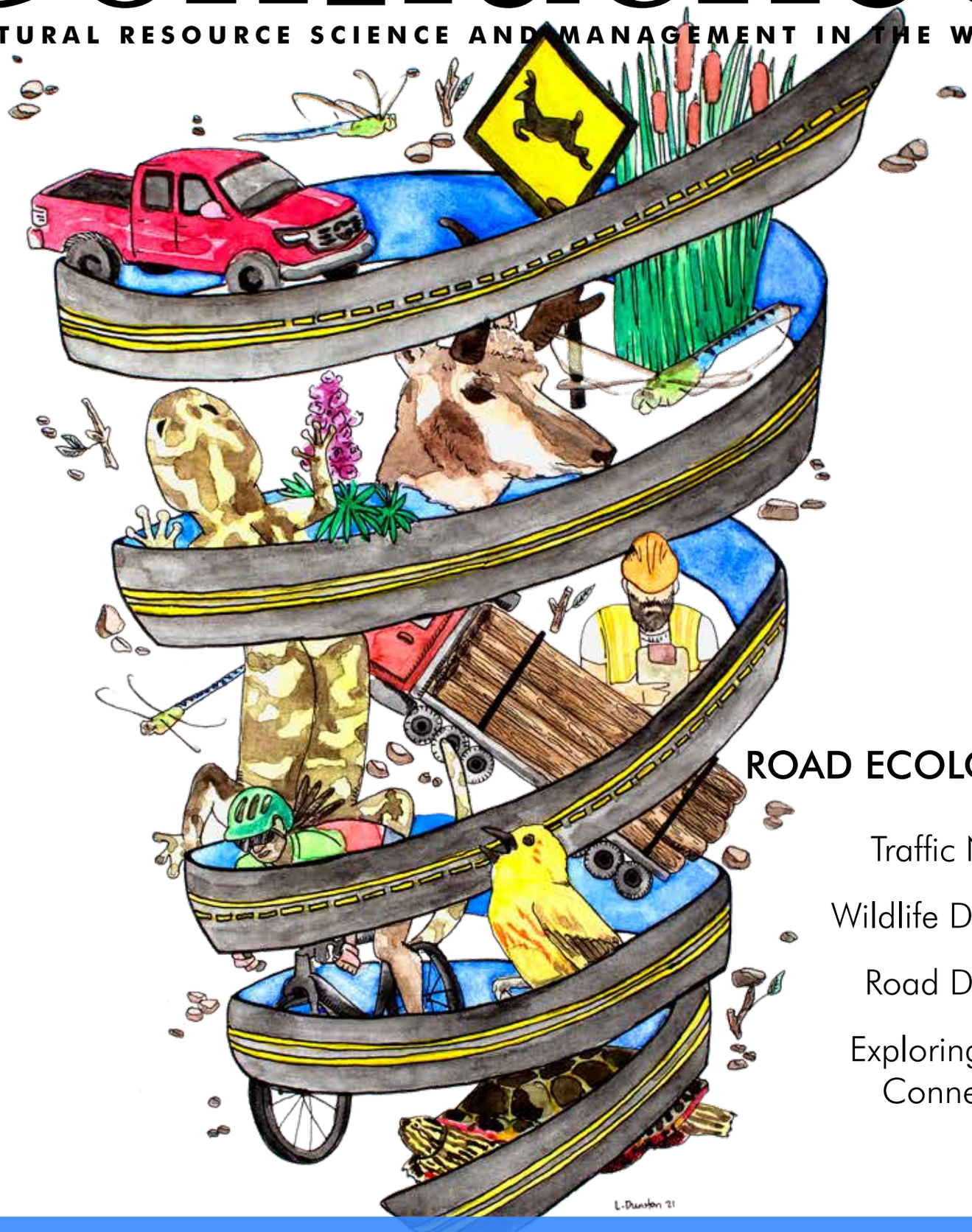
Western Confluence

Issue 11

NATURAL RESOURCE SCIENCE AND MANAGEMENT IN THE WEST



ROAD ECOLOGY

Traffic Noise

Wildlife Deaths

Road Design

Exploring and Connecting

A publication of the William D. Ruckelshaus Institute at the University of Wyoming's Haub School of Environment and Natural Resources

Contact Us

Western Confluence is published by the Ruckelshaus Institute of Environment and Natural Resources at the University of Wyoming, supporting effective decision making through compelling communication, applied research, and collaborative approaches.

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EDITOR'S NOTE

By Emilene Ostlind

"For many Americans, the open road best captures the essential character of the West—unfinished, open-ended, a marriage of the human psyche with the earth, sky, and highway," writes geographer William Wyckoff.

We've all been there, driving fast on a ribbon of asphalt, watching a distant thunderhead boil up, counting raptors on fenceposts, cresting a long geologic uplift only to have the last FM station flicker to static. These roads of the West mean everything to us, linking our scattered towns and cities with the most remote ranches and energy fields, carrying goods and newspapers, food and medicine, letters and visitors. We need our roads. We take our roads for granted, forgetting how extensively they shape our existence. And we curse our roads when they are clogged with construction or sheathed in deadly ice.

Like any human-built infrastructure, roads also change the places they cross. In the last few decades, researchers and ecologists have begun to look carefully at the ways roads disrupt natural systems. We open this issue with an introduction to the Western Transportation Institute, a research unit based at Montana State University in Bozeman, to illustrate the cutting-edge ways road ecologists are scrutinizing roadway impacts and devising solutions to mitigate the damages they cause (page 2).

Some of the damage is apparent, marked with legions of bloody wild animal carcasses, small and large, smacked by speeding vehicles (pages 4, 6, 10, and 12). Other influences are more subtle, such as the way roads alter wildlife behavior even when the animals aren't struck (pages 12, 14, 16). The more we learn, the better we can do to blunt the harsh disruptions roads bring to our wild lands. For example, ecological datasets can inform ways to divert new roads around fragile natural areas (page 30). One simple way to mitigate road damage is to reduce speed limits, especially at certain times of day or year when animals are most susceptible (pages 12 and 45). Researchers and highway managers are even designing crossing structures to safely ferry wild animals over or under roadways (page 26). In the case of massive Interstate 80, which acts like a wall across hundreds of miles of big game habitat in southern Wyoming, new wildlife crossing structures might begin to stitch a broken landscape back together (page 16). Of course, as one researcher in this issue puts it, "Not building new roads is the number one conservation action" (page 15).

This exploration into the field of road ecology took us in some less-expected directions, too. You'll find an essay about a highway engineer and his care in designing roads through the desert he loved (page 28). And you'll join an adventurer who explores abandoned mining roads by mountain bike and discovers something other than the ruined industrial site she expected (page 43). Roads are part of our human experience on the landscapes where we dwell. Even as they disrupt wild places, they also mediate our connections to the land, indeed linking our psyches to the earth and sky.

University of Wyoming
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On the cover: Roads disrupt the natural environments they cross. They also mediate human connections to those landscapes, and we rely on them for our daily existence. Emerging research is illuminating ways we can mitigate some of the damage roads cause to wildlife and wildlands.

*Artist **Latasha Dunston** brings her love of the outdoors to her paintings, drawings, illustrations, and digital creations from her studio in Denver, Colorado. Find more of her work at jitterbugart.com.*

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The Science of Road Ecology

Researchers are changing the ways we see, think about, and manage our roadways

By Kristen Pope

"People don't really think about this impact that roads have because roads and cars are such an important part of our life in North America," says Western Transportation Institute (WTI) senior research scientist Tony Clevenger. "We're an automobile nation, and we often go from Point A to Point B and [don't] think about the impacts that a six-lane highway will have on mule deer that are trying to migrate across."

Roads take up less than 1 percent of the landscape in the United States, but they have a disproportionate ecological impact, affecting up to 20 percent of the landscape. Researchers who specialize in the relatively young field of road ecology study those impacts, and their findings are changing the way we think about roads and informing ways to mitigate the negative side effects of roads. WTI is a leader in this research.

As the field of road ecology has emerged and become established, it makes us see roads not just as transportation corridors, but also as structures that change and influence surrounding landscapes. "The environment doesn't end at the road edge," Clevenger says. Now we are learning how to minimize the damaging impacts.

It all starts with research. The field covers everything from studying roads' impacts on wildlife—including large mammals, amphibians, reptiles, and fish—to plants, air quality, water quality, and even noise and light pollution from headlights. Road ecologists examine topics like carbon emissions, chemicals from deicing agents, heavy metals' impact on wetlands, the dispersal of exotic plants along roadways, ways to reduce erosion after construction, and even how to utilize right-of-ways to fight climate change.

For decades, the subject was scattered among other disciplines, with papers on related topics appearing in engineering, wildlife, and ecology journals, as well as publications from transportation safety institutes. However, around 25 years ago, the discipline became more cohesive, and people started publishing books about road ecology as its own field of study.

WTI, one of many university centers around the country conducting transportation research, was among the first to focus on rural transportation issues, from road ecology and creating safer wildlife crossings to public transportation in rural areas. Founded in 1994, WTI began as a joint effort of the Montana and California Departments of Transportation and Montana State University, and it is now based in Bozeman, Montana. The institute has 30 staff members, with a road ecology team made up of two civil engineers and three ecologists; they also work with around 15 professors. One computer science professor is helping develop a smartphone app for roadkill data collection, while a civil engineering professor is designing a bridge, and ecology professors specializing in bees and butterflies are assisting with a roadside pollinator study. WTI works on a variety of projects in North America in locations such as the Canadian Rockies, Montana, Alaska, and California. The institute's experts also share their expertise with planners around the globe, conducting workshops and otherwise collaborating on projects in Mongolia, India, Nepal, Malaysia, Kenya, Borneo, and beyond.

One of the biggest dilemmas in road ecology is protecting humans and animals from wildlife-vehicle collisions. Every year, between one and two million large animals collide with vehicles in the US, according to a 2008 study by the Federal Highway Administration. Many of WTI's projects involve wildlife crossings, and the road ecologists work to tailor each design to local species. It can be challenging to find the right type of crossing that animals will actually use, will be safe for the animals, and will be usable for as many species as possible.

"Different species may have different needs," WTI road ecology program manager Rob Ament explains. "How big do [structures] have to be? What do the approaches to the structures have to look like?

What kind of fencing do you use for elephants or tigers? Do they like underpasses or overpasses?" In one project in Asia that WTI collaborated on, old fire hoses were twisted and strung above roadways to provide primates and other species with a safe aerial crossing.

Another WTI project in Montana placed around 40 Denil fishways (fish ladders) to connect aquatic habitats in order to help boost the Arctic grayling population, which was declining. The researchers are working to see if retrofits of the fishways will allow the Arctic grayling to pass with less water. They are also looking at ways to analyze how small animals—including amphibians, reptiles, and terrestrial mammals—can cross roads. They are compiling case studies and synthesizing the information in order to find the best ways to reduce mortality on the roadways.

Crossings aren't the only way to keep wildlife off roads. WTI senior research ecologist Marcel Huijser is studying systems that can work for animals with paws the way cattle guards work for animals with hooves. He is working on a project involving electrified barriers to keep wildlife off roadways in areas such as fence end gaps and access roads—locations where cattle guards are sometimes used. "Where these wildlife guards, cattle guards, don't do a good job is with regard to species with paws, mostly carnivore species. Think bears, wolves, bobcats, coyotes," Huijser says. Huijser and collaborators are testing electrified barrier designs on a melon farm in northern Montana that is a magnet for black bears—previously half a dozen bears could be seen feasting on melons at a time. He says after a few modifications, the designs are working well.

Branching out from wildlife crossings, another WTI project studied wool erosion control blankets and other wool-based products for roadside reclamation projects. Transportation departments must mitigate soil erosion and surface runoff after projects to allow vegetation to reestablish, and the team examined whether wool products, which are commonly used in New Zealand, may be a good solution. They tested three different types of biodegradable wool products for erosion control and compared them to products already commonly used in the US such as straw and coconut blankets, woven plastic silt fence, and wood fiber compost. They found promising results for the wool products—which fertilize as they degrade—and are working to develop and optimize them for potential use

WTI also explores opportunities to use roadside right-of-ways for purposes like carbon sequestration and solar power. One project focused on ways to increase carbon stocks in right-of-ways in Montana. They tried mowing with a higher blade to leave taller grass, planting shrubs, disturbing the soil, and adding legumes to the seed mixes they applied. They found minimizing soil disturbance was the best way to increase carbon storage potential. "It's important to think of [right-of-ways] ultimately as an asset to manage, not just as a cost for transportation agencies to have to mow and control for the spread of noxious weeds," says Ament, WTI's Road Ecology Program Manager.

Roads are a powerful part of the ecosystem that can have a big impact. Work by road ecologists and institutes like WTI is helping us understand the many ecological impacts our roads cause and come up with creative ways to address those impacts and reduce the negative effects of roads.

***Kristen Pope** is a freelance writer and editor. Learn more about her work at kepope.com.*

A LAST LEAP TOWARDS

By Morgan Heim

As the last rays of light licked the hillsides in rural Idaho, I arced around one bend in the highway that I came to call the death trap. In the span of two miles, I passed the bodies of seven animals: two deer, an elk, a badger, coyote, fox, and the massive, bristled body of a porcupine, its quills waving in the wind as I passed.

