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Science FINDINGS

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INSIDE

"Science affects the way we think together."
Lewis Thomas

Predicting Where Elk Will Thrive: New Models Point the Way

Mike Middleton

As timber harvests on federal land in western Oregon and Washington have declined, so have elk populations. Elk forage on plants found in open areas revegetating after disturbance. A collaborative effort among federal and state scientists, tribes, and nongovernmental organizations has yielded models that are now being used to strategically improve elk habitat.

IN SUMMARY

Elk are an iconic species in the Pacific Northwest. The animals are valued as a cultural resource by American Indian tribes, and elk viewing and hunting bring economic and social benefits to many rural communities. Elk forage on grasses, shrubs, and other early-seral vegetation. As timber harvests have declined on federal land in the region over the past 30 years, so has the availability of quality elk forage. At the same time, recreation and other public uses of federal land have increased. As a result, elk are turning to private lands for forage and refuge from human disturbance. This leads to conflicts and reduced hunting opportunities.

Consequently, state and federal agencies, tribes, and hunting organizations are working to increase elk habitat on public and tribal lands where elk are a priority. In 2007, Mary Rowland and Michael Wisdom, research wildlife biologists with the USDA Forest Service, Pacific Northwest Research Station, were charged with developing new elk habitat and nutrition models for western Oregon and Washington. They enlisted the expertise of numerous scientists, and American Indian tribes provided telemetry data.

These summer range regional models of elk nutrition and habitat use incorporate the latest research on elk nutrition, elk response to disturbance, and other spatial landscape data to predict elk use of landscapes. National forests and tribes are using these models to identify areas where active management can improve elk habitat and the quality of their diets.

"Oregon was well supplied with elk, chiefly the coastal form... which roamed all through the Coast Ranges and eastward to the Cascade Mountains."
—Olaus J. Murie, *The Elk of North America*

The habitat niches of two iconic Pacific Northwest species couldn't be more dissimilar. Northern spotted owls (*Strix occidentalis caurina*) require mature forests with shaded forest floors, whereas elk (*Cervus canadensis*) thrive where herbaceous plants and shrubs grow beneath open sky. Following the adoption of the Northwest Forest Plan in 1994, protecting older (late-seral) forest habitat became a priority for the USDA Forest Service in western Washington and western Oregon. However, this protection came at the expense of early-seral habitat that develops when sun-loving grasses, forbs, tree seedlings, and shrubs fill in after disturbances, such as windstorms, fire, and timber harvests.

"One thing we realized as we stopped clear-cutting in response to the Northwest Forest Plan was that elk forage habitat declined, and there was a noticeable elk population decline," explains Joe Doerr, a wildlife biologist with the Willamette National Forest. "We haven't been able to meet our objectives in the Willamette National Forest's forest plan because of the importance of protecting late-seral habitat."

On actively managed timberlands, such as those owned by timber companies or state agencies, there is available early-seral habitat but not enough to reliably fulfill the states' goals for elk population levels.

The declines in elk populations in both Washington and Oregon hadn't gone unnoticed by such organizations as the Rocky Mountain Elk Foundation and the Oregon Hunters Association. Farmers had also observed elk herds moving onto agricultural lands in search of forage, which often led to damaged crops. To remedy the situation, the Sporting Conservation Council (a federal advisory committee) sent a letter to the secretaries of the U.S. Department of Agriculture and U.S. Department of the Interior in December 2007 that requested new elk habitat models be developed to predict elk distributions in western Oregon and Washington.

The agencies agreed such a project was needed, and Michael Wisdom, a research wildlife biologist with the USDA Forest Service, Pacific Northwest (PNW) Research Station, was asked to revisit a project he worked on 20 years earlier.

Collaboration

"It's ancient history," jokes Wisdom when describing how long ago he worked on the first elk habitat model. Released in 1986, the model incorporated the latest in statistical analyses and elk biology at the time. The Bureau of Land Management, U.S. Forest Service, Oregon Department of Fish and Wildlife, and Washington Department of Fish and Wildlife adopted it to manage elk habitat.

However, the model had never been formally evaluated with independent data, and some users were running it incorrectly because they didn't have all the data required for the model, explains Mary Rowland, also a research wildlife biologist with the PNW Research Station.

