Pacific Northwest Research Station

Science Update

ELK, DEER, AND CATTLE: THE STARKEY PROJECT

Frank Vanni

IN SUMMARY

Definitive results from the Starkey Project's first decade (1989–99) have given managers defensible options for managing roads, timber production, and range allotments in relation to elk, deer, and cattle. Study results have prompted changes in policies, management standards and guidelines, hunting regulations, and timber sale planning throughout western North America.

In the 1970s and 1980s, wildlife managers, hunters, and forest managers had intense debates about how elk, mule deer, and cattle should be managed on public lands. In response, scientists from the Pacific Northwest (PNW) Research Station and the Oregon Department of Fish and Wildlife (ODFW), in collaboration with over 40 partners, initiated the Starkey Project in the Blue Mountains of northeastern Oregon. Starkey is a controlled, landscape-scale study at the Starkey Experimental Forest and Range and the primary field location for research on mule deer, elk, and cattle in managed ecosystems of the Pacific Northwest.

Four major themes were identified for the Starkey Project's first decade of research: (1) roads and traffic, (2) timber production and thermal cover, (3) competition with cattle, and (4) breeding efficiency of male elk. The result of the research was a set of compelling findings about elk, deer, and cattle responses to a variety of forest and rangeland activities at scales compatible with management. The Starkey findings are described inside.

What is the science base for how elk, mule deer, and cattle are managed on public lands?

Elk and mule deer are highly valued for hunting and viewing in western North America. In the 1970s and 1980s, wildlife managers, hunters, and forest managers were involved in intense debates about best management practices for elk and mule deer on public lands. Timber harvest, an expanding network of forest roads, and recreational traffic on these roads were thought to affect elk and deer, but people argued about exactly what those effects were, with little definitive experimental data to back up opinions. Hunters, ranchers, and wildlife managers had long disagreed about whether or not cattle, deer, and elk competed for available forage on western rangelands. Finally, elk herd productivity, as affected by elk population management practices, was recognized as a major issue. State wildlife agencies regulated hunting, but agency staff did not have definitive science behind their regulations affecting the number of mature bull elk maintained for herd productivity and elk population goals.

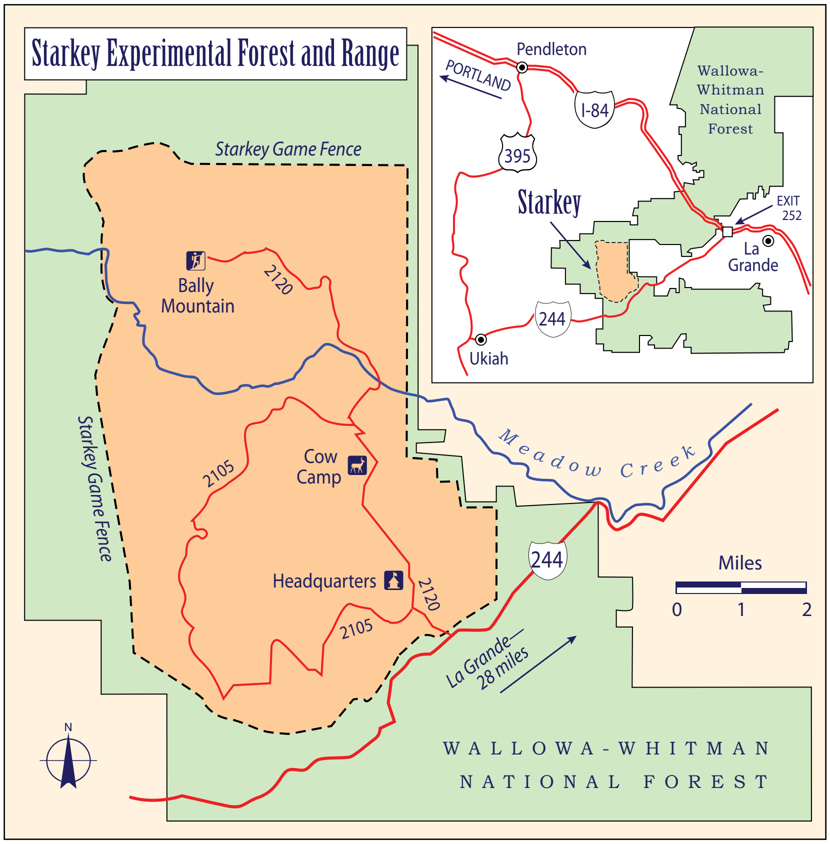
In response to these debates, the Starkey Project was initiated in northeastern Oregon at the Starkey Experimental Forest and Range. Scientists designed and carried out rigorous studies at a landscape scale to evaluate deer and elk responses to dominant land uses on public lands. Located in the Blue Mountains of northeastern Oregon (see map), the Starkey Experimental Forest and Range was designated as a research area in 1940, and many studies had already been done there. Starkey has open

