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INSIDE

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

HIGHWAYS AND HABITAT: MANAGING HABITAT CONNECTIVITY AND LANDSCAPE PERMEABILITY FOR WILDLIFE

From a wildlife manager's perspective, roads act as barriers to movement and dispersal, often isolating and fragmenting populations. They also introduce pollutants and provide access for humans and development. And then, of course, there are vehicle-animal collisions—a direct source of mortality for countless animals each year.

> *"As transportation-related environmental issues and associated public concern rapidly grow, fortuitously, the science of road system ecology also emerges."*
>
> —Richard T. Forman, Professor of Landscape Architecture, Harvard University, and author of *Road Ecology*

It is an ominous feeling to be cruising down the road at 70 miles per hour and see your headlights reflected in the eyes of a deer. Your heart leaps to your throat and you wordlessly beg the animal not to cross. Though there is some relief when you pass, you know the deer is still stuck, and the drivers behind you all face the same hazard. Indeed, the very abundance of carcasses on the highway's shoulder offers proof that many deer don't make it out of the headlights or across the roadway.

There are nearly 4 million miles of roads in the United States and their ecological footprint extends well beyond the pavement. From a wildlife manager's perspective, roads act as barriers to movement and dispersal of wildlife, often isolating and fragmenting populations. They promote human access and development into wildlife habitat, and they introduce a host of pollutants, such as exhaust, pavement de-icers, and oil. Then,

IN SUMMARY

Millions of miles of highway crisscross the United States. Highways fragment the landscape, affecting the distribution of animal populations and limiting the ability of individuals to disperse between those populations. Moreover, animal-vehicle collisions are a serious hazard to wildlife, not to mention people.

Researchers at the PNW Research Station in Wenatchee, Washington, have developed methods to evaluate landscape permeability—the ability of animals to move across the landscape. Using a geographic information system, in conjunction with snow tracking, automatic cameras, and road-kill surveys, they can now identify areas where animals are most likely to cross major highways. These techniques have been adopted by the Washington State Department of Transportation in a massive reconstruction project on Interstate 90 at Snoqualmie Pass. The new stretch of highway is slated to include several wildlife crossing structures.

In addition, the researchers have conducted a regional-scale evaluation of landscape permeability for grizzly bears, wolverines, grey wolves, and lynx in the Pacific Northwest. The analysis identifies highways and other landscape barriers that may fragment populations and limit dispersal opportunities. Their work provides tools that can be used to develop conservation strategies and help identify management priorities for these focal species.

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Awareness of the environmental impacts of roads is increasing, yet information remains scarce. Peter Singleton, an ecologist at the PNW Research Station in Wenatchee, Washington, is among a growing cadre of scientists seeking to understand the interplay between human and animal movement networks.

Singleton's recent work has paired him with transportation engineers at the Washington State Department of Transportation (WSDOT). Together they are trying to understand how Washington's highways, bridges, on- and off-ramps, and other highway structures affect the distribution of animal populations. Their work is leading to new highway construction that integrates animal movement patterns into their design.

"Incorporating highway alignment with an understanding of animal movement can contribute to safer highways for both animals and motorists," says Singleton.

"For example, our work along Interstate 90 in the Snoqualmie Pass Adaptive Management Area, and throughout the Pacific Northwest, has provided several tools that managers can use to create crossing opportunities for animals, help connect isolated populations, and minimize risks to motorists from animal-vehicle collisions," he says.

To identify where human and animal transportation routes overlap, Singleton has used remote cameras, snow tracking, and road-kill surveys. But perhaps his most valuable tool has been a landscape analysis model that maps regional habitat quality and predicts how wildlife will move from one habitat-area to the next.

"Just like human populations, most animals are not uniformly distributed across large landscapes," explains Singleton. "They occur in subpopulations centered in areas of suitable habitat. Ensuring that animals have the opportunity to move across broad landscapes, from one subpopulation to the next, is vital to their long-term viability. It can alleviate many of the negative effects related to genetic isolation and random disturbances, such as wildfires or storms."

