Has the Starkey Project Delivered on Its Commitments?

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Introduction

The Starkey Project was conceived from intense debate about how best to manage habitats and populations of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) in western North America (Rowland et al. 1997). Founders of the research effort promised to provide definitive knowledge about effects of the dominant public land uses on mule deer and elk and to transfer that knowledge in relevant and synthesized forms for easy management application.

In our paper, we review the commitments of the Starkey Project and summarize its major achievements. We also identify key research opportunities that, in our view, are optimally addressed by the project's unique research facility and compelling partnerships. Our review is focused on the historical performance of the Project in generating knowledge of high management utility, and the efficient transfer of that knowledge to land and wildlife managers in western North America.

Commitments and Accomplishments

The Starkey Project was designed to address the most contentious of resource uses of public land and to provide cause-effect responses of mule deer and elk to those uses. When the project was proposed in the early 1980s (Wisdom et al. 2004a), four resource issues were the focus of debate in relation to deer and elk: (1) road management, (2) intensive timber production and thermal cover, (3) competition with cattle, and (4) breeding efficiency of male elk. These four issues became the foundation of the Starkey Project's studies that began in 1989 and ended during the mid- to late 1990s at the Starkey Experimental Forest and Range (Starkey) and the Kamela research sites in northeastern Oregon (Rowland et al. 1997, Cook et al. 1998, Wisdom et al. 2004a).

Road Management

Project scientists undertook new research to estimate the long-term spatial relations of mule deer and elk to the type of road management (open, closed and administrative use) and to the rate of motorized traffic (number of vehicle trips per unit of time) on the roads. Scientists designed the research to estimate these relations, with sufficient sample sizes to clearly portray spatial patterns and at landscape scales commensurate with ungulate use and management decisions.

Investigators met this commitment by generating the largest data set ever amassed on locations of deer and elk in relation to distance from roads of different types and of different rates of traffic; scientists characterized these relations with spatially explicit models that could be directly applied in management (Rowland et al. 2000, 2004; Wisdom 1998; Wisdom et al. 2004b). Results are now used by state wildlife agencies and federal land management agencies throughout western North America. Findings constituted part of the foundation for the national roads policy established by the U. S. Department of Agriculture, Forest Service (FS), thus affecting road management on all national forests.

Intensive Timber Production and Thermal Cover

Thermal cover is defined as, "cover used by deer or elk to assist in maintaining homiothermy," and as, "any stand of coniferous forest trees 40 feet (12 m) or more tall with an average canopy closure exceeding 70 percent" (Thomas et al. 1979:113–4). Whether thermal cover was a requirement of elk (that is, whether animal performance suffered without thermal cover) constituted a major question that the Starkey Project promised to examine. A corollary question that the project pledged to answer was whether intensive timber harvest had any measurable effects on habitats and populations of mule deer and elk. Prior investigations had shown that elk avoided or substantially reduced their use of areas subject to timber harvest and associated road use. But, what if the entire landscape was so treated and deer and elk had to react to the resultant conditions?

The question of whether elk require or benefit from thermal cover was addressed in an experimental study at Kamela (Cook et al. 1998). Here, the nutritional condition of tractable elk maintained in pens was monitored in relation to varying amounts of thermal cover and no cover. Results, which detected no positive physiological benefits to elk from the presence of thermal cover, have changed managers' thinking about elk-cover relations (Cook et al. 2004a). As a result, many land managers have modified their thermal cover direction for elk. (Elk use of dense forest stands, such as for hiding cover and escapement, remain important considerations in management [Lyon and Christensen 2002]). Notably, contentious litigation related to meeting thermal cover standards on national forests was resolved, saving millions of dollars to the FS planning process.

Effects of timber management (harvest and roading) were addressed by conducting a landscape experiment to evaluate cattle and elk responses to intensive harvest and associated human activities at Starkey from 1989 to 1996 (Rinehart 2001, Wisdom et al. 2004c). Thousands of ungulate locations were collected before, during and after completion of a timber sale that substantially reduced canopy closure on over half the forested study site, and more than doubled the road density. Measures of animal response provided little evidence of lasting negative effects with the major exception of the substantial increase in elk vulnerability to harvest by hunters (Wisdom et al. 2004c). Results (Rinehart 2001, Wisdom et al. 2004c) are now available for timber sale planning on national forests.