I, too, have been that driver. A pheasant, a bat, and a juvenile black-tailed prairie dog weigh heavily on my conscience. Hitting these animals almost made me cause accidents of my own, with tears blurring my vision and as I frantically pulled over to the side of the road. Their lives existed one moment and not the next because of me. Here I am, the conservation photographer.

The scale of death caused by roads is almost too much to imagine. The Humane Society of the United States estimates more than a million animals die on our roads each day. Deer alone account for roughly 1.3 million accidents a year and lead to billions of dollars in damages and injury. Researchers have listed wildlife-vehicle collisions to be one of the single, largest human causes of wildlife mortality in the world.

We have put barriers around our eyes and hearts. If we stopped to grieve for all of them, the world would cease to function. But I can't help but feel I owe these animals something. So I began "A Last Leap Towards Flowers," a series of fine art portraits of wildlife of all kinds, killed on our roads. Each portrait is made in situ and without manipulation except for the bed of flowers.

I don't expect the world to stop driving. I have to drive to make the images. Perhaps this project can help, whether it's to support funding for wildlife crossings or reduced speed zones, or simply to grow empathy.

I know these animals are long gone by the time I photograph them, but I can't help wanting to give them one last moment of dignity and beauty. "A Last Leap Towards Flowers" began as, and remains, my way of saying "I wish you to have one last moment of light and promise to remember your journey."

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*Find more of **Morgan Heim's** conservation photography and videography at morganheim.com.*

FLOWERS

Who are these animals,
their lights gone out?
What journeys have
fallen apart here?

—Barry Lopez, *Apologia*

Ride for Roadkill

Montana cyclists are helping make the state's roads safer for wildlife and people

By Birch Malotky

Crowell Herrick, 63, rides his gravel bike down Montana Highway 1, wearing a high-vis vest. He's fresh off a night under the stars, sleeping bag and bivy sack strapped to his bike. Cruising along the road, he scans from the center line, to the lane, to the shoulder, to the right-of-way. Spotting a bloodstain up ahead, he brakes hard and dismounts, approaching the smear. Just as speculation sets in, he spots a porcupine, dead on the shoulder across the road. The kill is fresh; it wasn't there the night before. Photographing both the bloodstain and the carcass, he types some quick notes into his phone and hops back on his bike, knowing he'll stop many more times before he makes it home.

Herrick is a volunteer for the nonprofit organization Adventure Scientists, cycling for their Wildlife Connectivity project. The project, in partnership with Montana Department of Transportation and Montana Fish, Wildlife and Parks, aims to use citizen science to expand documentation of roadkill and by doing so, to better understand wildlife-vehicle collisions in the state. Ultimately, the data is meant to improve safety for both wildlife and people on Montana's roadways and beyond.

"Roadways are one of the main arteries through which humans and wildlife interact," says Marcus Pearson, director of program investments at Adventure Scientists. Unfortunately, the interaction is often negative, with wildlife-vehicle collisions killing more than 365 million animals, injuring 29,000 people, and causing $8.4 billion in damages each year in the United States. In Montana, where the wildlife is big—and in the case of grizzly bears and lynx, threatened—the impacts of wildlife-vehicle collisions can be particularly costly, dangerous, and visible. The Department of Transportation and Fish, Wildlife and Parks, each according to their mandate, are responsible for mitigating this harm as much as possible.

"The human world can have an outsized impact on how safe wildlife are on the roadway," Pearson says, so Fish, Wildlife and Parks needs to understand how animals' movements intersect with human roadways in order to protect the state's wildlife. At the same time, preventing animal-vehicle collisions is essential to the transportation department achieving "Vision Zero," which calls for zero fatalities and zero serious injuries for drivers on Montana highways.

To inform these goals, both organizations get regular reports directly from crashes, citizens gathering roadkill, carcass collections done by department employees, and surveys and radio collaring conducted by professional biologists. The data inform future management strategies. For example, "if we have a bridge that needs to be replaced," says Tom Martin, environmental services bureau chief at Montana Department of Transportation, "we look for accumulations of data…that point to some problem." Perhaps

Kyle Moon, Adventure Scientists

A citizen scientist records the size and location of roadkill on Highway 191 near Big Sky.

someone died in a crash, or department employees frequently collect carcasses from that spot. "Then we're going to design a feature, as economically as possible, to mitigate that problem." Moreover, because there are more needs than can be funded, Martin says the data help prioritize the projects and "get the biggest bang for the buck."

And yet, the information that both state agencies use is incomplete, because each data stream has certain limitations and biases. Some vary seasonally, others are opportunistic, and most are done from a moving vehicle. All represent an investment of precious resources, including personnel time and departmental funds. The limits of the data then limit the action that can be taken to prevent wildlife-vehicle collisions. Enter, Adventure Scientists.

"It may seem unusual that road cyclists would be recruited to gather information about motor vehicle accidents with wildlife," begins Jenn Shoemaker, associate director of communications at Adventure Scientists. But cyclists had something to offer that no one else did.

Volunteer cyclists are "better placed to see more wildlife than anyone who is trying to do this work from a car," says Shoemaker. Moving slowly, the cyclists notice the smallest signs and most faded evidence of roadkill, down to the blood smear Herrick noted on Montana Highway 1. Bikers also see into ditches and roadside vegetation that might otherwise obscure wildlife.

As such, volunteers report on a wider variety of species than existing data streams. "You expect it to be deer, deer, deer, all the way down the road," says Shoemaker, "and it's really not. When you're going slower you see a lot of smaller things." Indeed, Herrick said he got involved with Adventure Scientists because, as an avid cyclist, "one of the things [he] noticed right away was all the little birds that you don't see when you're driving down the road at 60 miles per hour." Prompted by these observations he asked, "I wonder if anyone knows about this?" In addition to the deer, elk, and antelope that dominate agency reports, volunteer cyclists have observed birds, snakes, skunks, foxes, racoons, voles, and even spiders.

Herrick says that, even with up to 40 stops on a ride, he can complete 50 miles of road in about four and a half hours; he overnights because he enjoys sleeping out under the stars and exploring a new part of Montana. Eric Noyes, another Bozeman-based volunteer, completes his segment in just an afternoon. He says he uses the time to contemplate the fraught and fractured relationship between people and nature. As a senior advisor for The Nature Conservancy's Indigenous Peoples and Local Communities program, he says he's "trying desperately to stop the collapse of the natural world." Cycling for Adventure Scientists "[is] a way to do something more tangible, collecting data on the ground in a certain place that contributes to an overall effort."

The Adventure Scientists' protocol accommodates these varying kinds of volunteers and styles of data collection, allowing cyclists to select the road they ride from a menu of options and making sure that volunteers can record an observation in just a few minutes. As well, volunteers receive training and safety gear and don't have to be able to identify roadkill species in order to participate.

And yet, these concessions to volunteer experience don't come at the cost of data quality. "There are a number of supporting research papers suggesting that data collected by community science are equal to data collected by experts," says Dr. Jenélle Dowling, scientific director at Adventure Scientists. That is, it can be just as good if the project is designed well.

Dowling says this is the benefit of focusing on data collection, while leaving analysis and implementation to partners. "We are specifically devoted to designing studies really well and carefully, and also managing the volunteers so they have a really good experience," she says. "That's pretty unique." Pearson adds that it is all in service to quality, usable science. "Our end goal is to work with our partners to identify what their need is," he says, "and to identify the direct line next steps from the data collection itself to some form of change, be it

Adventure Scientists

In addition to deer, volunteer cyclists have observed birds, snakes, skunks, voles and even spiders.

Adventure Scientists

Adventure Scientists provides volunteers with safety gear and training. Each observation can be input through an app in minutes.

Zoe Goodwin, Adventure Scientists

Two volunteers pedal through the Shields Valley in Montana. Cyclists choose their route from a list of priority roads.

management decisions or innovations in science."

As such, every observation that volunteers contribute is a result of collaboration between Adventure Scientists and their partners. For example, volunteer cyclists record not only the roadkill with its location, time, and date, but at the request of Montana transportation, also the road conditions, the weather, notable topographic features, and any existing infrastructure. They also record any live animals they pass. "One way that those types of observation can be helpful," says Martin, "is if [the volunteers] were to see a group of antelope congregated at a fence…it could indicate that the fence is acting as a successful barrier."

Volunteers also collect control data, recording all the same observations as their other reports, but at designated intervals rather than at carcass locations. This way, partners can compare the conditions at vehicle-wildlife collision sites to conditions elsewhere on the roads. This could help reveal contextual patterns at collision "hotspots." Roadkill may be concentrated, for example, where waterways get close to the road.

Dowling and her team also consulted quantitative biologists and the existing literature to decide how fast, long, and often their volunteers should ride. Volunteers have to ride during a ten-day reporting window each season and commit ahead of time to riding a section of road from a pre-approved list. Without these parameters, data would tend to clump around convenient or popular areas (spatial bias) during weekends and periods of nice weather (temporal bias). With the parameters, however, the project avoids these two most common pitfalls of citizen science.

As of February 2021, more than 100 volunteers had ridden a total of 6,712 miles of key Montana roads and made 3,368 observations. While the project is too young to draw solid conclusions from, Martin is hopeful that the information produced will help the transportation department improve road safety for people and animals. "It's a new take on wildlife-vehicle collisions, a different way to think about it, a different way to collect data and make it real," says Martin, "Who can't get excited about that?"

In fact, with momentum building around solving the issue of wildlife-vehicle collisions, Adventure Scientists has joined the private, state, and non-profit coalition Montanans for Safe Wildlife Passages. Because the coalition is currently working to coordinate and align science across its member groups, Adventure Scientists has paused its data collection for now, with plans to restart fall of 2021 or spring of 2022. The coalition includes Montana's Department of Transportation and Fish, Wildlife and Parks, as well as the Center for Large Landscape Conservation, with whom Adventure Scientists has already been sharing data.

It's not just about the data, though. Martin lauded the program for "starting a conversation, raising awareness, and building some personal accountability." We can all be part of Vision Zero, he said, if we "slow down, remain attentive and keep our eyes on the road." That's just what the project did for Shoemaker when she surveyed a section of road herself. "It was really enlightening for me to slow down, look around, and catch my breath," she said. "I realized there is all this bustle that I normally fly by in a car. It's given me an appreciation of all the other animals besides me and the impact we have on them."

Herrick, for his part, plans to continue volunteering for Adventure Scientists, saying that he likes exploring new parts of Montana, is happy to be helping out, and enjoys the novelty and detective work involved in the observations. "I saw a turtle near a wetland, and I thought it was probably trying to cross," he says. "It was sad, but neat…a highlight. There's not that many turtles in Montana."

Noyes echoed the sadness that such a project can entail. He said, "My ride was pretty heartbreaking, just to see in 25 miles each way, lots of birds, lots of snakes, lots of different amphibians, elk, and deer. One teeny strip of pavement in Montana full of death." But, he continued, "We can never lose hope. We have to latch on to these little things that each of us can do, collectively, and to stay spiritually strong because there are hard times coming for sure."

Birch Malotky *is a freelance journalist and MFA candidate at the University of Wyoming. She writes at the intersection of science, conservation, and recreation, with a special eye to when they support each other and when they conflict. Follow her @birch_breeze.*

Amphibian CROSSING

Carrying salamanders across roadways helps local populations persist

By Rhiannon Jakopak

On a rainy April night when temperatures peeked just above freezing, around 30 people spread out along a well-traveled street next to a city park in Laramie, Wyoming. Decked in rain gear and a head lamp, Mel Torres, a doctoral candidate at the University of Wyoming, held a large bucket previously used to make homebrew beer in one hand, and a western tiger salamander in the other. Western tiger salamanders might be as long as your hand, or even your forearm, with moist skin ranging from yellow to olive green to black; this one stretched across her palm. She carefully lowered it into the repurposed bucket and transported it across the street. After a damp, chilly evening of running back and forth, the volunteers helped nearly 40 salamanders to safely make the crossing. Without such a "bucket brigade," vehicles might have squished many of these amphibians while they migrated from winter burrows to breeding ponds in the nearby city park.

Roads often chop up habitat that amphibians such as the western tiger salamander need to live out complex life cycles. As migrating amphibians crawl, slither, or hop across roads, drivers can crush amphibians under their tires without realizing it. In a worst-case scenario, vehicle collisions wipe out amphibians in a particular area. When concerned amphibian enthusiasts shuttle salamanders across roads all night long, it certainly benefits each animal that survives the dangerous crossing. In terms of the overall population, volunteer bucket brigades also may have a small, but worthwhile, impact on amphibian conservation.

For western tiger salamanders and many other amphibians around the world, migrating is critical to their life cycles. Each spring, salamanders move from underground burrows that shield them from winter's chill to nearby ponds, where they breed and lay their eggs in the water. Over the summer, larvae—young salamanders that have gills—live in the vegetation along the pond's edge. As grasses change from green to brown later in the summer, some salamanders will stay in the pond, while others metamorphose into adults and venture onto land, eventually migrating back to the safety of their winter burrows.