Key Findings

- Elk avoid roads open to motorized traffic, and their avoidance increases as the rate of traffic increases. Mule deer avoid elk and thus can be displaced into areas least used by elk, such as areas near roads with the most traffic.
- Elk avoid cattle, and mule deer avoid elk. Elk can select habitats without cattle when cattle are rotated through livestock pastures, but mule deer may not have as many choices for avoiding elk. The diets of cattle and elk differ substantially during early summer, but become increasingly similar during late summer, with more potential for exploitative competition.
- Intensive timber harvest can benefit cattle and elk from the increased forage available after timber harvest. However, if roads are left open, elk are more vulnerable to harvest by hunters. Access management and maintenance of security cover can mitigate this effect. Elk do not benefit from homogeneous stands of thermal cover; a mix of open- and closed-canopy habitats is optimal for elk.
- Older male elk are more efficient breeders, resulting in earlier, more synchronous calf births the next spring, which may benefit calf survival.

Frank Vanni

Forests and grasslands at the Starkey Project are typical of much elk and mule deer habitat in western North America.



Keith Routman

The Starkey Project is a one-of-a-kind research facility, located in the Blue Mountains of northeastern Oregon. Starkey is the primary field location for scientific study of the effects of deer, elk, and cattle in managed ecosystems.

Purpose of PNW Science Update

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stands of ponderosa pine along with mixed-conifer stands of varying densities, intermingled with natural grassland openings.

The original champion of the Starkey Project was Jack Ward Thomas, who led the project from 1982–93. He went on to be Forest Service Chief from 1993 to 1996 and Boone and Crockett Professor at the University of Montana from 1996 through 2005. Larry Bryant, PNW Research Station, and Donavin Leckenby, ODFW, worked closely and diligently with Thomas to turn the vision of a controlled, landscape-scale study on wild and domestic ungulates (hoofed mammals) into a reality.

"The research done at Starkey was, and still is, designed to answer management questions," explains Marty Vavra, team leader and supervisory rangeland scientist located at PNW Research Station's La Grande Forestry and Range Sciences Laboratory. "The Starkey research is relevant West-wide for the management of elk, mule deer, cattle, forests, and rangelands."

A controlled study meant building an enclosure that would hold wild elk, animals that can easily jump high fences and break through ordinary fences, and a landscape-scale study meant enclosing a large area. The Starkey Project includes 25,000 acres (almost 40 square miles) enclosed by a game-proof fence. "The big fence" was built in 1987 and consists of 8-foot-high woven wire. More game-proof fencing further divides the project area into four study areas: the main study area (19,180 acres), Campbell Flat pasture (1,537 acres), the northeast study area (3,590 acres) subdivided into two pastures, and the winter feeding and handling area (655 acres). With the completion of the radio-telemetry system in 1989, the project became fully operational.

The big fence encloses about 500 elk and 250 mule deer year round, and 550 cow-calf livestock pairs during summer. The enclosure is larger than the summer home range of most deer and elk, with animals living under conditions similar to wild, free-ranging herds. Large predators, including cougar, black bear, and coyote, are able to go either over or under the big fence and are part of the ecosystem, just as they would be outside Starkey. Elk and deer at Starkey are wild, hunted animals that are handled briefly in winter feeding areas but are not acclimated to humans.

"All studies are spring, summer, and fall range investigations," explains Mike Wisdom, research wildlife biologist with the Starkey Project, also at the La Grande Laboratory. During winter, most elk move to the winter feeding and handling area. Most deer spend winter in the forest and are fed hay when they move into the winter handling area. The winter feeding evens out effects of winter weather on animal body condition, thus reducing any confounding effects that variation in winter severity may cause on elk or deer nutritional condition.