Although other elk models were available, these didn't provide all the answers either, so managers and wildlife biologist made do. When the Sporting Conservation Council requested that a model update be prepared, Wisdom agreed: "It was the right time for something better."

In 2008, Wisdom and Rowland formed the science team that would design the new elk habitat and nutrition models. They recruited Ryan Nielson, a biometrician now with Eagle Environmental Inc., because of his experience with innovative modeling. "We knew we needed a really good quantitative person because it was a sophisticated modeling process," explains Rowland.

Bruce Johnson, a wildlife biologist for the Oregon Department of Fish and Wildlife, provided both a research and management perspective, which was crucial because the team wanted the model to be useful for land and wildlife managers.

The addition of National Council for Air and Stream Improvement, Inc. (NCASI) staff members John Cook, a principal research scientist, and Rachel Cook, a senior research scientist, brought extensive research in elk nutrition that improved the original estimates of forage quality in the 1986 model. For more than 20 years, they have studied the diets and foraging habits of captive elk in many areas in western Oregon and Washington, as well as body condition in wild elk herds. Their research was funded largely by NCASI and more than 10 timber companies.

A component of their research included quantifying the dietary digestible energy needed by elk across the spectrum of forest stand ages and structural stages present in western Oregon and Washington. Their research also linked diet quality to measures of animal health such as pregnancy rates, a difficult task in wildlife ecology. "Without these nutritional data, it would have been impossible to model habitat use accurately across the region," says Wisdom.

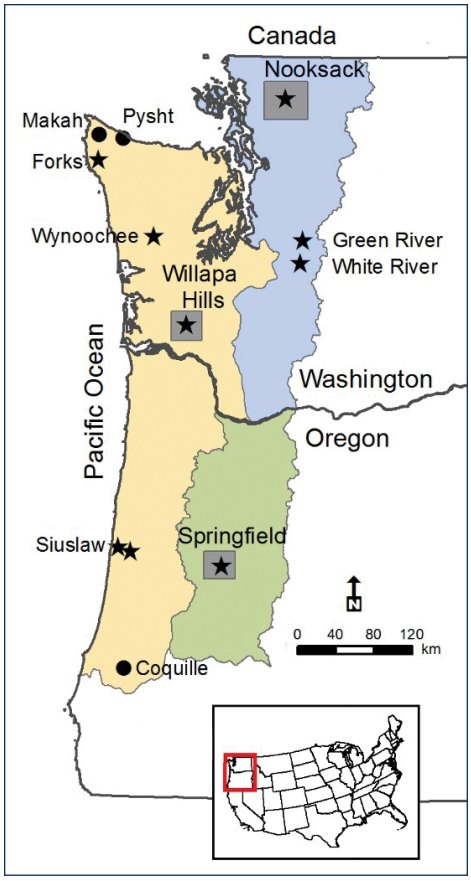
To build and validate these models, the researchers needed data on how elk move about the landscape. This sort of telemetry data is generated by outfitting individual animals with devices that track their movements. Because there was no funding to collect new telemetry data, Rowland recalls spending a lot of time making calls and sending emails to see if others already had that information. A working relationship with David Vales, a wildlife biologist with the Muckleshoot Indian Tribe, proved invaluable; the tribe had telemetry data going back to 2004.

"We were one of the first tribes to put GPS collars on elk," says Vales. "We wanted to know what the elk were doing out there more intensively than [what could be learned from data] we were collecting via very-high-frequency collars."

Prior to the widespread adoption of global positioning systems, telemetry data was collected by very-high-frequency collars, which use radio signals instead of satellites to track locations.

"The Muckleshoot data were foundational to this project," Rowland says. "I venture to say we could not have done it without their data."

Vales connected Rowland with other tribes in the Northwest, including the Quileute Tribe, Makah Tribe, and Lower Elwha Klallam Tribe, who had similar elk telemetry datasets and agreed to their use for the project.



Location of the 12 study areas used to develop and validate the elk nutrition and habitat-use models in western Oregon and Washington. Stars denote study areas where animal performance data were collected, gray boxes indicate sites where information from captive elk was collected to develop the elk nutrition equations, and circles depict sites used to develop or test the habitat-use model.