Climate change, the widespread chytrid fungus, and a suite of other factors are causing rapid declines to amphibians around the world; road mortalities just add to this bleak picture. When scientists compared how roads affect different types of species, they found that amphibians are particularly vulnerable. Depending on the species and the ecosystem, roads can fragment habitat, reduce species diversity, and even change behaviors such as the rate and type of breeding calls. On top of that, vehicles can kill a staggering 40–100 percent of migrating salamanders in some places. Bucket brigades, like Mel and the rest of the Laramie team, try to mitigate this direct threat to amphibian populations.

Christine Porter, iNaturalist

Jimena Golcher-Benavides, iNaturalist

A batch of salamanders await their ride to the breeding pond in a plastic bucket (left), fortunate to avoid the fate that meets many salamanders on the street (above).

Jimena Golcher-Benavides, iNaturalist

A western tiger salamander scoots across the asphalt (above), and a volunteer holds up a another with a gloved hand before lowering it into a bucket (right). All photos from Laramie, Wyoming.

Mel chuckles, noting that salamanders do not appreciate being picked up, but her technique of a "gentle but firm hand" allows her and the other volunteers to help salamanders make it safely to the pond. When the first rainy night in spring cues salamanders to start migrating, many adults move to the breeding pond at once. The predictable, mass migration makes it easy for volunteers to know when to grab their buckets and headlamps and where to focus their help. In the fall, however, salamanders return to their winter homes in a less concentrated and predictable way, which makes it much harder for volunteers to help them back across the roads. Volunteer efforts can be most beneficial if they help salamanders get both to their breeding ponds as well as back to their winter burrows after breeding; the return to their winter burrows is the tricky part.

Researchers and conservationists have explored other solutions that might appear better than these volunteer efforts for protecting migrating amphibians. For example, drift fences direct migrating amphibians toward culverts under roads, allowing them to cross unscathed. But even in a small area, amphibians need multiple opportunities to cross. The sites where amphibians migrate are all different, requiring site-specific research to inform crossing structure installation, and these expenses add up quickly. Without one obvious solution, reducing the damage that roads cause to amphibians might rely on using multiple techniques at once, including volunteer events, permanent migration crossing structures, and other efforts.

Meanwhile, there is some evidence that efforts like those in Laramie can help both individual salamanders and their populations. Researchers in one study simulated how much different types of volunteer efforts benefitted salamanders. In over 300 potential scenarios, almost every situation with volunteers helped salamander populations. In other words, nearly any volunteer effort is beneficial for the survival of a single salamander, as well as for conserving salamanders in an area. And volunteer efforts can provide valuable information, such as helping researchers identify what conditions prompt migration, observing when a species is declining, and informing where to target efforts such as crossing structures.

Amphibians live in a world increasingly crisscrossed by roads, and these roads are formidable obstacles on the paths between their winter burrows and summer breeding ponds. Volunteer efforts alone won't save salamanders, but they are one tool in the conservation toolkit. Reflecting on her time spent shuttling migrating western tiger salamanders across busy Laramie roads, Mel notes, "Anything is better than nothing to just help increase their survival."

Amphibians live in a world increasingly crisscrossed by roads, and these roads are formidable obstacles on the paths between their winter burrows and summer breeding ponds.

Rhiannon Jakopak *is a research scientist with the Haub School of Environment and Natural Resources at the University of Wyoming.*

FURTHER READING

Sterrett et al. 2019. The contribution of road-based citizen science to the conservation of pond-breeding amphibians. *Journal of Applied Ecology* 56:988-995.

Beebee. 2013. Effects of road mortality and mitigation measures on amphibian populations. *Conservation Biology* 27:657-668.

Mason Lee, iNaturalist

Crouching Scientist, Hidden Dragonfly

A researcher's quest to protect an endangered dragonfly

By Amber Furness

I stand on a large, cement bridge on Interstate 355 over the Des Plaines River Valley in northern Illinois. Waves of air blow over me as vehicles whiz by. Then I see them—the iridescent green eyes—an endangered Hine's emerald dragonfly flies towards me and then turns back, its wings shimmering in the morning sun.

This was one of a multitude of observations I made of dragonflies over the course of three summers as a graduate student seeking to understand the influence of roadway construction and vehicle speed on the behavior, mortality, and conservation of adult dragonflies, especially the Hine's emerald. I undertook three research projects to explore strategies for mitigating vehicle collisions for this endangered species. Numerous studies have looked into the negative impacts of roadways on wildlife, but the majority focus on vertebrates, especially mammals. Invertebrates make up a large percentage of road-killed wildlife; however, little is understood about these deaths, and still less is being done to mitigate them.

My goal was to better understand road impacts to dragonflies and the relationship between vehicle speed and mortality to produce findings that could guide conservationists and highway managers. Invertebrate mortalities tend to be ignored, but that doesn't mean that understanding them is any less important to the road ecology narrative.

I was already interested in threatened and endangered species recovery when I learned of the opportunity to earn a master of science in biology while researching an endangered dragonfly. The Hine's emerald is medium-sized—about 2.5 inches long with a wingspan up to about 3.3 inches—and has emerald-green eyes, a metallic-green body, and cream-yellow stripes on its thorax. It lives in spring-fed wetlands and sedge meadows overlaying dolomitic bedrock in Illinois, Wisconsin, Michigan, and Missouri. Habitat degradation and loss is the primary threat to this species that historically lived in Alabama, Indiana, and Ohio as well. Its larval habitat is incredibly difficult, if not impossible, to re-create. Thus, it has been a priority to focus on other ways to protect the species, including from the influences of roadways. This led to my projects researching how the Hine's emerald dragonfly responds to bridge construction, vehicle speeds, and diversion netting to help conserve this rare species.

To investigate how bridge construction influences dragonfly flight behavior, I spent the summers of 2011–13 observing dragonflies on and below the I-355 bridge in northern Illinois. My research lab initiated the study before the bridge's construction began in 2006 and followed it through 2007 as the bridge was completed and then for six more years after the bridge opened. This 1.3-mile long, six-lane bridge was designed with 80 feet of clearance below the

A Hines emerald dragonfly clings to a plant.

KaeCsImages, Shutterstock

deck to minimize its impact on wetland areas it passes over which includes Hine's emerald dragonfly habitat. The idea was that with such high clearance, the adult Hine's emerald would surely fly under, rather than over the bridge, thereby avoiding interaction with traffic altogether. My goal was to put all the data together to evaluate whether or not the bridge was hindering movement of Hine's emeralds.

Standing under the bridge and on the bridge deck (with one lane closed), lab members recorded when approaching dragonflies flew under, over, or away from the bridge. We found that the Hine's emerald dragonfly initiated crossing significantly more often prior to the completion of the bridge than when the bridge was nearly complete in 2007 and for the six years of the study that the bridge carried traffic. This indicates that the bridge impedes movement of the species despite its height. In 2013, the last year of the study, of all dragonflies observed, 91 percent never attempted to cross the bridge. Of those that did, nearly all flew over rather than under the bridge, putting them at risk of colliding with vehicles.

To determine how vehicle speed influences roadway mortality of dragonflies, we developed a study on roads in Door County, Wisconsin, during the late spring and summer of 2012 and 2013. We mounted GoPro cameras to the top of a truck, and I watched for dragonflies from the passenger seat while a driver drove 15, 25, 35, 45, and 55 miles per hour, mostly on a road known to pass through and along Hine's emerald and other dragonfly habitat. When we encountered a dragonfly, I recorded the type of dragonfly, its flight height, and its fate. I relied on the many hours I'd spent observing dragonflies in flight to identify them, making judgements based on silhouette, size, color, wing markings, and flight pattern. When I wasn't confident in my identification, I watched the videos captured by the GoPro cameras to assist me. On the occasion when we hit a dragonfly (17 times), we stopped to retrieve it and verify its identification.

We did this for almost 1,500 miles over two flight seasons. In all, we encountered 262 dragonflies from 15 species. Of the 262 encounters, at least 83 were Hine's emeralds or other species in the same genus as the Hine's (*Somatochlora*). I discovered that straight-fliers, including the Hine's emerald, are more vulnerable to dragonfly-vehicle collisions than those that fly in zig-zag/bobbing patterns. Additionally, simply reducing vehicle speed from 55 to 45 miles per hour lowered the probability that a dragonfly of any species would be hit from 28 percent to 11 percent. For species belonging to *Somatochlora*—like the Hine's emerald dragonfly—the probability of being hit drops staggeringly from 65 percent down to 27 percent.

As we thought about other methods to decrease the number of dragonfly carcasses along the roads, we wondered whether or not we could use netting to divert the insects from the road or force them to fly above traffic. A partner and I set up 3-meter-high diversion netting along the edges of two simulated roads, one 6 meters wide and one 12 meters wide, and then observed Hine's emerald dragonfly flight heights and reactions to the netting. I wanted to know whether the Hine's emerald would fly above the nets at either spacing, whether they would dip lower over the simulated road, or whether they would turn away from the nets, which would keep them out of traffic but also prevent them from moving between habitat patches. We found that the netting caused Hine's emeralds to fly higher than when no nets were present, especially when the nets were only 6 meters apart. It also deterred some Hine's emeralds from crossing the "road" at all.

Because this was the first look at this idea, more work needs to be done before this method could be implemented. Results do suggest that this, or similar options, might be worth exploring further to keep dragonflies away from vehicles.

Good science is crucial to helping us better understand the often-ignored impacts we have on other species. Even

Dan Soluk

Author Amber Furness holds a handful of road-killed dragonflies.

though these studies focused on a few specific areas in the Midwest and the dragonfly species found there, the findings and the methods we developed could have implications for mitigating the impacts of roads to dragonflies—and perhaps other invertebrates—in other parts of the United States and the world. At that time, two of these studies were the only of their kind, and the bridge study was only the second to document the effects of a bridge on insect flight behavior.

We learned that building a super high bridge makes no difference, that erecting roadside netting might be a lower cost solution, and that slowing down by 10 miles per hour could have the greatest impact, probably at the lowest cost. Discovering the relationship between vehicle speed and the likelihood of a dragonfly-vehicle collision has power because it tells us what we can do. Conservation and highway managers could actually put this new understanding into practice and reduce one threat to an endangered species.

Amber Furness *is a realty specialist with the US Fish and Wildlife Service in Lakewood, Colorado. She completed her master's degree in 2014. Visit fws.gov/midwest/endangered/insects/hed and usdbiology.com/soluk to learn more about the Hine's emerald dragonfly and other research by the Soluk lab.*

The findings and conclusions in this article are those of the author and do not represent the official views of the US Fish and Wildlife Service.

ROAD

Traffic sounds disturb wildlife

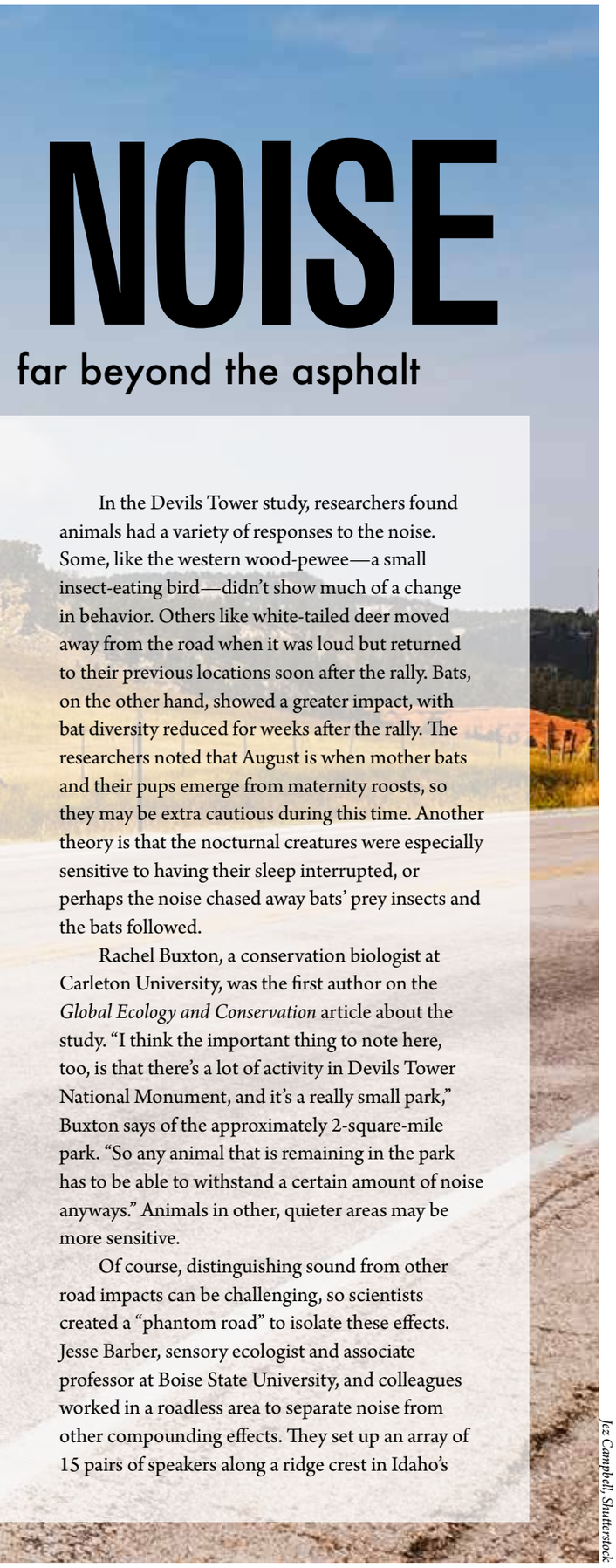
Kristen Pope

Leather-clad motorcyclists cruised around Devils Tower National Monument in August 2015, eager to spot wildlife, breathe fresh air, and take in views of the towering monolith. While the riders were enjoying their public lands, scientists wanted to learn how noise from motorcycles was impacting local wildlife during the Sturgis Motorcycle Rally's 75th anniversary. Researchers placed acoustic recorders in the park to monitor the impact of the "Devils Tower Run" August 5 event as well as the increased motorcycle traffic surrounding it. By placing recorders near the road as well as along a gravel road motorcycles couldn't access, they established study and control sites to monitor bird and bat vocalizations. Camera traps and visual observations also recorded how other animals reacted to the increased noise levels.

