elk. The 1,537-acre (622-ha) Campbell Study Area is for the study of ungulate breeding and grazing.

1997). To address these issues, vehicle travel by the public was monitored with traffic counters during the 1990s in the Main Study Area (Figure 1) from May through December of each year (Table 1). Radio-telemetry locations of

Table 1. Chronology of major research activities of the Starkey Project, 1982 to 2004 (from Rowland et al. 1997 and updated to early 2004).

Year	Research Activity
1982-1985	Initial discussions regarding the Starkey Project take place among scientists from the Oregon Department of Fish and Wildlife and U. S. Department of Agriculture, Forest Service Pacific Northwest Research Station, resulting in proposals for the original studies.
1986	Environmental assessment is completed and approved for construction of Starkey Project enclosure.
1987	Twenty-seven miles (43 km) of New Zealand woven-wire fence is installed to enclose 24,962 acres (10,110 ha) of Starkey (Figure 1), encompassing summer range populations of mule deer and elk.
1988-1989	Over 65 traffic counters are installed at intersections of open roads in the Main Study Area for the roads and traffic study.
	The 655-acre (265-ha) Winter Area and handling facility is completed (Figure 1).
	Loran-C automated telemetry system (ATS) becomes operational in Northeast Study Area, allowing ungulates to be radio-collared and monitored remotely to start the intensive timber management study.
	Limited entry hunting of deer and elk begins in support of breeding bull study in the Main Study Area.
1990	Timber harvest contract is awarded for intensive timber management study in the Northeast Study Area.
	Loran-C ATS is completed for the Main Study Area, making the telemetry system operational in all areas of Starkey, and allowing the start of the animal unit equivalency and roads and traffic studies.
1991	Elk thermal cover study begins at Kamela, 30 miles (48 km) northeast of Starkey.
	Starkey's Institutional Animal Care and Use Committee is formed under new regulations promulgated from the federal Animal Welfare Act, formalizing the existing procedures for humane care and treatment of ungulates used for research (Wisdom et al. 1993).
	Road construction and logging begins late in the year in Northeast Study Area as part of intensive timber management study.
1992	Campbell Study Area (1,537 acres [622 ha]) is established (Figure 1) in support of new breeding bull study.
	Study of ungulate herbivory effects on plant succession and nutrient availability begins at exclosures established more than 25 years ago throughout northeastern Oregon.
	Loran-C ATS is upgraded, resulting in improved accuracy of animal locations.
1993	Logging is completed early in the year in Northeast Study Area; over 7 million board feet is harvested.
	Elk breeding bull efficiency study is completed in Main Study Area.
	Performance tests of Loran-C ATS are initiated.

Table 1 (continued). Chronology of major research activities of the Starkey Project, 1982 to 2004 (from Rowland et al. 1997 and updated to early 2004).

Year	Research Activity
1994	Animal unit equivalency study is completed in Main Study Area.
1995	Prototype forage allocation model is built, tested and published as part of animal unit equivalency study.
	Validation phase of elk breeding bull study begins in Main Study Area.
	Roads and traffic study is completed in Main Study Area.
	Elk thermal cover study is completed at Kamela study site.
1996	Results from the elk breeding bull study are published (Noyes et al. 1996).
	Intensive timber management study is completed and elk-ecosystem processes study is designed for northeastern study area.
1997	New fuels reduction study is designed for Main Study Area.
	Cross-fencing of Northeast Study Area into east (1,500 acres [608 ha]) and west (2,090 acres [846 ha]) pastures is completed to start new research about elk-ecosystem processes.
1998	Results from elk thermal cover study at Kamela are published (Cook et al. 1998).
	Performance tests and bias corrections for ATS are published (Johnson et al. 1998).
	Results from the traffic study are summarized in a Ph.D. dissertation (Wisdom 1998).
1999	Manipulative experiment to validate results from traffic study begins in Main Study Area.
	Fuels reduction study begins in Main Study Area.
2000	Results from elk-roads study are published (Rowland et al. 2000).
	Results from study on ungulate herbivory effects on plant succession are published (Riggs et al. 2000).
	Additional results from the animal unit equivalency study on mule deer and elk are published (Johnson et al. 2000).
	Manipulative experiment to validate results from traffic study is completed in Main Study Area.
2001	Elk-ecosystem processes research in Northeast Study Area is completed.
	Results from the intensive timber management study for elk are summarized in a Master's thesis (Rinehart 2001).
	Additional results from the animal unit equivalency study on cattle-deer-elk interactions are published (Coe et al. 2001).
	Symposium held at Eastern Oregon University to summarize findings of more than 10 years of research of the Starkey Project; attended by more than 150 scientists and managers from western North America.
2002	Results from the validation phase of the elk breeding bull study are published (Noyes et al. 2002).