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Another dataset that Rowland found serendipitously was a vegetation map created by the Forest Service and Oregon State University to measure changes in late-successional habitat for the northern spotted owl and other old-growth-associated species. The dataset provided wall-to-wall vegetation metrics across the region, including information on hardwoods. Hardwood forests provide especially nutritious understory vegetation for elk, and Rachel and John Cooks' nutrition equation included a proportion of hardwoods in an area. "Frankly, if we had not had this dataset, I don't know how we would ever have gotten that forage piece," says Rowland.

Concurrently with Rowland's data hunting, discussions were underway with stakeholders about which variables to include in the model and what outputs were needed by managers. "We received feedback from a lot of different viewpoints," explains Wisdom, "Although it did make it more challenging to create the model because of the different viewpoints."

Perhaps the greatest modeling challenge was the synthesis of many voluminous datasets into a unified analysis. "We used telemetry data, which was collected by different partners for different reasons in different ways, and combined this with fine-scale data on nutrition, again, not collected for use in regional modeling," says Rowland. "The successful integration of these datasets represents a promising development for other forms of data synthesis in future ecological modeling."

The team designed two models to be applied across all land ownerships: a regional habitat-use model and nutrition model. Their focus was on elk distributions and forage quality from June through August because the availability of high-quality forage, which includes grasses, flowering plants, and certain shrubs during the summer, is crucial for the health of nursing females and their calves. And because elk move in response to hunters, the team wanted to limit the modeling period to exclude most hunting seasons.

An exhaustive list of variables that might affect elk behavior was tested. Advances in statistical analyses greatly improved the ways that researchers could relate the variables to the telemetry data, approaches that were not available in the 1980s. "This new model considered all the datasets and variables in an integrated way to weight the different variables," Wisdom says. "It replicates the way that animals actually perceive or react to the variables on the landscape."

KEY FINDINGS

- The elk nutrition and habitat-use models for western Oregon and Washington are robust tools for land and wildlife managers tasked with managing elk. When validated with independent telemetry data, the models accurately predicted where elk would be found on any landscape on the west side of the Cascade Range.
- Elk nutrition, as measured by dietary digestible energy, varied widely among the vegetation zones in western Oregon and Washington. Many west-side landscapes fail to meet basic requirements for lactating female elk. Forage quality appears to be strongly linked to animal fitness, as indexed by body fat and pregnancy rates.
- Summer forage conditions for elk were generally best in higher elevation early-seral habitats and worse in lower elevations and closed-canopy forests. Predicted elk use was greater in sites with better forage, farther from open roads, closer to forest edges, and on gentler slopes.

Mike Middleton

Aerial view of an elk herd. High-elevation meadows and early-successional forest stands where elk can forage on sun-loving grasses, forbs, tree seedlings, and shrubs provide the best summer nutrition for the animals.

Mike Wisdom

A researcher records the browsing habits of a captive, radio-collared elk in the Starkey Experimental Forest and Range, Oregon. Grazing trial data like these were used to develop the elk nutrition model.

When they validated the models against independent telemetry data, the team was surprised how well the results matched. The only place they didn't, Rowland says, was in southwest Oregon, but the telemetry data for that area were older and required reconstructing vegetation conditions from decades ago. More importantly, the area is a transition between the wetter western Cascades vegetation zone and drier southern Oregon vegetation zone.

The nutrition model confirmed that diet quality for elk was often lacking west of the Cascades and wasn't meeting the nutritional needs of nursing female elk. The habitat-use model predicted highest use by elk in sites with good nutrition that were far from open roads, close to forest edges, and on gentle slopes.

"There's a lot of stuff in our world that are 'duh' results," says Vales. "You go through a lot of analysis to find out what the old-school naturalists had been saying for a long time, but the model identified patterns of landscape use that were presented in a quantitative way and can be used to evaluate management scenarios."

Creating a Smorgasbord for Elk

In 2012, the team formally released the model for use. In 2018, they published peer-reviewed articles documenting the modeling approach and findings in *Wildlife Monographs*. Releasing the model prior to publication was a departure from how research is typically released to the management community.

"We took the approach to share the modeling process and results from start to end, being led by scientists, but in collaboration with managers and stakeholders," Rowland says. "This does have downsides, for example, if you get some things wrong that are later found in the peer-review process. But there are benefits to this integrated approach, such as the model being used in a lot of different and novel applications soon after it was released."