Noise isn't just annoying to animals—it disrupts some of their vital life functions. Chronic noise can make it difficult for animals to hear the cues they need for finding food, avoiding predators, communicating, and mating. Sudden, jarring noise can be perceived as a threat and cause animals to react by hiding, fleeing, or spending more time and energy on being vigilant rather than things like finding food. Especially loud noises can cause severe issues like hearing loss, but even if a species isn't directly impacted by noise—or when the noise is outside a species' hearing range—it can be affected indirectly, such as when a prey or predator species is impacted. Noise is considered a pollutant, and this is why researchers throughout the world are studying the impact roadway sounds have on ecosystems and wildlife.

NOISE

far beyond the asphalt



Jez Campbell, Shutterstock

In the Devils Tower study, researchers found animals had a variety of responses to the noise. Some, like the western wood-pewee—a small insect-eating bird—didn't show much of a change in behavior. Others like white-tailed deer moved away from the road when it was loud but returned to their previous locations soon after the rally. Bats, on the other hand, showed a greater impact, with bat diversity reduced for weeks after the rally. The researchers noted that August is when mother bats and their pups emerge from maternity roosts, so they may be extra cautious during this time. Another theory is that the nocturnal creatures were especially sensitive to having their sleep interrupted, or perhaps the noise chased away bats' prey insects and the bats followed.

Rachel Buxton, a conservation biologist at Carleton University, was the first author on the *Global Ecology and Conservation* article about the study. "I think the important thing to note here, too, is that there's a lot of activity in Devils Tower National Monument, and it's a really small park," Buxton says of the approximately 2-square-mile park. "So any animal that is remaining in the park has to be able to withstand a certain amount of noise anyways." Animals in other, quieter areas may be more sensitive.

Of course, distinguishing sound from other road impacts can be challenging, so scientists created a "phantom road" to isolate these effects. Jesse Barber, sensory ecologist and associate professor at Boise State University, and colleagues worked in a roadless area to separate noise from other compounding effects. They set up an array of 15 pairs of speakers along a ridge crest in Idaho's Boise Foothills, playing traffic recordings from a 45-mile-per-hour zone in Glacier National Park. For four days, they would gradually turn on the noise starting at 4:30 a.m. and gradually decrease the noise at the end of the day, turning the speakers off at 9 p.m. to mimic traffic cycles. Then, after four days of playing traffic sounds, they would silence the speakers for four days, before repeating the cycle.

The experiment was set during the fall bird migration, when almost all species stay in the area for fewer than eight days, allowing a new group of birds to be part of each experimental cycle. The Intermountain Bird Observatory has studied bird migration patterns in the area for over 20 years, so Barber knew birds' typical patterns. Fall migration is a crucial time for the birds, when they must rest and conserve their energy for finding food and being vigilant.

"The cool thing about working in migration is that the birds are coming to you," Barber says. "They're passing through the site in waves."

The researchers found a 31 percent decline in bird abundance when the speakers were on, with some species almost completely avoiding the experimental area. To further study the influence of noise, the scientists captured and examined birds, finding 5 of the 21 species surveyed had "significantly decreased body condition index" when they were in the group of birds exposed to the noise, as reported in a *PNAS* article. They "were largely unable to gain weight, like a migratory bird should be able to do," Barber says. "That's their only job—to pack on fat and evade predators."

While Barber emphasizes they don't know for sure, he says, "the effects that we found are really similar to what we see around real roads. That doesn't necessarily mean that noise is the only thing causing trouble from roads, but it's convincing experimental evidence that noise is a significant part of road ecology effects."

Noise can also affect mating, as experiments have shown for some birds like ovenbirds and reed buntings. A 2013 literature review in *Frontiers in Ecology*, which Barber co-authored, noted that while ovenbirds don't seem to leave when it's noisy, "males defending noisy territories are less successful in attracting mates," according to Habib et al, 2007. Reed buntings also have less success finding mates in noisy areas.

When more vigilant animals choose to leave an area to avoid noise, they leave the remaining animals—as well as themselves—more vulnerable since there is strength in groups. Further, when more risk-averse animals remove themselves, this could impact genetic diversity.

As scientists examine the impacts sound has on wildlife and ecology, they are also working to find solutions. Lower speed limits, instituting shuttle services in busy national parks, building berms along roadsides, and even a form of porous "quiet pavement" that absorbs traffic noise, could help. However, each option has limitations and trade-offs, from reducing habitat connectivity, to softer road surfaces requiring more frequent replacement. Barber points out it's easier to solve the dilemma of road noise by avoiding building unnecessary roads in the first place.

"Mitigating noise pollution from roads is not impossible, but it's complicated, and I think that not building new roads is the number one conservation action," Barber says.

While scientists seek answers to reduce noise, they also point to the amazing natural soundscape found in nature and urge people to fully appreciate it.

"Noise pollution is really negative but natural sounds are really quite amazing, and I think they're often underappreciated," Buxton says. "When you go to your local park or to a national park, natural sounds are just such an integral part of your experience. You think about the Grand Canyon and the beautiful expanse of the canyon but also you're hearing the wind blowing through canyon, the sounds of the river, the sounds of wind going through the trees and birds singing, and that's all part of your experience in a park and those are all natural resources that are really important…I really think that they're deserving of our protection."

***Kristen Pope** is a freelance writer and editor.*

Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming

REPAIRING A FRAGMENTED LANDSCAPE

Interstate 80 severed wildlife habitats 50 years ago. Can we reconnect them?

By Gregory Nickerson

When I drove across Wyoming's stretch of Interstate 80 to film a wildlife documentary in fall 2019, I saw animals confronting the highway barrier again and again. At Dana Ridge in southeast Wyoming, I saw pronghorn making heavily tracked trails through snow. Constrained by fences and traffic, their hoofprints paralleled the interstate just outside the right-of-way fences for many miles. Near Sinclair, 18 miles further west, I saw carcasses where pronghorn

Mule deer move along an eight-foot-tall game fence built to keep wildlife off of Interstate 80.

had somehow made it through the interstate fence, only to collide with the traffic.

West of Little America, 150 miles farther on, I met Wyoming Game and Fish Department biologist supervisor Mark Zornes, who showed me the spot where one semi truck killed 25 pronghorn in 2017. The animals were trying to move south to better winter range near Flaming Gorge but got trapped and run over on a foggy morning. At the Leroy exit near the Utah border, I saw mule deer tracks going through an underpass that the Wyoming Department of Transportation (WYDOT) had retrofitted for wildlife.

Thanks to GPS research, I can now fit all these wildlife anecdotes into the big picture of southern Wyoming's landscape, where 400 miles of I-80 chop up habitat and obstruct movements that animals depend on for their survival.

When the last major segment of I-80 in Wyoming officially opened for traffic more than fifty years ago on October 3, 1970, it bisected movement corridors for tens of thousands of big game animals. After eons of free-roaming life for these migratory herds, we'd plunked down a railroad, fences, and a superhighway through the middle of their home turf.

For wildlife, I-80 is something like a Great Wall of China across the desert basins of southern Wyoming. The traffic volume of 5,000 to 13,000 vehicles per day makes the interstate virtually impenetrable to wildlife. On top of that, sections of the interstate are lined with eight-foot-tall exclusion fences to prevent wildlife-vehicle collisions. The barrier bisects many otherwise functional migration corridors, cutting off access to vast seasonal ranges and potential habitat, and limiting animals' options to survive winter storms and summer droughts.

Worldwide, human development and roads are pressing in and slicing across the habitats of migratory ungulates (hooved mammals). These ecological changes ultimately threaten migratory behavior and the survival of entire populations. One doesn't have to look far, just to the Front Range of Colorado or the Wasatch Front in Utah, to see just how completely migration can be curtailed. These urbanized Rocky Mountain landscapes stand in contrast to Wyoming, where the naive first-time driver on I-80 may tell you there is *nothing* out there. Look closer though, and all that openness is punctuated with towns, the Union Pacific railroad, livestock fences, irrigated fields, subdivided private property, oil and gas wells, coal and trona mines, power plants, transmission lines, windmills, and solar farms. It's a working landscape, busier than it has ever been.

And yet, moving through it all is still-abundant wildlife—likely more than you will see *anywhere* on I-80 from New York to San Francisco. Amid the islands of development in southern Wyoming, animals roam over wide swaths of relatively intact habitat. Places like the Great Divide Basin, which I-80 crosses in south-central Wyoming, are not so badly degraded that they can't be returned to greater function.

In the last 50 years, scientists tracking wildlife have moved from radio collars to sophisticated GPS mapping, revealing that the most severe fragmentation is due to the single, solvable barrier of I-80. Wyoming biologists and engineers generally agree that the time has come to address this problem and find new solutions for connectivity on I-80. The revolution in wildlife movement science is creating a vision for a reconnected landscape, one that bucks the global trend of habitat fragmentation, and restores free wildlife movement on a grand scale.

CURTAILED MOVEMENT

Construction of I-80 in Wyoming began in 1959, with much of the Red Desert segment from Rock Springs to Rawlins completed by October 1963.

Signs of trouble for wildlife were already evident. As early as 1965, while construction was still ongoing, Wyoming Game and Fish Department biologist Bill Hepworth expressed concerns that I-80 and Interstate 25 would hamper pronghorn movements, because they generally do not jump over right-of-way fences like deer or elk. "Curtailed movement of some herds appears critical," Hepworth wrote. By 1967, biologist Darwin Creek had assessed that I-80 traffic and fences had virtually stopped north and south movements of pronghorn in sections where the road was completed.

The new I-80 barrier combined with grazing allotment fences to create fatal consequences for migratory animals. In October 1971, a devastating blizzard roared across the interstate west of Rawlins, dropping 18 inches of snow. Huge numbers of pronghorn looking for areas with less snow succumbed to exhaustion at woven-wire fences and along I-80. Many were scavenged by coyotes, or completely buried by snow, such that biologists Phil Riddle and Chuck Oakley couldn't make an accurate survey of the losses until the spring. Later aerial counts estimated that 3,111 pronghorn, or

more than 60 percent of the Chain of Lakes population near Rawlins, had perished. While these deaths didn't all happen along the interstate fence, they indicated a larger problem of lost connectivity for southern Wyoming pronghorn that rely on movement. Quite simply, when animals could no longer move freely to escape harsh conditions, they died.

At the request of the Wyoming Game and Fish Department, WYDOT built the Elk Mountain to Walcott Junction segment of I-80 with a number of underpasses for deer. On the western slope of Dana Ridge, workers built three box culverts and two machinery underpasses, but deer were very reluctant to use them. By 1976, six years after opening to traffic, some 725 animals had been killed on the 80 miles between Laramie and Walcott. The tally included 561 mule deer, 153 pronghorn, and 10 elk. The situation was bad enough that the Wyoming Game and Fish Department and WYDOT used funding from the Federal Highway Administration to solicit a study on how to reduce the mortalities and risks to motorists.

Lorin Ward at the US Forest Service Rocky Mountain Forest and Range Experiment Station led the research. In the winter of 1977-78, Ward tasked biologist Hank Henry with living in a trailer on the side of I-80 at the summit of Dana Ridge. It's a spot where about 900 mule deer migrated through every spring and fall, some going as far as 50 miles from the Snowy Range to the Haystack Mountains along the Platte River.

Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming

A trail camera catches mule deer jumping over a woven-wire gate in front of a machinery underpass that crosses below I-80 near Dana Ridge.

Henry was faced with the impossible task of trying to keep deer from doing an end-run around an eight-foot-tall exclusion fence designed to keep animals from getting hit on the highway. It was a long, lonely season, and sometimes he'd use roman candle firecrackers to scare deer away from the road. But the animals' urge to migrate was too strong. Some mornings he'd wake up to find holes in the fence where deer had squeezed through. Other times the pavement was covered with a mix of glare ice and blood where deer had met their end.

Ward and his team eventually settled on extending the exclusion fencing to better keep animals off the highway, and direct them toward the underpasses. Within a few seasons, deer encouraged by fencing and apples as bait had learned to use the crossing structures, allowing nearly 1,000 safe deer crossings per year, and a 90 percent reduction in mortalities at that location.