Table 1 (continued). Chronology of major research activities of the Starkey Project, 1982 to 2004 (from Rowland et al. 1997 and updated to early 2004).

Year	Research Activity
2002 (cont.)	New study on effects of off-road recreational activities on deer and elk begins in the Northeast Study Area.
	Construction of two ungulate exclosures, each 18 acres (7.3 ha) in size, is completed in the Main Study Area to begin new research on ungulate herbivory effects on ecological processes.
	Replacement of the Loran-C ATS with a new GPS-based telemetry system is identified as a key need, with initial design and cost estimates completed.
2003	Results from elk birth date-nutrition study are published (Cook et al. 2004b).
	Three additional 18-acre (7.3-ha) ungulate exclosures are built in support of new herbivory research in Main Study Area.
	New GPS-based radio collars are used on 16 elk in the Northeast Study Area as part of study on effects of off-road recreation.
	Study to validate Starkey elk resource selection patterns begins at Sled Springs Demonstration Area on Boise Cascade Corporation lands in northeastern Oregon.
2004	Off-road recreation study is completed in Northeast Study Area and preliminary results are published (Wisdom et al. 2004a).
	Field sampling and grazing trials begin for new herbivory research in Main Study Area.
	Treatments for fuels reduction study are completed in Main Study Area.
	Over 10 years of research findings from the Starkey Project are summarized in a set of 20 papers presented at the 69th North American Wildlife and Natural Resources Conference, and subsequently published in the conference's *Transactions*, reprinted in a book by Allen Press.

ungulates were collected and analyzed in relation to road type (open, closed, restricted) and traffic rate (zero, low, moderate, high, very high). The result has been a set of compelling findings about deer and elk distributions, in relation to their distance to roads with varying traffic rates (Wisdom 1998, Wisdom et al. 2004b) and and about distance of elk to open roads (Rowland et al. 2000, 2004). Results are now used for management of roads and access throughout western North America (Thomas and Wisdom 2004).

Considerable controversy also existed about the effects of timber management on mule deer and elk (Hieb 1976, Rowland et al. 1997). Consequently, ungulate response to intensive timber production was assessed in the Northeast Study Area of Starkey (Figure 1). Radio-collared cattle, deer and elk were monitored from 1989 to 1996, spanning periods before, during and after timber harvest (Table 1). Over half of the forested area was subjected to intensive logging, combined with a doubling of road density. Animal responses were monitored in a variety of ways (Rinehart 2001, Wisdom et al. 2004c). Results provided little evidence of negative effects on ungulates from activities or changes brought about by intensive timber harvest on summer range during nonhunting periods (Wisdom et al. 2004c).