Movements of over 150 elk, deer, and cattle are monitored annually with radio collars. The telemetry system used for the project's first 10 years, a LORAN-C system, is being phased out, as replacement parts are impossible to obtain. The new system, installed in 2005 and expected to be fully operational in 2006, is based on a global positioning system (GPS). The GPS provides animal locations as frequently as every few seconds with 1- to 2-yard accuracy, and it runs continuously for 24 hours a day, 9 months each year, with little maintenance. It allows real-time monitoring of the animals as well as human activities in relation to the animals. The telemetry systems have given scientists the largest, most accurate set of animal locations ever collected on ungulates in the world.

Hunting also is a key tool used in the research. Controlled, public hunts of deer and elk are administered by ODFW. Hunting puts the deer and elk under the same types of pressures that exist outside Starkey and helps control population levels in line with goals to sustain habitats and animal numbers.

Four major themes were identified for the Starkey Project's first decade of research: (1) roads and traffic, (2) timber production and thermal cover, (3) competition with cattle, and (4) breeding efficiency of male elk. Definitive results from the Starkey Project's first decade (1989–99) have given managers defensible options for managing roads, timber management, and range allotments, in relation to ungulates. These findings are commonly used by state, private, and federal resource managers across western North America.

How does traffic on forest roads affect elk, deer, and cattle?

Thousands of miles of forest roads were built on public lands from the 1960s through the 1980s for timber harvest, but the effects on elk were uncertain and highly debated. People had long noticed that elk avoided roads used by cars and trucks in managed forests where elk are hunted, but a widely used elk-road density model had not been thoroughly tested.

To test the road density model, scientists started the road management study in Starkey's main study area in 1989. Over 70 traffic counters were installed throughout the area, and traffic was monitored from May through December every year. The study area had about 2.5 miles of open road per square mile, with open roads spanning many environmental conditions. Other roads in the study area were closed.

When elk were unable to avoid roads and trails, subsequent studies showed that animals increased their movement rates, which can increase energy expenditures.

After several years, the result was a set of compelling findings about deer and elk responses to roads and traffic. Scientists found that cattle showed no particular reaction to open roads, neither avoiding them nor choosing to stay near them.

Elk, however, were strongly influenced by open roads. "Female elk consistently selected areas away from open roads in both spring and summer," Wisdom says. Elk response was affected by traffic rates, amount of forest cover near roads, and the type of road (which related to traffic rates). Once the elk were farther away from roads, they were more influenced by other factors such as conditions affecting forage.

The controlled study area allowed scientists to keep elk in areas with higher road densities. When elk were unable to avoid roads and trails, subsequent studies showed that animals

Leslie Naylor

The new global positioning system technology (elk on right) offers greater accuracy and more options for sampling designs than the original LORAN-C system (elk on left) now being phased out.

Frank Vanni

Automatic traffic counters throughout the main study area tallied how many vehicles passed and when. Traffic data could be correlated with telemetry data, showing how animals responded to the traffic.

increased their movement rates, which can increase energy expenditures. Higher movement rates could thus reduce the animals' fat reserves and undermine general animal condition and winter survival.

Mule deer behavior seemed to be affected more by elk than by roads. "Mule deer tended to avoid elk," Vavra explains, "and so the deer often used areas near roads." That is, mule deer are more likely to use areas least used by elk, which means deer end up in areas near roads with the most traffic.

These results support management of road access as part of elk management. Study results were incorporated into a model that could be used by managers; the model uses distance bands 328 feet wide as a basis for calculating disturbance to elk from roads. The research had shown that distance bands were more accurate for estimating disturbance to elk than road density alone.

State wildlife and federal land managers throughout western North America use these models to manage road access on public lands, and the findings were used in developing the national Forest Service road management policy. The Starkey studies of roads and elk contributed to the emerging discipline of road ecology, which is the study of the effects of roads on wildlife, plants, and watersheds.

How does intensive forest management affect elk, deer, and cattle?

In the last half of the 20th century, timber harvest in federal forests increased, affecting much elk habitat in the Western United States, but managers had limited knowledge about the specific effects. Part of the controversy focused on effects of timber harvest activities and resultant changes in forage and cover conditions, versus effects from increased disturbance of people and traffic following establishment of new roads needed for logging.