While pronghorn could not access the underpasses due to fences, and elk corridors were located elsewhere, about 400 deer still use these structures today. This was a major success story for deer, one that was repeated with underpasses at the "Sisters" area west of Fort Bridger. Yet, these were some of only a few wildlife crossing structures built in the state, and they only helped one species in a few specific areas.

Ward offered no suggested solution for pronghorn or elk crossings on I-80. "Since antelope are reluctant to jump fences and use underpasses, I-80 is a barrier and the herds are managed accordingly," Ward wrote. "Since elk are large, they present a greater hazard to motorists, and should be discouraged from crossing highways by proper fencing and road location."

Reading this statement today, it seems that for Ward the primary motivations behind the Dana Ridge crossing structures were preventing wildlife mortalities and reducing risks to motorists. If pronghorn and elk didn't cross the interstate, and deer could cross safely using underpasses, then the safety issue was largely resolved for WYDOT and the Federal Highway Administration.

On the flip side, Ward seemed to imply that the wildlife connectivity problem was one for wildlife managers and biologists, who would have to accept the I-80 barrier as they pursued more wildlife tracking research. It remained difficult to assess the full scale of movements for the different species across 400 miles of highway, and how they had been curtailed. Biologists had only limited technology to understand or address the problem and wouldn't get a more complete picture for several decades.

Biologists improvised tracking methods in creative ways, hoping to learn movement patterns and locations of summer and winter ranges that were affected by the interstate. Lorin Ward's team placed blaze orange collars on three deer in hopes of spotting them later in a different spot, but the effort only defined the winter range for a single animal.

Hepworth tried to mark pronghorn with ear tags, or with Nyanzol D black dye applied from an

A trail camera shows pronghorn looking toward a machinery underpass below I-80, but not attempting to cross the fence that blocks the opening.

aircraft. He hoped for the development of a long-lasting fluorescent green or red dye that would be more visible. In lieu of that, Hepworth was sometimes able to document large movements by spotting a pronghorn buck with atypical horns in two distant places, but he wanted better methods. "A satisfactory means of marking large numbers of animals, preferably on an individual group or individual animal basis, is a must to aid in the study of migration and movement," he wrote in 1965.

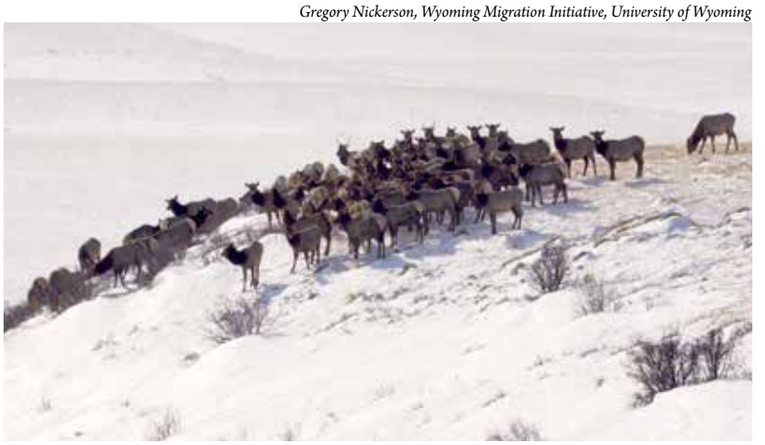
Connectivity was also on his mind. "The effects of various barriers to antelope movement, particularly barriers to the critical movement to winter or summer range and water, are of primary concern at present.… Much work needs to be done to find fences and/or devices to allow movement," Hepworth wrote, but, he lamented, "investigations into the basic ecology of antelope are still lacking."

Wildlife managers knew there was more to the story, but they would need better tools to fill in the picture of how much I-80 was altering wildlife movements. It would take half a century for the technology to catch up and make answers to these questions come into focus.

THE GPS REVOLUTION

When the long-desired animal-tracking revolution arrived, it brought many surprises about where migratory ungulates go, and how they interact with barriers.

Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming



Elk maneuver through snow just south of I-80 near Elk Mountain, possibly searching for a way to cross the interstate to the north and lower elevations.

On November 12, 2013, biologist Adele Reinking's team collared pronghorn Yellow-13 on the west side of US 789, 11 miles south of I-80. When Reinking later mapped the data on her computer, the thousands of GPS fixes of Yellow-13's movement were all arranged into a mysteriously precise rectangle with an area of less than six square miles.

Zooming in, Reinking realized that the day after the pronghorn was collared, it had made its way into a grazing enclosure in a natural gas extraction area. Yellow-13 remained inside that same fenced area for 16 months, until April 7, 2015, at which point she escaped confinement, only to die of unknown causes at the end of September.

"So, most of the last two years of her life were spent in a very small, highly-developed area that she was likely not able to leave because of fencing," Reinking said. For a species that can run 50 miles per hour and range over hundreds of miles, one can only imagine the feeling of being trapped in a wire cage under open Wyoming skies.

The seeds of the GPS revolution had been planted decades earlier, at about the same time I-80 was completed across Wyoming. NASA first experimented with a satellite tracking collar on a Jackson Hole elk named Monique early in 1970. The technology was cumbersome and prone to malfunction, but it was the start of Wyoming's role in an animal tracking revolution.

Later, very high frequency (VHF) radio telemetry collars became the standard wildlife tracking technology used by biologists, though they required laborious triangulation fieldwork and often revealed just a handful of data points. Even so, radio tracking yielded dense information about winter ranges where animals spent a lot of time, and informed a major push to conserve those ranges for big game herds during the 1980s and '90s.

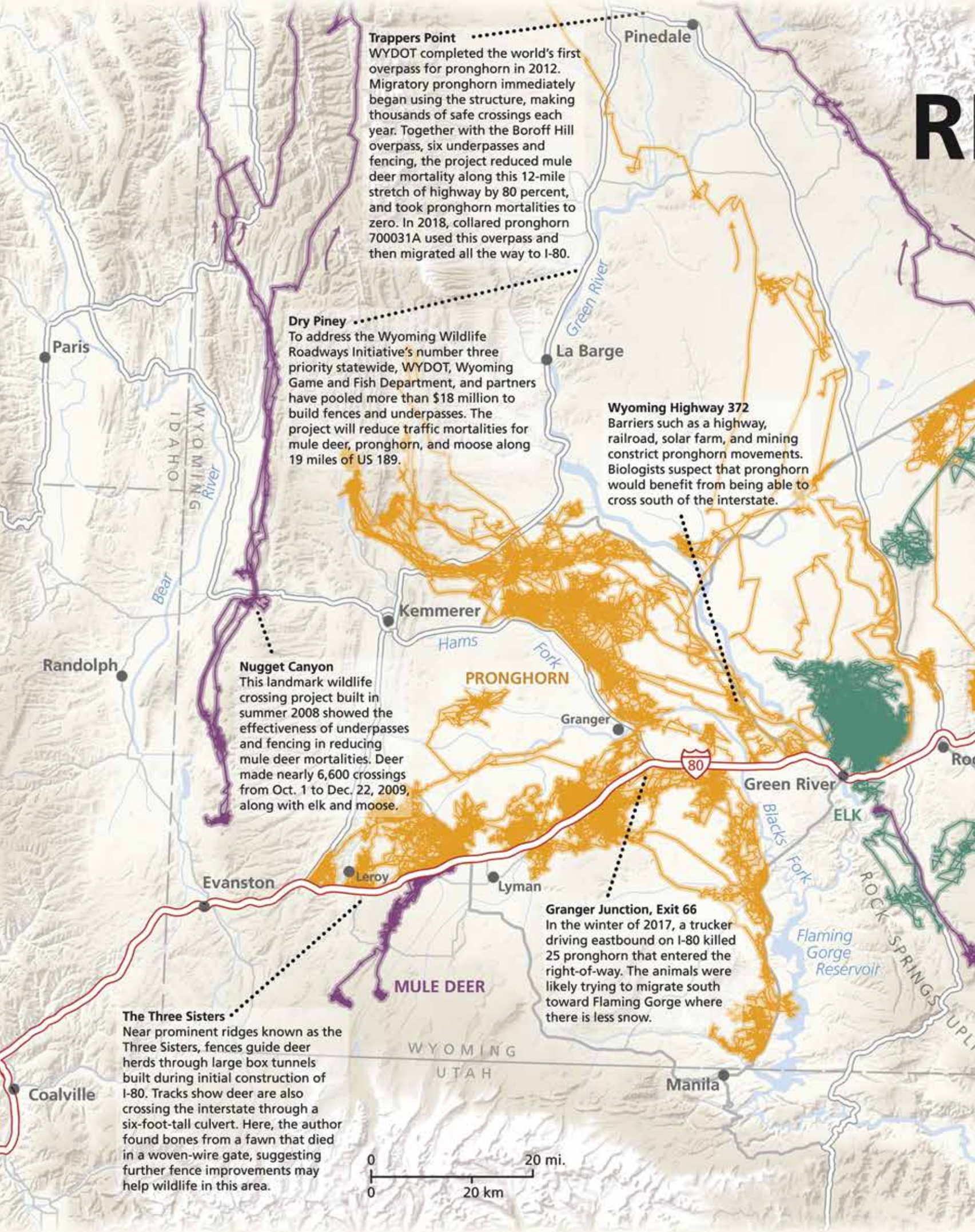
By the early 2000s, satellite monitoring of wildlife became much more accessible to biologists due to the development of GPS collars with a year or more of battery life. The initial iteration was "store on board" GPS collars that weighed very little and held the satellite antenna and storage chip in compact boxes worn around an animal's neck.

These devices communicated with satellites to pinpoint locations at programmed intervals and kept the data on the internal chip. After a year or two, a release mechanism activated and dropped the collar to the ground. The biologist then retrieved the collar from the field and downloaded the data.

Despite the inconvenient delay in accessing data, store-on-board collars represented a major technological leap forward, and they ignited a rapid advancement of migration science in Wyoming. The patchwork of radio telemetry data gave way to a clear picture showing how animals move 24 hours a day, through all four seasons and multiple years.

Fast forward to 2020, and GPS collars have advanced further to real-time collars linked to remote computers via the Iridium satellite network. Such devices can log locations every few hours for two to

Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming


Trappers Point
WYDOT completed the world's first overpass for pronghorn in 2012. Migratory pronghorn immediately began using the structure, making thousands of safe crossings each year. Together with the Boroff Hill overpass, six underpasses and fencing, the project reduced mule deer mortality along this 12-mile stretch of highway by 80 percent, and took pronghorn mortalities to zero. In 2018, collared pronghorn 700031A used this overpass and then migrated all the way to I-80.
Dry Piney
To address the Wyoming Wildlife Roadways Initiative's number three priority statewide, WYDOT, Wyoming Game and Fish Department, and partners have pooled more than $18 million to build fences and underpasses. The project will reduce traffic mortalities for mule deer, pronghorn, and moose along 19 miles of US 189.
Wyoming Highway 372
Barriers such as a highway, railroad, solar farm, and mining constrict pronghorn movements. Biologists suspect that pronghorn would benefit from being able to cross south of the interstate.
Nugget Canyon
This landmark wildlife crossing project built in summer 2008 showed the effectiveness of underpasses and fencing in reducing mule deer mortalities. Deer made nearly 6,600 crossings from Oct. 1 to Dec. 22, 2009, along with elk and moose.
Granger Junction, Exit 66
In the winter of 2017, a trucker driving eastbound on I-80 killed 25 pronghorn that entered the right-of-way. The animals were likely trying to migrate south toward Flaming Gorge where there is less snow.
The Three Sisters
Near prominent ridges known as the Three Sisters, fences guide deer herds through large box tunnels built during initial construction of I-80. Tracks show deer are also crossing the interstate through a six-foot-tall culvert. Here, the author found bones from a fawn that died in a woven-wire gate, suggesting further fence improvements may help wildlife in this area.
Pinedale
La Barge
Green River
Paris
WYOMING
IDAHO
Bear River
Kemmerer
Hams Fork
Randolph
PRONGHORN
Granger
80
Green River
ELK
Blacks Fork
Evanston
Leroy
Lyman
MULE DEER
Flaming Gorge Reservoir
ROCK SPRINGS UPL
WYOMING
UTAH
Manila
Coalville
0
20 mi.
0
20 km

ECONNECTING A VAST LANDSCAPE

GPS tracking collar data reveals how Interstate-80 disrupts migratory big game movements in Wyoming. New wildlife crossing structures could reconnect habitats that have been severed for 50 years.

Lander
Casper
Douglas
Wheatland
Sweetwater River
Pathfinder Reservoir
North Platte
Seminoe Reservoir
Laramie River
Hanna
Medicine Bow
Rock River
Arlington
Rawlins
Fort Steele
Walcott
Creston Junction
Wamsutter
Table Rock
Tipton
Point of Rocks
Superior
Elk Mountain
Laramie
Cheyenne
Baggs
PRONGHORN
ELK
MULE DEER
MOOSE
RED DESERT
GREAT DIVIDE BASIN
KINNEY RIM
SIERRA MADRE
MEDICINE BOW MOUNTAINS
WYOMING
COLORADO
80
25

Dana Ridge
When the interstate was completed in 1970, this migration thoroughfare became a hotspot for collisions with mule deer. In the late 1970s, workers added fences to funnel deer through a machinery underpass and tunnels. Deer, such as the GPS-collared animal shown here, still cross I-80 using these structures, but elk and pronghorn do not.