Throughout the 1980s, some studies documented high use of dense forests by elk (Leckenby 1984), and others postulated that elk were selecting these sites for thermal cover (Thomas et al. 1988). These ideas generated considerable debate about how forests should be managed and why elk were selecting dense cover. To address this issue, an experimental study was conducted at Kamela, Oregon, approximately 30 miles (48 km) northeast of Starkey (Cook et al. 1998). Here, the nutritional condition of tractable elk maintained in pens was monitored in relation to four treatments: (1) dense thermal cover, (2) moderately dense thermal cover, (3) no cover and (4) a combination of no cover and thermal cover. Results indicated no positive benefits to animal condition from thermal cover. Instead, a negative effect was associated with high levels of cover (Cook et al. 1998, 2004a). These results have changed the way that managers think about and plan for maintenance of elk thermal cover across western North America (Thomas and Wisdom 2004), in balance with the need to maintain dense cover for elk security, especially during hunting seasons (Lyon and Christensen 2002).

The issue of whether mule deer and elk compete with cattle for available forage on summer range was addressed by a long-term study of ungulate interactions in the Main Study Area (animal unit equivalency study, Table 1). By evaluating the spatial distributions, resource selection patterns and behavioral interactions of the three ungulates as cattle were rotated through livestock pastures on summer range (Coe et al. 2001, 2004; Stewart et al. 2002), scientists were able to devise a realistic allocation of forage among the ungulate species by month and season (Johnson et al. 1996, Ager et al. 2004). Based on these results and a subsequent study of diet overlap among the three species (Findholt et al. 2004), a new forage allocation model is now available for beta testing as part of allotment planning on national forests of the interior western United States (Ager et al. 2004).

The issue of whether elk productivity is affected by age of breeding bulls also was addressed in the Main Study Area (Table 1). From 1989 to 1993, breeding male elk were allowed to increase in age, beginning as 1.5 year-old (yearling) bulls in 1989. During each of these five years, this single cohort of male elk functioned as the only breeders in the study population. As bulls grew older, conception dates in female elk were earlier and more synchronous (Noyes et al. 1996). As a result, calves were born earlier and over a shorter time period each spring, which may provide a number of survival benefits (Noyes et al. 2004). Results have caused substantial changes in hunting regulations for bull elk across many states and provinces in western North America (Thomas and Wisdom 2004).

Continued Need for Information Drives Additional Studies

The original studies at Starkey were completed during the mid- and late 1990s (Table 1) and were used by management agencies soon after publication (Thomas and Wisdom 2004). Results also spurred follow-on research, such as validation tests of the original breeding bull study (Noyes et al. 2002) and original traffic study (Wisdom et al. 2004b). Results from the original studies also were the catalyst for subsequent studies on the interactions of nutrition and bull age in affecting elk condition (Cook et al. 2004b) and the assessment of ungulate diets (Findholt et al. 2004) to realistically allocate forage among cattle, mule deer and elk (Ager et al. 2004).

New research continues today to complement the original research. While past studies focused on mule deer and elk responses to management, new research also considers the effects of these ungulates on the ecosystem (Riggs et al. 2004, Vavra et al. 2004). In addition, new research has recently been completed, or is nearing completion, regarding deer and elk responses to off-road recreation (Wisdom et al. 2004a), fuels reduction (Vavra et al. 2004), hunting (Johnson et al. 2004), breeding-nutrition interactions on elk condition (Cook et al. 2004b) and fine-scale movement patterns of deer and elk (Ager et al. 2003).

New research also is underway on nonfederal ownerships near Starkey to complement past and current studies at Starkey. As an example, the resource selection models derived at Starkey for the animal unit equivalency study (Johnson et al. 2000) are being validated at the Sled Springs study area, on land owned by Boise Cascade Corporation (Coe 2003). This research at Sled Springs will strengthen and expand the inference space for the Starkey forage allocation model (Ager et al. 2004) to improve its use across larger areas of the western United States (Coe 2003).