Starkey was the ideal place to carry out controlled studies that isolated these factors. Cattle and elk responses to intensive timber management were studied in Starkey's 3,590-acre northeast study area. Telemetry data were collected in 1989–91 before timber harvest, to establish a baseline, and collection continued during logging (1992) and throughout the postlogging site preparation, tree planting, and tree stocking surveys from 1993 through 1996. Grand fir and Douglas-fir were harvested from 1,207 acres of the 3,590-acre study area, or about 50 percent of the area, but in a patchwork pattern of harvest units ranging from 3 to 55 acres each. Units were dispersed so no large areas of escape cover remained, and dense cover was deliberately **not** maintained. About 24 miles of new roads were built, in addition to 10 miles of existing roads. The area was closed to public access except during hunting seasons, and hunters were allowed entry for hunting purposes only (no camps allowed).

D. Johnson

Cattle used roads for travel routes, and they preferred grasses to other forage plants.

Courtesy Starkey Project

Although elk avoided active logging operations, they were attracted to harvest units a year or two later when new grasses and forage sprouted.

Timber harvest and road traffic had little measurable effect on cattle. Elk, however, avoided the short-term disturbance of the logging activity itself, but elk did not avoid the harvest units or the log-hauling roads during and after timber harvest. In general, the elk population became more dispersed during and after the timber harvest, suggesting that the elk were moving farther over larger areas to meet their needs.

After the timber harvest and site preparation activities were finished, cattle used the timber harvest units as new grazing areas, and domestic cows and calves in the study area had higher weight gains than cows and calves in the main study area. Annual weight gains for elk after timber harvest were similar to annual weight gains for elk before harvest. Average annual weight gain varied considerably from one year to the next for cattle and elk in both study areas, but these variations correlated most closely with summer rain or drought, and the weather's effects on forage growth and quality.

Although elk and cattle productivity was not negatively affected by timber harvest, the vulnerability of elk to hunting increased substantially. The open landscape after logging made elk more visible, and the new roads gave hunters better access. Hunter success improved significantly during and after timber harvest, even though elk performance (weight gain, general body condition) had not changed.

Timber harvest may have the strongest and most enduring effects on elk vulnerability to hunting.

"Timber harvest may have the strongest and most enduring effects on elk vulnerability to hunting," Wisdom comments. To reduce elk vulnerability, managers have several options, including timber sale designs that include security areas for elk in the landscape design and restricted hunter access until hiding cover grows back. Hiding cover is related to but different from the concept of thermal cover, another issue that Starkey scientists studied.

Other studies have shown that the flush of increased forage after timber harvest may last 10 years or longer, but forage will likely decline as young trees shade the ground again. Thus, consideration of findings from these studies, combined with results from the timber management study, suggests that an optimal timber harvest schedule for elk is one that maintains a variety of foraging conditions in a watershed over time. Importantly, the logging schedule would be combined with effective management of elk security and human access to meet goals for elk hunting and animal numbers.

Do elk, deer, and cattle use habitat differently?

In the 1980s forest managers had two working hypotheses related to elk and deer management. The first was the thermal cover hypothesis, which said that elk and deer needed dense forest cover to stay warm in cold, windy winter weather and to stay cool in summer heat. The second was the animal equivalency hypothesis, which assumed that mule deer, elk, cattle, and sheep competed directly for forage; under this hypothesis, animal forage amounts and equivalency formulas based on species and body weight were being used in grazing management plans. Neither hypothesis had been rigorously tested, and the shortage of hard data showed how little was known about elk and deer in relation to management of cover and livestock grazing.

People knew that elk sought dense forest cover, and the thermal cover hypothesis attempted to answer why the elk used dense forests. The definitive study on elk and thermal cover was done at Kamela, Oregon, about 30 miles northeast of Starkey, and was conducted by John Cook, National Council for Air and Stream Improvement, in collaboration with the Starkey Project. The nutritional condition of elk was monitored under four treatments: dense thermal cover, moderately dense thermal cover, no cover, and a combination of no cover and thermal cover. This study was conducted in very controlled conditions relying on bottle-raised elk maintained in pens, so the effects of cover could be isolated from other factors.