Dunlap Ranch
In the harsh winter of 2010-11, many pronghorn migrating west to Seminoe Reservoir died, while a similar population south of Interstate 80 survived in greater numbers.

Interstate 25
This highway is a known barrier to mule deer and pronghorn along the Laramie Range, Casper Mountain, and the Bighorn Mountains. Research and mitigation efforts are underway, especially between Kaycee and Buffalo beyond the north edge of this map.

Halleck Ridge
This is the Wyoming Wildlife Roadways Initiative's highest-priority location on I-80. In 2020, WYDOT and Wyoming Game and Fish Department began assessing improvements to existing underpasses and fences, along with new crossing structure options.

Wamsutter
Few pronghorn have ever been observed to cross I-80. Biologist Adele Reinking collared pronghorn Orange 25 some 50 miles south of the interstate near Baggs. Later, she spotted the same animal on the north side at Love's truck stop in Wamsutter, though the collar battery died and the data was never retrieved.

Southeast Wyoming
Research in the 1970s tracked deer and elk responses to the interstate from the Laramie Range to Dana Ridge. One study showed that elk heart rates increased when they approached I-80. Only minimal recent wildlife movement data is available from the Colorado and Nebraska borders to west of Laramie.

Point of Rocks
Mule deer run up against I-80 after migrating 150 miles from the Hoback Basin to the Red Desert, and crossing two highways and more than 100 fences. Biologists wonder how far these deer might continue if I-80 didn't stop them.

Table Rock
GPS data shows pronghorn obstructed on both sides of the interstate. A wildlife crossing structure here could enable long-distance animal movements. Biologist Ben Robb tracked a Table Rock pronghorn 100 miles south to near Sunbeam, Colorado across the state line.

Baggs
In summer 2009, WYDOT and Wyoming Game and Fish Department installed a wildlife underpass on US 789 six miles north of Baggs. Cameras recorded an impressive 5,700 crossings by migrating mule deer from Sept. 1 through Dec. 21, 2010. Elk also use this structure.

To Sunbeam, Colorado

Cartography by University of Oregon InfoGraphics Lab, derived from *Wild Migrations: Atlas of Wyoming's Ungulates*, Oregon State University Press © 2018 University of Wyoming and University of Oregon. Additions and captions by Gregory Nickerson, Wyoming Migration Initiative. Map created May 2021.

Leon Schatz and Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming

Interstate 80 bisects wildlife habitat for 400 miles across Wyoming.

three years, feeding a constant stream of information to researchers in the office.

Biologists coupled this wealth of data with computerized statistical methods to open up vast new analytical avenues and questions. In recent years, biologists have produced landmark studies on the outsized nutritional contributions of stopover habitat, and shown how migration dynamics are a complicated dance with springtime snowmelt and the greenup of plants. Such discoveries have enabled a shift from a focus on protecting just winter range or summer range to a holistic approach that includes both seasonal habitats and the migration corridors in between.

"With the advent of GPS, it has shown a much finer scale of habitat use and movement by animals than was available when using the older style of VHF," said Scott Gamo, environmental services manager for WYDOT. "The technology had to catch up to ideas and show if they were wrong or right or different."

In the last ten years, the data trove has revealed that I-80 is a nearly complete barrier to wildlife movement. Scientists have now created maps for virtually the entire length of the highway in Wyoming, showing animal movement patterns like tangles of spaghetti balled up along the right-of-way fences.

The stories coming out of the data allowed scientists and managers to dig into the specifics of how I-80 impacts wildlife habitat across southern Wyoming.

BROKEN HABITATS

For Hall Sawyer, a biologist with Western EcoSystems Technology, Inc. (WEST), the power of mapping revealed the I-80 barrier early in his study of the 150-mile-long Red Desert to Hoback Migration Corridor. The data showed how in the severe winter of 2010-11, mule deer pushed south as they sought relief from heavy snows, only to pile up along the interstate near Point of Rocks. They were cut off from potentially better habitat beyond I-80, where there is often reduced snowfall.

That same winter, a similar movement to avoid snow played out further east at Dunlap Ranch near Shirley Basin. In early 2011, graduate student Katie Taylor tracked 27 collared pronghorn to evaluate the effect of wind energy development on pronghorn habitat use. As the particularly harsh winter set in, 13 of the Shirley Basin pronghorn made a notable movement west toward Seminoe Reservoir, likely seeking relief from deep snow. All 13 animals died throughout the relatively poor desert scrub habitat several miles north of I-80, representing half of the Shirley Basin study population.

A far milder outcome played out in a control population of 35 more Platte Valley pronghorn south of the interstate, where only one animal died in February 2011. Taylor surmised that better-quality sagebrush on winter habitat, plus excellent summer range east of Elk Mountain, might have contributed to higher survival for the south-of-I-80 herd. The habitats that meant the difference between life and death for the two study populations were separated by only a few miles—and four lanes of interstate traffic.

"Once we looked at several of these GPS datasets together, it just became clear that the interstate blocks ungulate movements, not just in one spot, but for a couple hundred miles across southern Wyoming," Sawyer said. "And that movement barrier reduces the options that animals in these populations have…. That's problematic during severe winters when big game are trying to find areas with less snow."

Researchers who study pronghorn along I-80 can count on their fingers the collared study animals that ever crossed the highway. They can recall the individual animals, where the crossings happened, and what happened when animals got stuck.

Taylor said only one doe pronghorn from the Dunlap Ranch study ever crossed the "huge barrier" of the interstate. "We were pretty surprised to see that," Taylor said. "That individual crossing there was a bit baffling to us. It is interesting to see an animal [move] across that high-level of a disturbance corridor. … to do that once is really impressive."

"And somehow, she made it back across without dying," added Taylor's adviser Jeff Beck, a professor in the University of Wyoming's Department of Ecosystem Science and Management. "How she did that, you got me. Katie and I, we thought that was crazy."

The mystery of how this doe crossed I-80 was never solved definitively, but a decade of subsequent GPS data, trail camera research, and tracks have suggested that a passage under I-80 at the Platte River Bridge may be providing limited connectivity for individual pronghorn in the Shirley Basin population, and also for a few mule deer.

Yet such stories of wildlife crossing the highway using infrastructure not designed for them are an extremely rare exception. Of 186 pronghorn that biologist Adele Reinking fitted with VHF radio and GPS collars, only one crossed I-80. "Her ID was Orange 25," Reinking recalls. She collared the pronghorn 50 miles south of I-80, a little north of Baggs. "I saw her living at the big Love's gas station in Wamsutter on the north side of I-80." Reinking expects that Orange 25 used the underpass at the adjacent interchange to get under the interstate, but she isn't certain because the collar battery failed and the data was never retrieved.

Ben Robb, a recent master's degree graduate of the Wyoming Cooperative Fish and Wildlife Research Unit, compiled pronghorn data from multiple studies along I-80 from 2002-20, amounting to 400 animals and 700 animal-years. The massive dataset covers a region between Cheyenne and Evanston and stretches north of Pinedale in the west. At the time, there were likely no other pronghorn datasets of this scale in the American West.

Across all those pronghorn in all that time, Robb found only six with functioning collars that ever crossed the interstate. Three of these were at the Table Rock and Bar X Road areas in the Red Desert, one was at the Blacks Fork River crossing near Lyman, and two more crossed under the Platte River bridge at Fort Steele.

The volume of data has enabled Robb to calculate, for the first time, how likely it is for a pronghorn near I-80 to negotiate the barrier in any eight-hour period. "The odds that a pronghorn successfully crosses the interstate is equivalent to a royal flush in Texas Hold 'em," said Robb, a novice poker player. "Technically it's a little more likely for a pronghorn to cross, but we're talking odds of 0.00009 vs 0.00003 here, so that's splitting hairs."

Now, after decades of research and hundreds of tracked animals, we can say with certainty what biologists in the 1970s could only guess at: I-80 is virtually a complete barrier for pronghorn. Keep in mind that Wyoming is a state with 436,000 pronghorn, or 47 percent of the 916,000 pronghorn in North America, as of 2017. Given that Wyoming is the pronghorn capital of the world, the rarity of interstate crossings is astounding.

However, none of that means that animals don't want to cross.

> "Once we looked at several of these GPS datasets together, it just became clear that the interstate blocks ungulate movements, not just in one spot, but for a couple hundred miles across southern Wyoming. And that movement barrier reduces the options that animals in these populations have…"
>
> —*Hall Sawyer*

When I placed trail cameras at Dana Ridge and the Platte River bridge, the videos documented pronghorn eyeing underpasses that are fenced off, presumably to manage livestock. The clips seem to show pronghorn gazing through the barbed wire and beyond to the opening underneath the highway, as if wanting to cross. Seeing no way through, they walk away instead.

The seldom few that cross the interstate anyway do so in less than ideal conditions, like busy road interchanges or by fighting their way through difficult fences. "I find it exciting that pronghorn are using locations that are not designed with them in mind," Robb said. It speaks to the possibility that pronghorn would readily use crossings that are designed for them. The evidence suggests that if offered a little more help, their wild instincts would readily reconnect this fragmented landscape, mending vast habitats and benefitting movement and survival.

LOOKING FORWARD

Back in 1976, Lorin Ward's report on deer along I-80 ended with this prescient recommendation: "Cooperation between highway designers and wildlife managers can effectively reduce the number of deer-vehicle collisions."

Today, Wyoming Game and Fish Department and WYDOT have teamed up on the Wyoming Wildlife Roadways Initiative, a collaborative effort between agencies. The coordination is empowered by an enormous amount of data that can help to identify potential crossing designs and locations, reconnecting suitable habitat both on I-80 and across the state.

The initiative evolved out of WYDOT and the Wyoming Game and Fish Department's Wyoming's Wildlife and Roadways Summit held in Pinedale in April 2017. The conference set in motion efforts to identify the top wildlife-roadway "opportunity zones." These represent the most pressing areas for improving wildlife passage across Wyoming's highways, using criteria like migration corridor data and wildlife-vehicle collisions. Of the 43 projects identified, eight are along I-80.

The agencies are using GPS technology and mapping to share wildlife-roadway information with the public through the Wyoming Wildlife Roadways Initiative website. All the data is helping to design solutions that range from simple and inexpensive, to complex engineering feats that cost in the millions or tens of millions of dollars.

Starting on the simple end, improving fences to benefit wildlife is the easiest to implement. The most common actions are removing fences or changing woven-wire fences to wildlife-friendly designs. Such actions help improve connectivity on habitats adjacent to I-80 and provide an ecological benefit even without crossing structures for I-80.

"Someone asked me what's the best way to invest our money, and I think fence modifications," Reinking said. Significant gains could be made for Red Desert pronghorn by improving fences in ranges north and south of the highway, she thinks. "I would prioritize that over making it easier to cross I-80. I think the fencing is a much easier, faster, lower investment fix, than an overpass, which we know for pronghorn is almost required."

Wildlife movement data can help target these fence retrofits efforts. Rawlins Bureau of Land Management (BLM) Office biologist Mary Read consulted with Reinking to identify fences that were blocking pronghorn movement, working off an initial $50,000 budget. In 2018 and 2019, the BLM and partners funded more than $250,000 in fencing work, addressing almost 22 miles of range fence in 55 locations. While most of these projects are not immediately adjacent to I-80, they reduce the movement barriers for herds that are also dealing with the highway.

"When Mary Read came to us with $50,000," Reinking said, "that is not enough for an overpass, but it can fix a hell of a lot of fences."

The next step up for restoring connectivity is modifying existing infrastructure like underpasses and bridges to enable or enhance wildlife passage. There are more than 200 existing underpasses between Cheyenne and Evanston for livestock and machinery, and many have the potential to be retrofitted to enhance wildlife movement. Hall Sawyer and Bill Rudd compiled a 2006 report documenting some of these existing structures along I-80.

Ben Robb has placed dozens of camera traps at existing machinery underpasses and bridges to monitor any wildlife usage. "Spoiler alert: We are finding that underpasses that have a fence on them are not used by pronghorn," Robb said. One way to increase use of these structures could be to retrofit woven-wire fences and use smooth bottom wires that are high enough for pronghorn to scoot under. Such retrofit projects could build on the knowledge acquired by 1970s crossing projects at Dana Ridge and the Sisters, and more recent underpasses built at Trappers Point, Nugget Canyon, and Baggs (see map).

Then there is the option of creating new crossing structures: underpasses or overpasses. There is wide agreement that the best solution for pronghorn to cross the interstate is a wildlife overpass. In Wyoming, that impression is largely shaped by the success of the Trappers Point overpass over the two-lane US 191 near Pinedale, Wyoming. A 2016 *Wildlife Society Bulletin* paper by Hall Sawyer, Patrick Rodgers, and WYDOT's Thomas Hart found that pronghorn vastly preferred to use overpasses compared to adjacent underpasses.

Migrating pronghorn began using the Trappers Point overpass immediately after it was completed in 2012. During the next three years, the overall project of 12 miles of fencing, six underpasses, and two overpasses eliminated pronghorn-vehicle mortalities, and reduced mule deer road mortalities by 79 percent. Mule deer made more than 40,000 crossings, and pronghorn made more than 19,000 crossings. Many of these were back-and-forth movements that allowed animals the flexibility to intermingle during the autumn rut and respond to changing environmental conditions on winter ranges.