KEY FINDINGS

- The Interstate 90 Snoqualmie Pass wildlife habitat linkage assessment identified five areas of increased landscape permeability. These areas have higher relative levels of animal crossings and are likely candidates for mitigation efforts during the reconstruction project.
- The regional assessment identified eight important fracture zones (areas of reduced landscape permeability) in Washington and Oregon that may be important for populations of wolverine, lynx, grizzly bears, and wolves.
- A geographic information system model that utilizes widely available data to find animal movement routes and wildlife-highway interaction zones was found to correspond well with field data and road-kill surveys.

AN EMERGING FIELD: ROAD ECOLOGY

Landscape ecologists are always talking about the connectivity of wildlife habitat. The idea is straight forward enough—large blocks of habitat are better than fragmented ones. As such, wildlife managers should strive to connect habitat to produce the largest blocks possible. Though Singleton finds no fault with this theory, he prefers to talk about "landscape permeability."

"Connectivity implies uniformity," says Singleton "and we know landscapes are never uniform; instead they are patchworks of habitat types interspersed with various types of barriers. Landscape permeability, on the other hand, describes the amount of resistance animals perceive when navigating across barriers and from one patch to the next."

Barriers come in many forms, and their permeability is, in some respects, in the eye of the beholder. In the case of natural barriers, like rivers or rugged topography, the barrier effect is perceived differently depending on the species in question. To an river otter or mountain goat, these may not be barriers at all. Humanmade barriers are the same way. A deer may easily traverse a rural subdivision, whereas to a wolverine, that same subdivision may be as good as a brick wall.

Highways are the archetypical landscape barrier.

"Few features in the modern landscape have such dramatic influence on human development, landscape change, and habitat fragmentation as highways," says Singleton. Concerns over the impact of roads on ecosystems have led to an emerging academic field: road ecology.

Road ecologists are concerned with the adverse impacts of roads on natural systems at many spatial scales. "At regional scales, it is important to understand how highways can affect the distribution of individual animals between populations," explains Singleton. "At smaller, local scales, it is important to be able to identify specific places where animals are likely to cross highways in order to manage for landscape permeability, provide crossing opportunities for animals, and minimize risks to motorists from animal-vehicle collisions."

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PLANNING FOR A WILDLIFE-FRIENDLY SNOQUALMIE PASS

To drive on Interstate 90 through the breathtaking Cascade Mountains is to straddle a barrier that fragments a uniquely valuable ecosystem. Of particular concern is the Snoqualmie Pass region. In the past few years, Snoqualmie Pass has been the focus of a major land exchange and land acquisition effort by the Forest Service and a variety of nonprofit conservation groups interested in protecting old-growth forests and other biological resources.

Much of this region is managed by the Forest Service and is 1 of 10 regions designated as an adaptive management area (AMA) by the 1994 Northwest Forest Plan. The primary purpose of the AMA is to re-establish habitat connectiveness and permeability for late-successional species.

Interstate 90 at Snoqualmie Pass sees nearly 27,000 vehicles per day and bisects the central Cascades ecosystem, effectively halving the habitat available to many wildlife species.

In response, WSDOT and the PNW Research Station entered into an agreement in 1998 to conduct an assessment of the barrier effects of Interstate 90. Soon after the assessment was started, planning began for a major overhaul of the 15-mile stretch of highway. "It may seem odd for a transportation project, but habitat connectivity is a major emphasis of Interstate 90 reconstruction," says Randy Giles, a project manager at WSDOT.

Knowing that millions of dollars would be spent on animal crossing structures, WSDOT asked Singleton to identify exactly where along the highway that investment could be best applied.

Singleton and his colleagues developed a unique methodology by using a geographic information system (GIS) to recognize places along the highway corridor with high landscape permeability. "Our model identified areas in the surrounding landscape with the best wildlife habitat and then sought the linkages between them that had the least exposure to unsuitable habitat," says Singleton. The approach is called "least-cost corridor analysis."

The model evaluated road and human population density, land cover type, elevation, and slope to highlight places along the highway most likely to have wildlife crossings. They tested the model by using a combination of automatic camera stations, snow tracking surveys, and an analysis of road-kill distributions that looked back 16 years. Through this methodology they identified five areas with greater landscape permeability along the stretch of highway.

Snow tracking, automatic camera stations, and road-kill surveys have been used to identify areas along Interstate 90 in the Snoqualmie Pass region with high animal crossing rates. This information is being used by the Washington State Department of Transportation in a major reconstruction project that includes habitat connectivity as a primary objective.