New Technologies Support the Studies

The main goal of the Starkey Project has been to measure the habitat, behavioral and population responses of mule deer and elk to intensely managed forests and rangelands at the landscape scales at which management occurs. Meeting this goal for the plethora of studies that have taken place required innovative technologies and a unique research environment with the following characteristics:

1. a closed system to ungulates, with defined ungulate populations whose responses to management experiments on spring, summer and fall ranges could be measured accurately
2. an expansive area over which the experiments could be implemented, allowing inferences to be made at landscape scales to be used for management
3. an animal tracking system capable of accurate and continuous monitoring of animal movements
4. a network of traffic counters for close monitoring of human activities and movements
5. a winter facility, where mule deer and elk could be fed to minimize the confounding effects of winter weather
6. a database and mapping system capable of storing and displaying a comprehensive set of environmental variables in relation to animal movements and human activities
7. an effective strategy of hunter management and mule deer and elk harvest, using limited entry hunts to achieve desired management treatments on ungulate populations, to collect data from harvested animals, to meet research goals and to evaluate ungulate responses to varying levels and types of hunting pressure.

Establishing these technologies and the needed research facility at Starkey required innovation, persistence and persuasion on the part of the founders of the project (Rowland et al. 1997). Scientists, such as Jack Ward Thomas and Donavin Leckenby, with the U. S. Department of Agriculture, Forest Service's (Forest Service) Pacific Northwest Research Station and the Oregon Department of Fish and Wildlife, developed novel study plans not conceived in past wildlife research. The plans called for the most intensive radiotelemetry monitoring of ungulate populations ever attempted, and they called for novel, experimental treatments and controls for evaluating animal responses to management activities at landscape scales not considered possible.

Thomas then convinced a regional forester, John Butruille, of the worth of the proposed studies. Butruille responded by committing millions of dollars from the management branch of the Forest Service to establish the needed technologies and research facility. Larry Bryant, another scientist with the Pacific Northwest Research Station at the time, then directed the development, acquisition and implementation of every major technology and facility improvement during the late 1980s, each of which is still in use today.

Ungulate-proof Enclosure

Forty miles (64 km) of 8-foot-high (2.4 m), New Zealand woven-wire fence were constructed in 1987 to establish the Starkey ungulate enclosure (Bryant et al. 1993). An additional 27 miles (43 km) of internal fence were constructed to establish three separate areas (Figure 1): the Main Study Area (19,180 acres [7,768 ha]), the Northeast Study Area (3,590 acres [1,454 ha]) and the Winter Area (655 acres [265 ha]). In 1992, the 1,537-acre (622-ha) Campbell Study Area was built to accommodate additional research needs (Figure 1, Table 1).

The total area of 24,962 acres (10,110 ha) functions as one of the largest ungulate research enclosures in the world. Its completion established a closed but ecologically extensive system for ungulates. The result was a research environment that provided ungulates with unconstrained habitat choices over expansive areas, commensurate with the size of their spring, summer and fall ranges in the western United States, but also forced the ungulates to respond to the management experiments.

Importantly, the New Zealand woven-wire fence was designed as an effective but humane barrier to ungulates. When ungulates run into the fence, it acts as a trampoline, pushing animals away from the fence without injury (Bryant et al. 1993). The fence was designed to function more than 30 years before major repairs are needed.

Automated Telemetry System

Long range navigation (LORAN-C) technology developed by the U. S. Coast Guard for ship and airplane navigation was adapted by Starkey scientists to establish an automated telemetry system (ATS) in 1989 (Dana et al. 1989, Table 1). The Starkey ATS can generate up to one animal location every 20 seconds, 24 hours a day, from April through December each year. The frequency and order of obtaining animal locations is programmable, such that more than 100 radio-collared animals can be relocated at a frequency of approximately one location for each radio-collared animal/hour (Rowland et al. 1997, Kie et al. 2004). Or, a subset of animals can be relocated more frequently, such as one location for a given animal every minute, depending on the sampling schedule required to meet research needs.