These impressive numbers for a 12-mile project on a two-lane highway only begin to suggest the magnitude of connectivity that could result if crossing structures were built at key places along Wyoming's 400 miles of I-80. While Wyoming has no I-80 wildlife overpasses so far, in Washington, Nevada, and Utah there are several that bridge four-lane interstates, proving the concept is feasible. The track record for these structures goes back to 1975, when Utah built the first wildlife overpass in the United States across Interstate 15 near the town of Beaver.

In the absence of an overpass, anecdotes show pronghorn use interstate underpasses under certain conditions. UW biologist Jeff Beck once saw a group of about 15 pronghorn crossing under the Wolcott Junction interchange of I-80, heading south toward Saratoga. In September 2019, transmission line inspector Waylon Dyess of Rock Springs saw about 50 pronghorn cross under the interstate from south to north at the Tipton interchange, on the west edge of the Great Divide Basin. In the winter of 2019-20, Phil Damm, Fort Bridger biologist for Wyoming Game and Fish Department, saw tracks that substantiated reports of hundreds of pronghorn crossing east to west at the US 789 underpass north of Baggs.

"I have had professionals outside of Wyoming tell me that pronghorn don't use underpasses, end of story," Robb said.

Adele Reinking

Adele Reinking collared pronghorn Orange 25 some 50 miles south of I-80, and later took this photo of her on the north side near the Love's truck stop at Wamsutter, one of the few cases of documenting a pronghorn crossing the interstate.

Leon Schatz and Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming

A sign warns motorists to watch for deer in an area where animals try to migrate across I-80 in southern Wyoming.

"And I hope [my research] could change the story, that actually, the underpasses may not be ideal, but they will use it in the absence of other options."

Wyoming biologists generally agree underpasses could also be a good solution for mule deer or elk when placed in the right locations. It's possible that such structures, combined with exclusion fencing, could help prevent deadly elk collisions that have occurred near Little America, Jim Bridger Power Plant, and Rawlins in recent years.

There are a number of hurdles in the way of building new crossing structures across I-80. These range from design challenges due to drifting snow conditions and proximity of the railroad, to land ownership issues that would require coordination between public agencies and private interests. However, the biggest challenges may lie in current policy priorities and limited funding streams.

When WYDOT and the Wyoming Game and Fish Department prioritize wildlife-highway projects, restoring habitat and migration movement is only one of several considerations. Projects that are most likely to improve driver safety tend to rise to the top in terms of urgency, and on the local level some two-lane highways are greater hotspots for wildlife-vehicle collisions. Overpasses on I-80 may benefit wildlife immensely, but they might not do a lot for driver safety.

There is also the sheer cost. Along I-80 at the Pequop Range and Silver Zone Pass in Nevada, a series of three wildlife overpasses, numerous underpasses, and fencing required an outlay of about $20 million. Depending on the location, a project could cost more in Wyoming if a separate overpass were required to go over an adjacent access road, not to mention the Union Pacific railroad. "We don't want to just pour [animals] out across the interstate and right onto the railroad," said Scott Gamo, environmental services manager for WYDOT.

Despite WYDOT's buy-in on the importance of wildlife connectivity, sufficient money for that purpose alone won't come from the agency, so the state would need to find other funding sources. A federal appropriation would be one solution, and there are potential ways to raise funds through grants. For the Dry Piney wildlife crossing project over a two-lane highway near LaBarge, WYDOT secured a $14.5 million grant and additional matches from Wyoming Game and Fish Department and other partners for a total of $18.5 million. Construction of up to eight wildlife underpasses and associated fencing will begin in 2022.

The collaboration is a realization of Ward's call for highway engineers and biologists to work together. Such interagency projects demonstrate how safer highways and wildlife connectivity are complementary goals.

"We [at WYDOT] want to do our part to certainly minimize if not eliminate mortalities for wildlife if we can," Gamo said. "If we can do that to benefit people and wildlife, that is obviously a win-win…. A bigger push now, than it was in the past, is looking at the habitat. It's moving that way for WYDOT."

The Wyoming Game and Fish Department's statewide wildlife-roadway work with WYDOT continues long-standing habitat and research efforts that Hepworth and others undertook along I-80 in the 1960s and '70s. "It's exciting to see how evolving technology, like GPS collars, has allowed us to better

understand wildlife movement in relation to I-80," said Wyoming Game and Fish Department Deputy Director Angi Bruce. "Game and Fish is committed to working with WYDOT and other partners to rely on this expanding data to improve wildlife connectivity and public safety on I-80 and throughout the state."

Finally, engineers and biologists have to decide where to site crossing structures to best restore movement across I-80, when corridors have been severed for 50 years. To analyze the options, Ben Robb completed an analysis of high-quality pronghorn summer range and winter range, and then modeled ways to "connect the dots" across I-80. He successfully defended his thesis on this research in fall 2020.

"This will give us valuable information of feasible options that can let pronghorn continue to freely move, and have the right to roam in Wyoming," Robb said.

Any future gains for wildlife connectivity, both on I-80 and elsewhere, will likely be built on a foundation of public interest, collaborations, and creative funding. There are murmurs that a federal infrastructure bill could include funds for wildlife projects, but if experience is any indicator, Wyoming's own initiative will be the deciding factor.

As of this writing, work has begun to enhance wildlife connectivity in the Halleck Ridge area of I-80, just east of Dana Ridge. This is the Wyoming Wildlife Roadways Initiative's number two priority wildlife-roadway project for all of Wyoming. WYDOT contracted with Western EcoSystems Technology (WEST) to analyze GPS data and create a list of potential enhancements. The project is looking at ways to upgrade fencing or enhance culverts or underpasses to help animals cross. WEST has also contracted with an engineering firm to examine potential locations for an overpass and do initial drawings. The planning doesn't mean an overpass will be built, but that it could be one of the options on the table for WYDOT's consideration. Fence crews are already working in the area.

If a large-scale wildlife overpass or underpass project does come to fruition at Halleck Ridge, that could lay the groundwork for future efforts along the length of the interstate. Research suggests intriguing possibilities, most of which match with priorities set by WYDOT and Wyoming Game and Fish Department.

Crossing structures on I-80 could enable mule deer and pronghorn corridors that start as far away as Jackson Hole or Yellowstone to continue across I-80, and even into Colorado, connecting the great wildlife winter ranges of the two states. In particular, biologists wonder how much father mule deer on the 150-mile-long Red Desert to Hoback mule deer corridor might go if I-80 didn't block them at the southern end.

Near Fort Steele, Creston Junction, Wamsutter, or Table Rock, crossing structures could enhance pronghorn winter range movements. If a crossing structure were built in those areas, there is a chance that pronghorn north of the interstate would find a way to move a long distance south. In 2019, Ben Robb tracked a pronghorn from the Table Rock area to near Sunbeam, Colorado along the Yampa River, a distance of 100 miles.

Further west of Green River, I-80 wildlife crossings could help relieve connectivity issues along WY 372 created by a solar farm. "It almost looks like that place needs a relief valve because animals get trapped in there," Gamo said. "If the animals could have an outlet to the south there, that may alleviate some of those issues." An ongoing study by Western EcoSystems Technology will help pin down pronghorn movement patterns in this region and evaluate whether fence removals and a 50-meter movement corridor between the solar farm and WY 372 could help pronghorn. A separate study is looking at Uinta Range mule deer movements from The Sisters to Kemmerer.

Since that day in October 1970 when I-80 was completed across Wyoming, 50 years of research has clearly laid out the wildlife problems, and the options to fix this barrier once and for all. Any connectivity projects could stand to make a large difference for wildlife along I-80, effectively multiplying the amount of habitat available.

"A lot of places just don't have that open swath of sagebrush habitat that Wyoming does, and that's something to be proud of," Ben Robb said. "Rather than just restoring a square mile, you would be practically doubling the access to the habitat, just by hopping a road."

Across the Mountain West, it's hard to imagine a bigger opportunity for restoration.

Gregory Nickerson *is a writer and filmmaker for the Wyoming Migration Initiative at the University of Wyoming.*

Leon Schatz and Gregory Nickerson, Wyoming Migration Initiative, University of Wyoming

In the Three Sisters area of far western Wyoming, mule deer tracks lead into an underpass retrofitted for wildlife by WYDOT. More crossing structures could reconnect vast big game habitats.

Wildlife Crossing INNOVATION

Research shows the promise and peril of a new material

By Kylie Mohr

Scientist Rob Ament and then-grad student Matthew Bell were on a quest. In the Dutch city of Rotterdam for a conference on ecology and transportation in 2018, they wanted to find a pedestrian bridge made of an entirely new material—fiber reinforced polymer, or FRP, plastic. They had hopes of putting it to use on a bigger scale for wildlife back in the United States. But after being stood up by the company who made it, the two Montana researchers were at a loss.

"So we went to our hotel and we talked to the woman at the front desk," said Ament, the Western Transportation Institute's road ecology program manager. "We said, 'This is crazy, we're looking for these plastic bridges.' We showed her a picture that we'd seen on the website of this company. And she goes, 'I know where that is.'"

She pulled out a map. Bingo.

While in the Netherlands, Ament and Bell also managed to find the world's only wildlife overpass made of FRP. They think the material has the potential to solve some of the problems of traditional wildlife crossings, which are designed to shepherd animals over or under busy roads. Wildlife crossings in North America are usually large concrete structures, sometimes with foliage on top, spanning highways. This makes them expensive, permanent, and slow to build, and requires carbon-intensive concrete and other materials.

People like Ament are rethinking what goes into the crossing structures. The potential for lower maintenance costs and quicker construction could solve some of these problems and get more crossings on the landscape.

"We know our highways are barriers and we didn't design them with landscape connectivity and wildlife movement in mind," Ament said. "They just weren't built that way and now we're retrofitting to reconnect the landscape." That retrofitting is increasing in pace. The first wildlife bridge in the US was built in Utah in the 1970s. Today, Banff National Park in British Columbia boasts almost 40 underpasses and six overpasses and new ones are popping up every year over highways all across the West.

Scientists want to make wildlife crossing structures cheaper, more versatile, and easier to build and maintain, and combining resources can help. Eleven states, Parks Canada, and the Canadian province of Ontario collectively put up $1.2 million under a US Department of Transportation program to improve rural travel, which includes helping drivers avoid hitting wildlife. The Western Transportation Institute, the country's largest university-based research center focused on rural transportation issues based at Montana State University, won the funding with their creative proposal. Wildlife overpasses and underpasses with fencing are fairly well studied, so Ament and his team took a different approach, plunging into FRP research. Who makes FRP bridges, how could they be designed to work at a bigger scale, what are their strengths and weaknesses?

"The question isn't, 'Do they work?' but, 'Can we do them with new materials with the idea of trying to bring the cost down,'" Ament said. Bridges have traditionally been made of the same three materials—steel, concrete, and wood—for hundreds of years. "It hasn't ever changed," Ament said. "Isn't that amazing? We're just starting to introduce our fourth material."

Six areas were nominated as sites to build out the solution to the funded challenge. California's two-lane US 97 in Siskiyou County was ultimately chosen. A site hasn't been finalized yet, but it'll likely be on a ridge above Grass Lake. Project proposals state that Caltrans maintenance staff remove six or seven animal carcasses monthly from the highway in this stretch and between 2015 and 2019, California Highway Patrol recorded that vehicles struck 68 mule deer and five elk. Numbers are likely higher, since not all incidents are reported.

Now a team of engineers, wildlife biologists, and road ecology gurus from California to Montana are drawing up plans for an FRP overcrossing there, which will be the first bridge of its kind in North America. They'll also design accoutrements, like fences and sound barriers, once a site is finalized. They hope doing time-intensive research and consultation now will work as

A bridge made from fiber reinforced polymer allows small wild animals to cross safely over a highway near Grebbeberg, Netherlands.

a blueprint to expedite the process in the future and show other clients that the material can work in practice and not just on paper. Caltrans has already expressed interest in a second structure if the process goes smoothly.

"The idea of someone trying to do something new and different, the potential uses of something like that, interested us from day one," said Wesley Stroud, a senior environmental planner for Caltrans.

The challenge now is scaling up FRPs for the bigger wildlife seen in the western United States. In the Netherlands, "they're looking at hedgehogs and badgers, and we're looking at elk and wolves," said Bell, now a research associate at the Western Transportation Institute and the lead materials researcher on this project. "They don't compare." The Northern California bridge will need to be between 30 and 50 meters wide to convince elk, skittish in tight spaces, that it's safe enough to cross. Bell is working with different companies and materials to determine the best fit for the project; structural engineer Damon Fick is making sure the eventual bridge doesn't collapse.