Doerr adopted it for use by the Willamette National Forest. "The model was really useful because it gave us new science," he says. "It also provided a more scientific spatial way of looking at open roads compared to relative road density. It was definitely an improved way of analyzing things and telling the scientific picture."

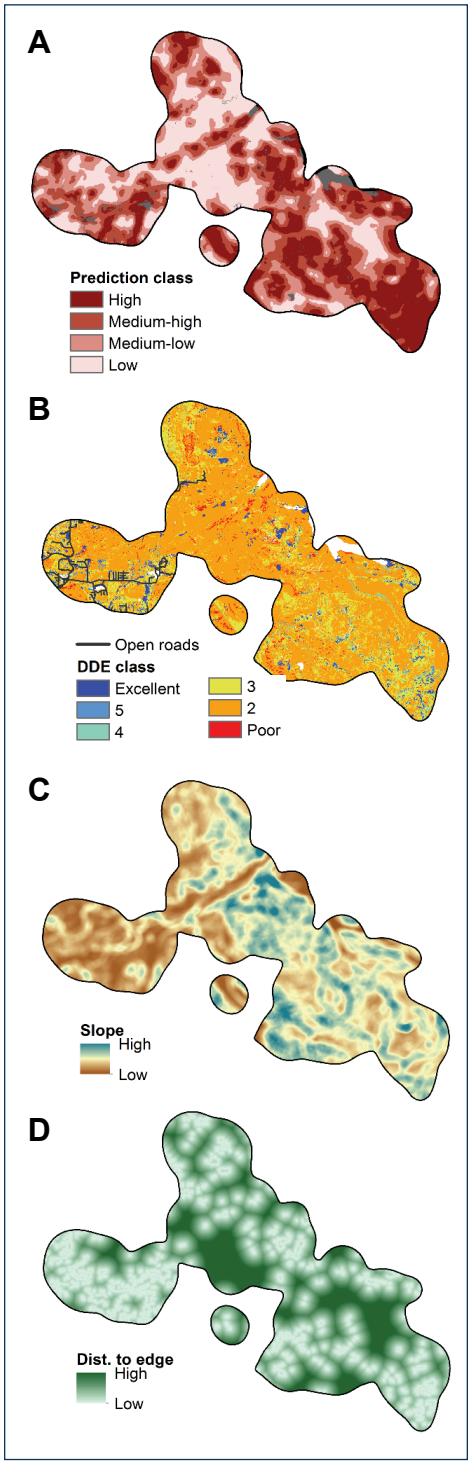
Doerr is using the model to assess the potential forage quality (dietary digestible energy) for elk in thinned units, as well as monitoring forest-wide for how forage availability has changed over the years. "The value of the model is telling our story at the broad scale," he explains. "It's a little general at the site-specific level, but then the biologists are using their own field reconnaissance to supplement that data."

The Muckleshoot Indian Tribe recently acquired former industrial timberlands that will be managed for timber harvests and cultural resources. Vales' goal is to develop a continuous supply of elk forage across spatially diverse areas, rather than to have boom and bust cycles of cover and forage within small areas of a larger landscape. With the elk nutrition model, Vales can identify the ideal forage areas and present the data to forest managers for use in their forest management decisions. "The model gives us a peer-reviewed tool that's widely accepted, and that strengthens any of the arguments we make," he says.

Dave Bailey, a wildlife biologist with the Tulalip Tribes of Washington, is a recent user of the