Competition with Cattle

The degree to which mule deer, elk and cattle compete for food and space was another key research problem. By evaluating the spatial distributions, resource selection patterns and behavioral interactions of the three ungulates as cattle were rotated through the livestock pastures each summer during the 1990s (Coe et al. 2001, 2004), scientists estimated a realistic forage allocation among cattle, deer and elk by month and season (Johnson et al. 1996). Combined with a subsequent study of diet overlap among the three species (Findholt et al. 2004), scientists used the results to build new models capable of assessing the trade-offs and benefits of different grazing management scenarios on summer ranges shared by cattle, mule deer and elk (Ager et al. 2004).

These models of forage allocation (Johnson et al. 1996) and grazing management (Ager et al. 2004) allow rangeland managers to evaluate trade-offs of changing stocking rates among the three ungulates under different assumptions that reflect ecological differences in ungulate use of summer ranges. Application of these tools is expected to facilitate timely completion of new allotment plans now under development in national forests in the western United States.

Breeding Efficiency of Bull Elk

Determining the degree to which elk productivity is affected by age of breeding males was a major objective of the Starkey Project in the 1990s (Noyes et al. 2004). During two separate, five-year studies, conception dates in female elk were shown to occur earlier and to be more synchronous with increasing breeding age of male elk (Noyes et al. 1996, 2002). That is, breeding by older bulls resulted in calves being born earlier and over a shorter time period each spring, conferring a number of survival benefits (Noyes et al. 2004).

As a result, states and provinces throughout western North America modified their hunting regulations to protect older male elk from being taken by hunters. Protection of older males from hunting is now recognized and implemented as an important management strategy, owing to the benefits of older males as breeders, in combination with the recognized social and aesthetic benefits of viewing these animals (Bunnell et al. 2002).

Additional Accomplishments

As project investigators completed their initial studies during the 1990s, several new resource issues in public land management emerged that could be addressed with the use of the project's novel research technologies (Wisdom et al. 2004a). Those issues became the focus of subsequent ungulate research at Starkey. New research completed or underway includes:

- effects of woody fuels reduction on distributions and on forage conditions for mule deer, elk and cattle (Vavra et al. 2004)
- deer and elk responses to off-road recreation, including travel by all-terrain vehicles, horseback, mountain bike and foot (Wisdom et al. 2004d)
- development and testing of new road models for elk management (Rowland et al. 2004)
- synthesis and modeling of factors that affect elk vulnerability to harvest by hunters (Vales 1996, Johnson et al. 2004)

- energetic costs to deer and elk exposed to, but not harvested under, varyious levels of hunting pressure and season designs (Johnson et al. 2004)
- hourly, daily and seasonal changes in movements and habitat use by mule deer and elk, measured at fine resolution with one of the largest data sets on ungulate locations ever amassed (Ager et al. 2003)
- effects of sampling design on resource selection and home range estimators for wildlife research (Garton et al. 2001, Leban et al. 2001)
- exploration and use of diffusion theory to model animal movements (Brillinger et al. 2004)
- consideration of nutrition demands and animal condition to enhance elk productivity (Cook et al. 2003, 2004b)
- effects of ungulate herbivory on vegetation development and ecosystem processes (Riggs et al. 2004, Vavra et al. 2004)
- validation of resource selection patterns for elk to strengthen and expand inference space for management (Coe 2003).

Results from these follow-on studies have yielded compelling benefits to managers. For example, defensible options for managing off-road vehicles and other off-road recreation on public land are now being developed. Findings are expected to provide information about effects of off-road recreation, particularly motorized recreation, the most-rapidly growing use of public land in the United States (Havlick 2002).

Another example is the current research on management of deer, elk and other wildlife in relation to fuel treatments to reduce fire risk (Vavra et al. 2004). The FS identified Starkey as a national research site to evaluate success of fuel treatments to reduce fire risk in national forests and to assess effects on wildlife.

Two other studies of keen interest and utility to managers are (1) energetic and movement responses of deer and elk to hunting, specifically when animals are exposed to hunting activities but not harvested (Johnson et al. 2004), and (2) effects of nutrition on elk productivity (Cook et al. 2003, 2004b). State, federal, private and provincial resource managers are using findings from this new research to meet increasing demands for hunting and viewing of elk, which generate hundreds of millions of dollars annually to local and regional economies in western North America (Bunnell et al. 2002).