One of these areas, Easton Hill, was the sight of a tragic accident in 2004 that killed four people when their vehicle collided with an elk and crashed over an embankment.

"Several factors come together to make Easton Hill a hot spot of wildlife activity," says Singleton. "It is linked to some very high-quality habitat, and there is little human access off the roadway. Also, there is a wide forested median that separates the east- and westbound lanes of traffic, which makes for a shorter cross. What's more, because of the steep hill, traffic gets clumped up and tends to slow down quite a bit. In fact, it is the only area that my field crews could safely cross when we were conducting snow tracking surveys."

Easton Hill and the other four areas with high wildlife activity are now likely candidates for mitigation work during the reconstruction project—much of which is still undergoing environmental review. "So far, $387 million have been funded toward the highway project, which includes several wildlife crossing structures—and that's just for the first 5 miles," explains Giles.

"As far as Easton Hill goes," he says, "we are still trying to find the structure that will benefit the widest range of wildlife species. For now, a large forested overpass seems most likely."

Automatic camera stations were used to test the landscape permeability model developed for the Interstate 90 assessment. Several animals were photographed near the highway, including these black bears.

A REGIONAL PERSPECTIVE ON ANIMAL MOVEMENT

The GIS analysis was very good at locating regions along Snoqualmie Pass with high densities of wildlife. The cameras, snow tracks, and road-kill analysis all confirmed the model's findings. Seeing this, Singleton took the logical next step: he scaled up.

"We modified the landscape permeability model that we developed for the Interstate 90 project and applied it at a regional scale throughout Washington, Oregon, and southern British Columbia," he explains.

Singleton and his colleagues were particularly interested in finding the barriers to long-range movement between large blocks of wilderness found in this region, such as the north Cascades Range, the Selkirk-Columbia Mountains, and the British Columbia Coast Range.

"Understanding patterns of landscape permeability is particularly important for the conservation of species with large home ranges and low-density populations, such as large carnivores," says Singleton. So this time they catered the habitat assessment to the needs of four species: grizzly bear, wolverine, lynx, and grey wolf. All are known to travel long distances, and all are listed as threatened, endangered or are of special concern by the state of Washington.

The analysis identified several fracture zones, which are areas of low permeability separating high-quality habitat areas. In addition to highways, the fracture zones contain recreation and residential development and fragmented forest cover resulting from logging. One fracture zone in southwestern Washington had such low permeability that carnivore populations in the southern Cascades and Olympic Mountains are likely to be completely isolated.

Also of particular concern was landscape permeability for grizzly bears in and out of the north Cascades. The north Cascades area has been identified as a grizzly bear recovery zone and the current population is small and isolated. Female grizzlies, in particular, are known to avoid crossing roads or moving through other human developments. As a result, the long-term viability of grizzly bears in this region is in question.

Singleton's research may offer some help in identifying areas that have the potential to reconnect north Cascades grizzlies to other populations in Canada or the Rocky Mountains.

Transportation engineers are increasingly collaborating with ecologists to design creative wildlife crossing structures. Some are simple oversized culverts, which assist movement for small, low-mobility species like rodents and amphibians; in contrast, others are complex networks of tunnels and grass-covered bridges that facilitate movement of large and small animals.

More immediately, the regional analysis is already helping land managers identify areas where landscape permeability for all carnivores can be improved. "Our results have been incorporated into the WSDOT long-range highway maintenance planning process. This has given them more information and predictability on the issues they are likely to face in implementing future highway projects at regional scales. The WSDOT had been very supportive of this work," says Singleton.

LAND MANAGEMENT IMPLICATIONS

- The geographic information system model developed for this project is a useful tool for land managers and road engineers seeking to find the best location for placing animal crossing structures along major highways.
- Field techniques developed during this research, such as roadside snow tracking, automatic cameras, and road-kill surveys, are useful for evaluating animal movement near highways.
- The analysis of landscape permeability for large carnivores in the Pacific Northwest can be used to develop conservation strategies, contribute to future field survey efforts, and help identify management priorities for these focal species.