Results showed no positive benefits from thermal cover—in fact, high levels of cover had a negative effect. Instead, a mix of open- and closed-canopy habitats resulted in superior animal performance compared to homogeneous stands of thermal cover. Other studies suggest that elk use of dense cover is related more to protection and security needs, especially during hunting seasons. The findings helped resolve contentious litigation over thermal cover standards on national forests. Management direction for thermal cover has been changed in many places.

The widely used animal equivalency formulas were based on the second hypothesis about forage competition. Scientists realized that the formulas could be correct only if the different species were in the same place at the same time, eating the same plants, an assumption that had never been rigorously tested.

Elk, mule deer, and domestic cattle have different foraging ecologies. The three species select and use habitats differently, and they strongly partition their use of habitats.

The long-term animal unit equivalency study, led by Bruce Johnson and other ODFW staff, was conducted in Starkey's main study area. Over a number of years, scientists evaluated distributions, forage selection patterns, and interactions of elk, deer, and cattle under various cattle rotations. Again, new findings emerged with significant implications for management.

Elk, mule deer, and domestic cattle have different foraging ecologies. The three species select and use habitats differently, and they strongly partition their use of habitats, particularly by elevation, slope steepness, and aspect. Cattle are habitat generalists, and elk avoid areas where cattle are concentrated.

"Elk just don't want to hang out with cows," Vavra remarks, "and mule deer are intimidated by elk." Elk use low elevations if no cattle are there, but move to higher elevations when cattle are moved on to low-elevation range, showing that cattle can displace elk.

The three species also have different forage preferences, each species with a distinctive dietary niche that varies by season. "Diets of cattle, mule deer, and elk are very different during early summer," Wisdom comments. "Cattle diets have more grasses, deer diets have more shrubs and forbs, and elk diets are in between those of cattle and deer." The diets of the three ungulates became increasingly similar during late summer, when forage biomass and quality declined with summer drought, suggesting increased potential for competition in late summer.

Scientists used the results to develop a new forage allocation model for use in allotment planning. Rangeland managers can use the model to evaluate tradeoffs and benefits of different grazing management scenarios on summer ranges shared by cattle, mule deer, and elk.

G. Zahm

Elk avoided cattle, and mule deer avoided elk, leaving the deer with fewer choices for grazing areas.

Does the loss of older bull elk affect elk reproduction?

Hunters like to take home bull elk with large, branched antlers, which are the older males. Before the Starkey Project, most state hunting regulations allowed unrestricted kill of bulls, and with hunter preferences for branched-antler bulls, most male elk were harvested before they became fully mature. In general, most bulls present during the fall breeding period were less than 2 years old and often were yearling males with spike antlers. Wildlife managers were concerned that healthy, older bulls, which tend to dominate elk herds, were being removed prematurely from the herds, with negative effects on herd structure and elk reproduction. Restrictions on the number of mature bulls taken in hunting season could be unpopular with hunters, and state agencies needed rigorous data before changing their regulations, if they were to have hunter support and cooperation.

The research on breeding bulls, led by ODFW, was conducted in Starkey's main study area. 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 5 years, this single cohort of male elk functioned as the only breeding bulls in the study population. The experiment was repeated again from 1995 to 1999.

As the bulls grew older, conception dates in the female elk became progressively earlier and synchronous (in the same time period) during the fall rut. Breeding by yearling (1.5-year-old) bulls resulted in the latest dates of conception and

John Kie

Older bull elk succeeded in breeding female elk earlier in the fall rut, leading to earlier elk calf births and better calf survival in the spring.

Frank Vanni

Older, branched bulls are prized by hunters, but play an important role in elk herd productivity. Starkey research influenced state game regulations on bull elk harvest in Western States.

most variation in conception dates; breeding by mature (5.5-year-old) bulls resulted in the earliest dates of conception. As conception dates became earlier, the elk calves were born earlier each spring, giving individual calves more time to gain weight before their first winter. Calves were born in a more compressed time period, which may reduce their susceptibility to predation during early life.

After the breeding bull study showed that older bull elk are more efficient breeders, with survival benefits for elk calves, many Western States and provinces throughout western North America modified their hunting regulations to protect older male elk from hunters. The protection of older bulls is now one of several management strategies for improving the survival of elk calves.

Partnerships

Most major ecological research projects are collaborations among several partners, but the Starkey Project has more partners than most. Starkey's expensive infrastructure—the big fence, radio-telemetry system, winter handling facilities—and the requirements for maintenance, data management, and animal handling—rely on multiple sources of funding.