Effective Transfer of Knowledge to Management

The Starkey Project has been one of the few research programs in the FS with a full-time focus on the science of technology transfer (Rowland et al. 1997). The transfer program has served as an effective liaison between management and research. As a result, the project has shared research technologies and results directly with more than 200,000 recipients, encompassing local, regional, national and international organizations, groups and agencies. These communication mediums beyond scientific publications included field tours, presentations, workshops, symposia, news releases, newspaper features, magazine articles, radio interviews and television coverage. More than 600 field tours and presentations have been given, and scientists have organized over 15 field tours and more than 20 presentations per year during the past decade.

The technology transfer program helped garner widespread public acceptance and support of the project's research and results (Rowland et al. 1997). Transfer efforts have been viewed as one of the primary reasons that many land and wildlife managers have adopted Starkey research findings.

Starkey's Future: Best Uses of a Unique Facility

The unique research facility at Starkey (see Rowland et al. 1997, 1998; Wisdom et al. 2004a) is an optimal environment in which to conduct manipulative experiments and to elucidate cause-effect responses of ungulates at landscape scales. We know of no other research facility that has the combination of experimental controls and animal tracking technologies needed to conduct such cause-effect research at landscape scales. There are emerging, significant research questions ideally suited for study within the project's unique research facility.

Effects of Elk Removal on Mule Deer

Scientists have noted the anecdotal evidence suggesting that as elk invade mule deer ranges and become plentiful, mule deer numbers decline (e. g., see Wallmo 1981, Wisdom and Thomas 1996). In support of this hypothesis, one of the more interesting findings at Starkey has been the consistently strong avoidance shown by mule deer for elk (Johnson et al. 2000; Coe et al. 2001, 2004; Stewart et al. 2002; Wisdom et al. 2004b). Interference competition may be operating, causing mule deer avoidance of elk and reducing population performance of deer.

The only definitive manner in which to document whether mule deer avoidance of elk results in reduced population performance of deer is to conduct a manipulative experiment, where elk are removed from an area and the population response of deer is measured. Then, elk could be reintroduced to the study area, first at low density, as the mule deer population response was measured. Finally, elk could be allowed to reach high density, and mule deer response again could be measured. The cycle could be repeated to validate the initial set of mule deer responses to elk removal and reintroduction.

Starkey is one of the few sites in which such removal experiments could be done in a definitive manner to document whether interference competition is operating between mule deer and elk. Given that mule deer populations are declining throughout much of western North America (Kie and Czech 2000), this research should be viewed as one of the highest priorities of the Starkey Project.

Effects of Hunting Season Designs on Mule Deer and Elk

Research at Starkey has documented substantial energetic costs to mule deer and elk under different types and lengths of hunting seasons (Johnson et al. 2004). What remains to be evaluated, however, are the effects of the full spectrum of different hunt types, season lengths, hunter densities and associated options for road and off-road access on deer and elk. In particular, how all-terrain vehicles (ATVs) with full access to the hunting landscape affect harvest rates of targeted animals and energetic costs of nontargeted animals has not been studied. This issue is a major concern of state wildlife agencies. Starkey, with its capability to design and administer a variety of hunts as part of landscape experiments and to accurately measure the population responses of ungulates, is well-suited for such research.

Off-road Vehicle Effects on Wildlife and Other Resources

Use of ATVs during nonhunting periods can substantially increase movement rates of elk and, consequently, is likely to increase the daily energetic expenditures of animals (Wisdom et al. 2004d). What remains unclear, however, is the effect of ATVs on elk during hunting seasons. Moreover, the effects of ATVs and of other forms of off-road recreation on additional species of wildlife, on exotic plant invasions and on other resources, such as soil productivity and water quality, have not been studied experimentally.

These topics are well suited for new research at Starkey, to complement and to validate current research on effects of off-road recreation (Wisdom et al. 2004d). ATV riding is the most rapidly-growing recreation on public land (Havlick 2002), and other forms of off-road recreation, such as mountain biking, horseback riding and hiking, also are increasing. New research on the comparative effects of these different forms of off-road recreation is urgently needed. Starkey is ideally suited for conducting such research with appropriate experimental controls to elucidate cause-effect relations.

Effects of Ungulate Herbivory on Forest Development and Productivity

Ungulate herbivory has profound effects on vegetation development and productivity in forest ecosystems (Hobbs 1996; Riggs et al. 2000, 2004). Livestock grazing has long been recognized as an agent of change in composition, structure and development of plant communities (Fleischner 1994), but herbivory by wild ungulates has not always been recognized as an ecological force in western North America (Augustine and McNaughton 1998).