HELPING THE CRITTER CROSS THE ROAD

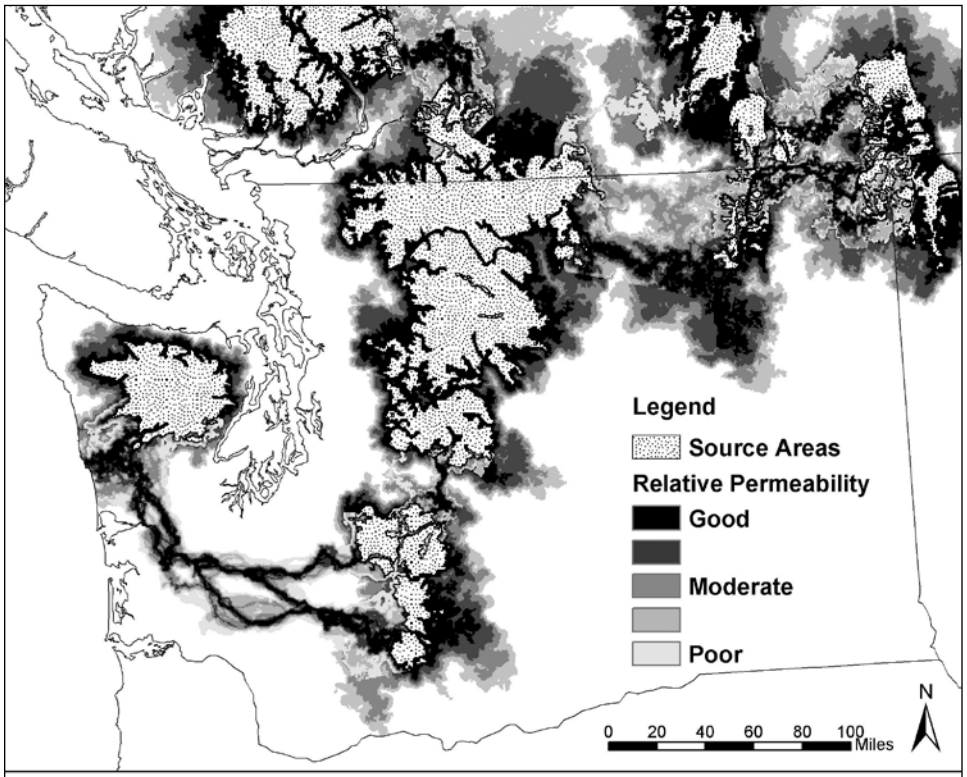
Once land managers know where wildlife crossings are most likely to occur, the question becomes: How can we get them across safely? Increasingly, transportation engineers are collaborating with road ecologists to design creative wildlife crossing structures. Some are as simple as oversized culverts, which assist movement for small, low-mobility species like rodents and amphibians. On the other end of the spectrum, some highways have incorporated complex networks of tunnels and grass-covered bridges.

Engineers on the Trans-Canada Highway in Banff National Park in Alberta have been leaders in developing wildlife-friendly roads. The park contains miles of fencing, all designed to funnel animals toward one of the wildlife tunnels or grass-covered overpasses—some of which are more than 150 feet wide.

Lessons learned in Banff and elsewhere have shown that a primary challenge for road ecologists is finding the right structure for each species. For example, on the Snoqualmie Pass project, Singleton used track plates and automatic cameras to determine if the existing bridges and culverts were allowing animal crossings. He found that mice and chipmunks were readily utilizing these structures, but few other species were using them.

"I was surprised that we didn't see any use of the larger culverts by medium or large carnivores," he says. "We found evidence of one river otter, but that's it."

As the reconstruction project on Interstate 90 unfolds, it will likely include dozens of different animal crossing structures including culverts, bridges, and viaducts. From the sounds of it, Snoqualmie Pass will certainly be more than just another ribbon of highway.



Landscape permeability for forest carnivores in Washington and southern British Columbia.

Landscape permeability is particularly important for the viability of species with large home ranges and low density populations, such as large carnivores. Singleton's landscape analysis model produces habitat maps that identify likely movement corridors for wolves, bears, lynx and wolverine.

Matching the appropriate crossing structures to the target species is often an important challenge in managing highways for landscape permeability as highlighted by this automatic camera photo of a deer investigating a tracking plate placed inside a drainage culvert.

"It is a fact, patent to both my dog and myself, that at daybreak I am the sole owner of all the acres I can walk over. It is not only the boundaries that disappear, but also the thought of being bounded."

—Aldo Leopold (1949)

FOR FURTHER READING

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