The many partnerships also contribute to strong ownership in the results. Agencies that are involved have a better understanding of the validity of the research and are more likely to use the findings.

The Starkey Project is conducted jointly by the USDA Forest Service Pacific Northwest (PNW) Research Station and the Oregon Department of Fish and Wildlife (ODFW). The state agency has been a full partner since the beginning, contributing funds and staff time. Four ODFW staff work full time on Starkey, led by Bruce Johnson, long-time Starkey Project leader for ODFW. On the first four studies, the Forest Service took the lead on the roads and timber studies, and ODFW took the lead on the forage and breeding bull studies.

Starkey and all its activities are administered cooperatively by PNW Research Station and La Grande Ranger District, part of the Wallowa-Whitman National Forest. "The Wallowa-Whitman National Forest provided funds for the original fence and much of the road management and traffic monitoring for the first 10 years," Vavra says. "The Forest Service at all levels—national, Pacific Northwest Region, Wallowa-Whitman National Forest, and La Grande Ranger District, and PNW Research Station—has supported Starkey."

Wisdom adds, "We've had strong support from hunters and the Rocky Mountain Elk Foundation. Other partners who have been essential include Boise Cascade Corporation, National Council for Air and Stream Improvement (NCASI), and the Eastern Oregon Agricultural Research Center of Oregon State University." Boise Cascade Corporation did the timber harvest that was needed as an experimental treatment for the intensive timber management study, and the company has been an ongoing research partner.

Funding is provided by the USDA Forest Service, ODFW, the Rocky Mountain Elk Foundation, and a variety of other sources. Research partnerships occur with Boise Cascade Corporation, NCASI, Oregon State University, the University of Alaska Fairbanks, University of Idaho, University of Montana, Purdue University, and other organizations. In total, over 40 partners, including federal and state agencies, universities, tribal nations, and private organizations, have participated in the project.

Getting the results out to managers, hunters, and other interested people has always been a vital part of the Starkey Project. The Starkey staff host many field tours and educational workshops for hundreds of people, including agency staff, professional societies, tribal foresters, Congressional staff, international visitors, and college students. A major symposium in 2004 emphasized how the findings relate to land and resource policies and management.

Frank Vanni

Many partners contribute to the success of the Starkey Project. A crew works on the game-proof fence that separates study areas.

Additional Studies

As Starkey Project investigators completed their initial studies during the 1990s, they used the project's research technologies to study several emerging resource issues in public land management. New research completed or underway includes the following studies.

- Effects of fuel treatments on the distributions of and forage conditions for mule deer, elk, and cattle.
- Deer and elk responses to off-road recreation, including travel by all-terrain vehicles, horseback, mountain bike, and foot.
- Development and testing of new road models for elk management.
- Evaluation of elk sightability models to improve methods of population estimation.
- Synthesis and modeling of factors that affect elk vulnerability to harvest by hunters.
- Energy costs for deer and elk exposed to differing levels of hunting pressure and hunting season designs.
- Hourly, daily, and seasonal changes in movements and habitat use by mule deer and elk, measured at fine resolution with one of the largest ungulate data sets ever amassed.
- Effects of sampling design on resource selection and home range estimators for wildlife research.
- Exploration and use of diffusion theory to model animal movements.
- Consideration of nutritional demands and animal condition to enhance elk productivity.
- Effects of ungulate herbivory (grazing and browsing) on vegetation development and ecosystem processes.
- Validation of elk resource selection patterns to strengthen inference space for management.

These and other follow-on studies have yielded additional benefits to managers, and results are now available in a variety of scientific publications.

The Starkey Project in the 21st Century

Starkey's original research, completed in the 1990s, has been the catalyst for new studies underway in the project's first decade in the 21st century. "The new studies for the next 10 years are an evolution of the original study questions," Wisdom explains.

Studies are underway at Starkey on how fuel treatments such as thinning and prescribed fire affect elk, deer, and cattle.