Rachel Cook

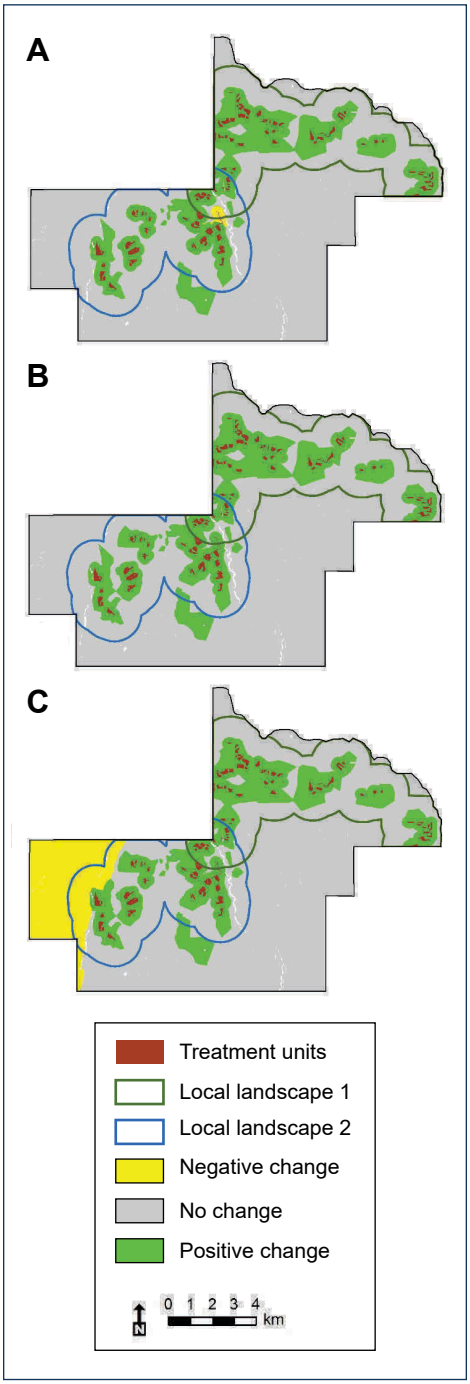
A captive cow elk and calf. Many west-side landscapes fail to meet basic nutritional requirements for lactating female elk.



The habitat use model predicts relative use by elk across the landscape (A) based on four variables: (B) dietary digestible energy and distance to nearest open road, (C) slope, and (D) distance to nearest cover-forage edge.

model and is applying it to a game management unit within the tribe's treaty area. A small population of elk is currently within the unit, and Bailey is using the model to predict how many elk the unit could sustain based upon the forage availability and quality. Eight other tribes have treaty rights to the area, and because this unit is close to the Tulalip reservation, it provides more hunting opportunities for tribal members.

"The tribe is always trying to manage the resource for seven generations out," Bailey says. "We're always trying to do our best decisionmaking for the resource as possible. Elk is a species the tribe depends on for a food source and cultural resource, and being able to practice their treaty rights is a concern for the tribe."



Example output from the west-side elk habitat-use model. Resource managers can use the model to predict the effects of various management alternatives on the probability of elk using the area after treatment.

LAND MANAGEMENT IMPLICATIONS

- Forest management, such as regeneration harvest and thinning, that leads to early-seral habitat yields better nutrition and productivity for elk. Other wildlife species that use early-seral habitat also benefit. The benefits of active management to create summer habitat for elk will vary by elevation and typically persist longer at higher elevations.
- Treating as little as 3 to 5 percent of the landscape can substantially improve elk nutrition. However, elk may not use the improved habitat if it is too close to roads, on too steep a slope, or nested in a landscape mosaic without adequate blocks of cover and forage.
- With strategic management to improve habitat quality and elk distribution across the landscape, public lands can maintain elk populations for viewing and hunting, which are activities highly valued by the public.
- The nutrition and habitat-use models provide consistent methods for evaluation and management application across 27 million acres in western Oregon and Washington, comparable to the expansive area managed for northern spotted owls in the two states.

Using the model results, Bailey helped write a draft management plan for the Washington Department of Fish and Wildlife, and the agency is now reviewing it. As for his reaction to the model, "I appreciate people dedicating the time to create these tools. I think it's effective to have these tools in our back pocket for short-term and long-term management decisions."

In reflecting upon their work, Wisdom says that the models represent an example of "knowledge coproduction," or the process of producing usable science through collaboration between scientists and those who use it to make policy and management decisions. "Ecological research is just beginning to formalize approaches based on knowledge coproduction, which involve a wide variety of stakeholders and collaborators to make the management applications successful," he says. "This modeling process and its management uses are a testimony to the success of this approach."

"Recognize management as experiment. To do otherwise ignores reality. It also encourages unhealthy distinctions between researcher and manager."

—Fred Bunnell,
professor emeritus of forest wildlife management,
University of British Columbia

For Further Reading

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MICHAEL WISDOM is a research wildlife biologist with the Pacific Northwest Research Station. His research focus is on elk and mule deer at the Starkey Experimental Forest and Range and replicate sites in the Western United States.

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Eric Cole, U.S. Department of the Interior Fish and Wildlife Service

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