Locations from the ATS have a mean accuracy of 164 feet (50 m) of the true location (Findholt et al. 1996). This location accuracy allows for reliable estimation of resource selection patterns and spatial distributions of ungulates in time and space to meet Starkey research goals (Findholt et al. 2002). Performance of the ATS has been well documented (Johnson et al. 1998, Garton et al. 2001). Over 2 million locations of elk, mule deer and cattle have been collected since 1989, with location data used in a variety of Starkey publications. Examples of uses include Johnson et al. (2000), Rowland et al. (2000), Garton et al. (2001) and Leban et al. 2001.

Winter Feeding and Handling

Mule deer and elk traditionally migrated to winter range at lower elevations far from Starkey. Construction of the Starkey enclosure in the summer and fall of 1987, however, surrounded the populations of mule deer and elk on their spring, summer and fall range, preventing migration to traditional winter range. Consequently, a 655-acre (265-ha) Winter Area (Figure 1) was established to feed animals and, in the process, minimize the confounding effects of winter weather and foraging conditions on deer and elk responses to the summer range experiments (Rowland et al. 1997).

Mule deer and elk are baited to the Winter Area or live-trapped and moved to the site each December. Deer and elk are fed alfalfa pellets and hay, respectively, from December through March, and then released back into the study areas for another year of research. This ration is fed ad libitum, thus reducing potential variation in physical condition of animals owing to variation in winter weather.

The Winter Area also has an elk handling facility that allows scientists to handle animals humanely and efficiently to check their condition and equip them with radio collars (Wisdom et al. 1993). Handling in December and January includes tests for pregnancy, disease, percent body fat and weight, for analysis of these data in relation to the summer range experiments.

Network of Traffic Counters

Over 65 traffic counters were installed at open road intersections throughout the Main Study Area in 1989 as part of the roads and traffic study (Table 1). The counters record the number of motorized vehicles that pass over an inductive loop buried underneath the road, as summarized by 15- or 30-minute intervals, 24 hours a day, from May through December of each year.

The counts have been used to estimate the rate of motorized traffic (number of vehicles per unit time) on each road at Starkey, as summarized by time of day for each season of each year. The traffic rates were used to evaluate mule deer and elk distributions in relation to distance from roads with varying rates of motorized traffic in the Main Study Area (Wisdom 1998, Wisdom et al. 2004b).

Use of Hunting for Research

From 1989 through 2003, 58 limited entry hunts of deer or elk have taken place in support of Starkey research goals (see Rowland et al. 1997). These hunts are used to maintain population characteristics (e. g., sex and age ratios) for mule deer and elk similar to those outside Starkey, so results are relevant to extant populations. Rowland et al. (1997:31) listed five additional reasons for use of hunting as part of Starkey Project research: (1) to collect data on animal condition, (2) to obtain baseline population data from harvest statistics, (3) to provide traditional recreational opportunity, (4) to provide data for a model of elk vulnerability to harvest and (5) to subject animals to hunting pressure and disturbance similar to that outside the enclosure. The incorporation of hunting as part of the Starkey Project research also has allowed scientists to evaluate deer and elk responses to being hunted, measured in terms of energy expenditures, changes in spatial distributions, changes in resource selection patterns and harvest rates in relation to hunter density (Johnson et al. 2004). Finally, the use of hunting as part of the research has facilitated detailed studies of hunters' willingness to pay for a variety of harvest opportunities and hunting experiences (Fried et al. 1995).

Data Collection and Mapping of Environmental Variables

Data for more than 100 environmental variables have been collected and mapped for Starkey Project research (Rowland et al. 1998). Example variables include slope, aspect, elevation, convexity, canopy closure, ecoclass, distance to water and distance to open roads (Kie et al. 2004). These variables have been used in a variety of Starkey publications, such as those as described here and in Table 1. Examples of uses include evaluation of resource selection patterns (Johnson et al. 2000, Coe et al. 2001); effects of roads (Rowland et al. 2000, 2004), traffic (Wisdom 1998, Wisdom et al. 2004b) and timber harvest (Rinehart 2001, Wisdom et al. 2004c); and forage allocation modeling (Johnson et al. 1996, Ager et al. 2004).