Wisdom continues, "In the 1990s, we documented the effects of roads and traffic on elk. The follow-on questions are about the effects of off-road recreation on elk and mule deer." The off-road recreation study, which began in 2002 and was funded by the Oregon Department of Parks and Recreation, compares the effects of four typical off-road recreation activities—all-terrain vehicles, hiking, mountain bike riding, and horseback riding—on elk and deer. Animal responses are being measured in terms of how far elk and deer move and how much energy they expend before, during, and after the off-road recreation activity. Eventually, the results should be useful in managing recreation on national forest lands.

As far as timber management, Vavra explains, "We expect that in the next 10 years, managers will be focusing more on fuel

D. Johnson

New studies at Starkey are examining how popular forms of recreation affect elk.

reduction than on standard commercial harvest." So studies are underway at Starkey on how fuel treatments such as thinning and prescribed fire affect elk, deer, and cattle.

Ungulate grazing and browsing is probably an ecological force in western North America but, Vavra points out, "We don't know the effects of different levels of grazing by cattle and elk on plant succession, soil nutrients, biodiversity, and ungulate nutrition, as measured over long periods, such as 10 years or more."

For example, it's well known that elk and deer are attracted to the flush of green vegetation in recently disturbed areas, such as after fire or logging, and thus their herbivory is likely to influence the composition of the developing plant communities. Little is understood, however, about how ungulate herbivory may eventually affect the structure, composition, and productivity of entire forest and rangeland ecosystems. Herbivory might influence successional trajectories after wildfires or fuel treatments or be a factor in the spread of invasive plants, but scientists have limited knowledge about what happens. New studies at Starkey are aimed at gaining a better understanding of how all these ecological forces interact to affect biological diversity in forest ecosystems.

New questions are coming up about elk and mule deer productivity. Big game surveys in many Western States are showing declining productivity in elk and mule deer populations, a disturbing trend that is so far unexplained. The Starkey scientists and partners and land managers have a common interest in understanding how well elk and deer will fare in the forests and rangelands of the 21st century, and new studies are being discussed to address these issues.

"The enclosures at Starkey allow us to manipulate elk, deer, and cattle numbers for new research to evaluate these species' productivity in relation to changes in their density and under different cattle grazing systems," says Wisdom. "We are discussing ways to design new studies to evaluate these factors in relation to ungulate productivity." Again, the Starkey enclosures, some of the largest ever constructed for research, continue to provide a mechanism for conducting landscape-scale experiments previously not thought possible. Combined with a new GPS telemetry system and a myriad of essential support technologies, the future of the Starkey facility for ungulate research appears bright.

"We expect that results from ongoing studies at Starkey will continue to be used to modify policies, management standards and guidelines, hunting regulations, and timber sale planning throughout western North America," says Vavra. "We will continue to respond to management needs for new knowledge about the role of elk, mule deer, and cattle in managed forests, and to design research accordingly." Combined with an ongoing technology transfer program to share results efficiently with managers, and in forms easily understood for management applications, the Starkey Project appears likely to continue its role as an important provider of scientific knowledge about ungulate management well into the future.

Mike Wisdom

Starkey scientists share research results with others. Over 200,000 people have toured Starkey or heard a presentation. Even more have read reports and articles about research results.

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Resources on the Web

The Starkey Project. Detailed information about the Starkey Project, including current studies, photo gallery, data, and publications. http://www.fs.fed.us/pnw/starkey/. (1 December 2005)

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Information about all the Station's research and access to all Station publications. http://www.fs.fed.us/pnw. (1 December 2005)

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Red Lion Hotel on the River,
Portland, Oregon

For more information: http://www.fs.fed.us/pnw/about/programs/fsd/biodiversity.shtml

This conference will review important concepts and demonstrate tools for managing Pacific Northwest forests for biological diversity. Focus is on conserving biodiversity while balancing management goals.

Advances in Threat Assessment and Their Application to Forest and Rangeland Management

July 18–20, 2006
Millennium Harvest House, Boulder, Colorado

For more information: http://www.forestencyclopedia.net/encyclopedia/threats

This 3-day conference will explore the latest information on the assessment and management of environmental threats, including invasive species, insects, diseases, uncharacteristic fire, severe weather, climate change, and wildland loss.

More information coming in June *Science Update* on this conference:

Forest land conversion and forest conservation strategies

Fall 2006
Bend, Oregon
Exact days and site to be determined

This conference will explore rates of development in Pacific Northwest forests and definitions of forest land conversion, highlight successful forest conservation strategies, and provide on-the-ground conservation tools.