New research is being planned at Starkey that would evaluate effects of varying levels of grazing by cattle and elk on plant succession, soil nutrients, animal biodiversity and ungulate nutrition, as measured over long (10 or more years) time periods (Vavra et al. 2004). This research will use a series of 18-acre (7.3-ha) exclosures, each subdivided into 7 pastures with different levels of elk and cattle grazing during summer. The research, however, requires substantial funding (at least $500,000 per year) that currently is unavailable. Moreover, herbivory by cattle versus elk is a highly contentious issue, fraught with uncertainty. And, it is clouded by strong political interests. For example, stringent utilization standards are often imposed on cattle grazing in riparian habitats to meet objectives for management of salmonids. Yet, effects of herbivory by wild ungulates may also affect habitat conditions in ways neither acknowledged nor understood. The new herbivory research at Starkey is needed to understand the effects of wild versus domestic ungulates in relation to management goals for wildlife, vegetation, silviculture, nutrient availability and other measures of forest productivity (Vavra et al. 2004).

Habitat Management Relations with Ungulate Nutrition

The individual, stand-level effects of timber management, fuels reduction, prescribed burning, wildfires, insect defoliation and other episodic disturbances on the nutritional condition of ungulates is understood at a coarse level. However, the nutritional effects of the combination of these disturbance events in time and space on the landscape are complex and poorly documented. For example, episodic disturbances create open-canopy forests, resulting in substantial increases in forage biomass for ungulates (Peek et al. 2001). Yet, the degree to which these episodic disturbances meet the nutritional demands of wild and domestic ungulates is not well understood or well studied (Cook et al. 2003).

New studies of ungulate foraging dynamics and of nutritional intake are needed with the use of tame elk, deer and cattle. The Starkey Project and its many partners maintain tractable mule deer, elk and cattle for such grazing studies (Cook et al. 2003). These animals and these scientists experienced in the use of these animals could be quickly put to work at Starkey to discern the nutritional benefits of fuels reduction treatments, of timber harvest and of other habitat manipulations at the mosaic of stands across the landscape.

Moreover, project scientists have developed a compelling set of maps depicting the probabilities of habitat use by elk, mule deer and cattle across the landscape, estimated by month and season from years of research at Starkey (Ager et al. 2004). These probabilities could be linked to the underlying nutritional conditions of each habitat type, using the tractable cattle, deer and elk available at Starkey. Such research would provide insight about the nutritional consequences of ungulate habitat choices. Given current concerns about declining productivity in elk and mule deer populations (Kie and Czech 2000, Johnson et al. 2004), a basic management question still needs to be addressed. That is, how well are current habitat conditions and conditions planned under future landscapes providing for the nutritional needs of wild and domestic ungulates? New studies on ungulate nutrition in relation to habitat conditions at Starkey could fill this important gap in current knowledge.

Conclusions

The Starkey Project has delivered on its promises. In fact, the project has paid off far in excess of those promises. To drive home that point, consider the following: over 140 publications are complete or are in press; over 40 partners are involved in the research; over 50 studies are complete or are underway; more than 600 tours and presentations to local, regional, national and international audiences are provided. Results are now being used by state, federal, tribal and private land and wildlife managers across western North America. Keys to the project's remarkable success have been many: (1) unique technologies that have facilitated the completion of needed studies, previously considered difficult or impossible to conduct under appropriately controlled conditions, (2) long-term commitments by diverse federal, state, private and tribal interests, (3) continued focus on ungulate issues of highest relevance to wildlife management and (4) constant and open dialogue and sharing of the research with all interests and resource users (see Kie et al. 2004, Quigley and Wisdom 2004, Wisdom et al. 2004a).

Perhaps most impressive is the economic return from the research, which is conservatively estimated to substantially exceed the 20 million dollars invested by partners during the project's 22-year history. This economic return will increase in the future as use of resulting information by land and wildlife managers continues to expand. This unique and long-lasting research program is a shining example of applied research conducted under controlled and rigorous conditions and made available through publications, tours, presentations and media outlets. We urge partners in the Starkey Project to continue supporting this long-term research for the benefit of land and wildlife managers and for the benefit of those who care about forests, rangelands and the wildlife these habitats support.

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