New Technologies Support Research Beneficial to Management

Use of the innovative technologies at Starkey allowed the original and subsequent studies to be completed during the 1990s (Table 1). Findings from the many studies are diverse and compelling. Highlights of key findings from the original studies are summarized here as an example of what has been learned. Details can be found in the papers cited.

- Elk avoid roads open to traffic, validating observational studies from the 1970s and 1980s that first identified this relation (Rowland et al. 2000, 2004).
- Elk avoidance of roads increases with increasing rate of traffic, providing further evidence that elk are not reacting to roads, per se, but to the activities associated with roads (Wisdom 1998, Wisdom et al. 2004b).
- Mule deer generally do not avoid roads and show increasingly strong selection toward areas near roads with increasing rate of traffic (Wisdom 1998, Wisdom et al. 2004b). This pattern is a result of mule deer avoiding elk, rather than deer selecting particular habitats near roads and traffic (Johnson et al. 2000, Coe et al. 2001).
- Elk avoid cattle and mule deer avoid elk, but the degree to which interference competition is operating is less clear (Johnson et al. 2000, Coe et al. 2001, Stewart et al. 2002). Elk may have ample opportunity to select a variety of habitats where cattle are not present, owing to rotation of cattle through a series of livestock pastures (Coe et al. 2001). Mule deer may not have these same habitat choices when avoiding elk, owing to the presence of elk throughout their summer range.
- Diets of cattle, mule deer and elk differ substantially during early summer, with cattle diets containing a higher composition of grasses,

deer diets containing more shrubs and forbs, and elk diets intermediate to those of cattle and deer (Findholt et al. 2004). Diets of the three ungulates become increasingly similar during late summer, when forage biomass and quality decline with the onset of summer drought, suggesting increased potential for exploitative competition.

- During the fall rut, the date of conception in female elk becomes progressively earlier and synchronous with increasing age of male breeders (Noyes et al. 1996, 2002, 2004). Breeding by yearling (1.5 year-old) bulls results in the latest dates of conception and highest variation in conception dates; breeding by mature (5.5 year-old) bulls results in earliest dates of conception. Earlier and closely synchronous dates of conception allow calves to be born earlier in spring and over a compressed time period, with potential benefits to survival (Noyes et al. 2004).
- In the absence of hunting, elk, mule deer and cattle do not appear to be negatively affected by intensive timber harvest (Rinehart 2001, Wisdom et al. 2004c), but timber harvest increases the vulnerability of elk to hunting (Wisdom et al. 2004c).
- Elk do not require or benefit from thermal cover to ameliorate their thermoregulatory requirements in response to extreme weather during winter and summer (Cook et al. 1998). Instead, a mix of open and closed-canopy habitats results in superior animal performance compared to homogeneous stands of thermal cover. Importantly, elk appear to select dense forest for security during both hunting and nonhunting seasons (Ager et al. 2003, Johnson et al. 2004).

Starkey's Future Appears Bright

The Starkey Project now has one of the most voluminous and intensive data sets ever collected on ungulates. Over 140 publications have been produced, with more than 50 studies underway or completed (Thomas and Wisdom 2004). More than 100 scientists have conducted the research, with support from the timber industry, livestock industry, hunting groups, conservation organizations and state and federal agencies (Quigley and Wisdom 2004). Results have been used widely to improve management of timber, grazing, roads and recreation in relation to the needs of mule deer and elk (Thomas and Wisdom 2004).

The future of ungulate research at Starkey and at associated, nonfederal sites appears bright. A unique set of technologies and research facilities remain in place, allowing scientists to investigate a wide range of management issues related to ungulates. Continued focus on studies to integrate the needs of mule deer and elk with economic, social and recreational interests in western North America represents an ongoing, compelling need that will continue to be addressed by the Starkey Project.

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