Rob Ament

FRPs are made using materials like crude oil, natural gas, chlorine, nitrogen, glass, and sometimes recycled plastics. These materials can't be welded like steel, so the researchers are considering different bolted connections to help the bridge be as wide as it needs to be. Fick, an assistant professor of civil engineering at Montana State University, said FRPs bring about a unique set of engineering concerns he's excited to tackle. One that's on his radar is "slouching," which can happen with composite materials that are less stiff than steel or concrete. "The bridge won't necessarily fall down," Fick said. "But it's a cosmetic or a serviceability issue. Nobody wants to walk underneath a beam that looks like it's sagging." Selecting the right manufacturer of FRP and designing it properly will help solve this problem. While there's inherent risk and logistical challenges of using something new and trying to scale it up, the attitude across state lines is gung-ho.

Researchers think there are strong reasons this material is worth pursuing. They've poured over case studies that show the average FRP bridge is half the weight of a steel bridge with the same strength and is five times lighter than its concrete equivalent. Smaller bridges—not this particular project over US 97—could be assembled like Legos, with precast molded blocks being plopped into place. This could theoretically mean quicker construction with fewer traffic detours and re-routes as well as the possibility for bridges that aren't as long or wide as the California design to be picked up and moved if migration routes change. And FRP materials can last four times as long as, say, wildlife fencing made of wood.

"Generally speaking, FRPs are an extremely strong material, they make construction a lot easier, they last longer, there's little maintenance required," Bell said. "Depending on the way your materials are used, they can even be fire, impact, or UV resistant."

Neil Hetherington, Western Transportation Institute

Matthew Bell, a research associate with the Western Transportation Institute's Road Ecology Program, speaks about structure design for fiber reinforced polymer wildlife crossings at a meeting.

The first few FRP bridges likely won't be too much different in overall cost, but the hope is that in time costs will come down when less preliminary research, materials reconnaissance, and design work is needed to lay the foundation. Avoiding sticker shock is a strong motivator: a recent price tag for an overpass near Banff, Alberta, clocked in around $4 million and average costs for wildlife crossing construction range from there up to $10 million.

Potential future savings include lower construction method costs, less time to complete a structure, and less maintenance compared to conventional methods. While wildlife crossings with the material are unchartered territory, Bell said pedestrian bridges using FRPs are bid against conventional methods and come up the same price or cheaper. For now, some structural components of the bridge in California—like fence posts or sound barriers—could be fully FRP. Others might be a hybrid of FRP on the outside and concrete on the inside to leverage the beneficial properties of each.

The project is in its design phase. Caltrans is looking for funding partners to pay for construction. If all goes according to plan, construction will occur in the summer of 2023. While there's still a lot to learn about how FRP bridges will work for North America's larger mammals, the innovative material could change the landscape for wildlife connectivity.

"It needs to be looked at as a whole conservation goal as well as an economically sustainable goal when it comes to what we're trying to do," Bell said. "It could definitely be the future of wildlife crossings."

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Text and images by Claire Giordano

My mom tells stories of a magic road. It wound from a gleaming blue alpine lake to the desert below. It required no gas, didn't wear out brakes, and had the most beautiful vistas. From the top, a car traveling at 50 miles per hour could be slipped into neutral and coast through every turn to the arid land below. This road, winding gracefully eastward from Lake Tahoe to Carson City, was designed by highway engineer Ernest Muller. It was Grandpa's road.

Ernest, or Big E as he was known due to his distinctive signature with an oversized "E" and a line of waving squiggles not unlike the undulating desert landscape, worked for the Nevada Highway Department (now the Department of Transportation) for 37 years. When he retired, he continued to walk the desert as a surveyor outlining land and water rights.

As the breadwinner for a family of seven kids, Ernie spent most of his time wandering the desert with pen, paper, and plans in hand. His youngest daughter Virginia (my mom), recalls how, "My dad was happiest outside. Home was crowded and loud, and I treasured the days I got to join him 'out in the field' as he called it. I was always struck by the silence. I think he was the most at home with an endless view of cacti, sand, and sagebrush." During the long days outside Ernie filled his pockets with small details from the landscape: rocks, barbed wire, date nails, pottery shards, and arrowheads.

Over a lifetime of wandering, Grandpa's yard and basement filled with rocks. Each represented a relationship with place forged over a lifetime of walking, working in, and learning from the desert. My favorite activity when I saw him once each year was to sit quietly amid the piles of stones and arrange them by color. When I was lucky, he told me their stories.

I remember how his hands looked like the land, crisscrossed with wrinkles and suntanned brown. He smelled like the desert: sage and petrichor. Sometimes it seemed the edges between person and place blurred—khaki clothes and grey hair a mirror of golden yellows, sun faded brown, and silvery pines beneath a cobalt blue sky.

Ernie was unusual among his fellow engineers. He worked out of Carson City (the state capitol), and when most of his peers visited other cities, they completed a very brief obligatory site walk before retiring to air-conditioned restaurants to discuss development plans. Not so with Big E. The minute he stepped out of the car he always headed straight into the desert regardless of the weather. During one notorious

Ernie's Road

The engineer behind a lonely desert highway

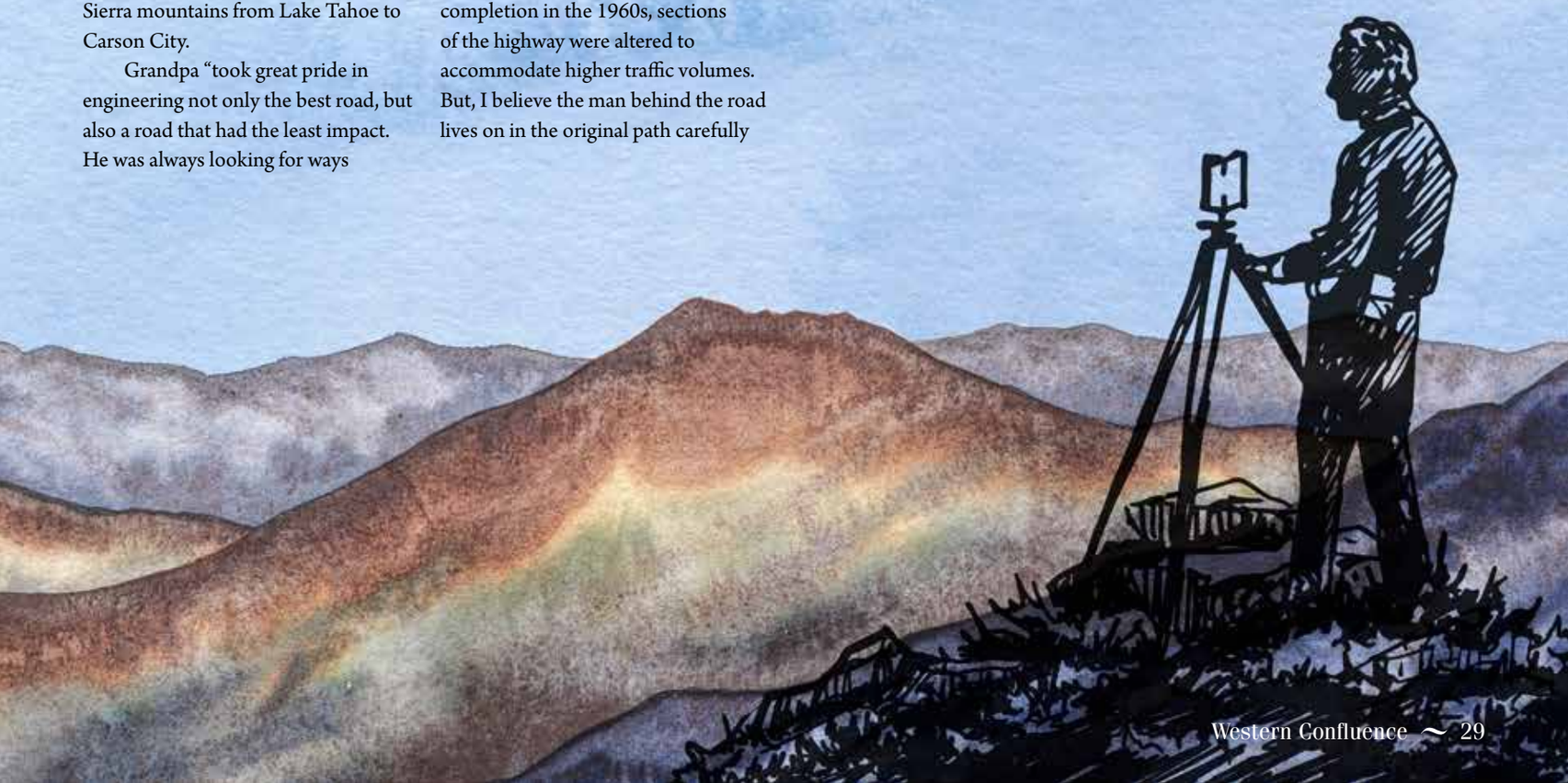
visit to Las Vegas the local engineers followed him from the rental car into a sun cracked valley. All struggled to keep up with his long legs over the eight-mile trek in 100+ degree heat. "They didn't even stop for lunch," his son Jon recalls. "My dad always had a pocketful of peanuts and that was it. The engineering department still talks about that day 25 years later."

Grandpa left an equally large impression on the roads of Nevada. Highway 50, infamously known as the "loneliest highway in the nation," crosses the entire state of Nevada from west to east. It was one of the largest projects he worked on, and Ernie engineered an incredibly difficult section. He designed the safe and beautiful route through the Sierra mountains from Lake Tahoe to Carson City.

Grandpa "took great pride in engineering not only the best road, but also a road that had the least impact. He was always looking for ways around streams and how to minimize blasting rock," recalls Jon. Ernie was dedicated to crafting a road that felt part of the landscape and encouraged people to experience the beauty of where they were. "Dad insisted on making the road look like it was exactly where it should be. He thought of everything. From requiring tunnels for deer to hiding the entry road to a development behind swales of earth, he engineered each turn to maintain the beauty of the desert. He even helped pioneer the use of browned guard rails because he hated how the reflective metal was visible from miles away when he was out surveying."

Decades later, it is no longer possible to coast down the entirety of Grandpa's old two-lane road. Since completion in the 1960s, sections of the highway were altered to accommodate higher traffic volumes. But, I believe the man behind the road lives on in the original path carefully plotted through the mountain passes. Grandpa is also in the box of stones willed to me and carefully arranged in my studio beside rocks I collected on my hikes and painting expeditions. When I sit for hours painting outside, I often think of Grandpa and the places we can go because of his roads. And I imagine the intersecting lines our creations trace across a landscape.

Claire Giordano *is an environmental artist and writer following the interwoven patterns of people, place, and climate change. See more of her work at www.claireswanderings.com.*



Paving Paradise to Put Up Parking Lots

Can Western cities grow without displacing their neighboring natural wonders?

By Aubin Douglas

My first visit to the Great Salt Lake was a graduate course field trip to the Bear River Migratory Bird Refuge. Upon arrival, I was awestruck by the sheer number and variety of birds. Acrobatic barn swallows dove and swooped amongst the bridges; red-winged blackbirds perched atop cattails while calling to each other; scampering plovers chased brine flies along the shoreline; graceful American avocets waded through the shallows; swift-moving grebes and ducks dove below the water's surface and reemerged with mouthfuls of invertebrates, plants, or seeds; and stoic American white pelicans glided along the water's surface at a lackadaisical pace. The lake was truly a bird metropolis.

This is possible due to the freshwater inlets that flow from the Wasatch Mountain Range into the eastern side of the lake, creating ideal wetland habitat for migrating birds. Great Salt Lake wetlands comprise 75 percent of Utah's total wetland acres, a true oasis in the desert. In fact, over 7.5 million birds representing 250 different species call the Great Salt Lake home at one or more times during their annual migrations, which is why all five of the lake's bays are recognized as globally Important Bird Areas. According to the National Audubon Society, the Great Salt Lake and its wetlands are one of the most important wetland habitats located in the Pacific Flyway.

At the same time, the West is one of the fastest-growing regions in the US, and Utah is no exception. The state has one of the highest human population growth rates in the nation and its population is expected to double by 2065; much of that growth is predicted to occur along the Wasatch Front, a rapidly expanding urban corridor along the eastern edge of the Great Salt Lake. The Government of Utah is enticing businesses from around the globe to move to the Wasatch Front with tax incentives and by creating new infrastructure such as roads, housing, commercial and industrial districts, a new state prison, a new inland port, and a new terminal at the international airport. Those in government highlight the Wasatch Front's "sense of place and community," natural beauty, and adjacency to wildlife and the great outdoors as reasons why businesses and people should immigrate from other states and countries to live and work there.

These two concepts of urban expansion and beautiful natural areas seem at odds with each other. How can one rapidly expand an urban center that's already pinched by two natural landscape features—in this case the Wasatch Mountain Range to the east and the Great Salt Lake to the west—and expect to maintain adjacent rolling farmland, lush wetlands, spring creeks, mountain meadows, and the diverse wildlife that depend on these

Stephanie Creekpaum, Shutterstock

A pelican swims through the Bear River Migratory Bird Refuge, a wetland that is part of the Great Salt Lake in Utah.

habitats? Currently, the Wasatch Front is developing at the cost of these ecosystems, trading sense of place and natural surroundings for sprawling suburbs, shopping malls, and more roads. The truth is, growing cities in the West can continue to prosper while maintaining the unique and important habitats that support the wildlife who depend on them. All it takes is some forethought, cooperation, and bioregional planning.

Jeremy Christensen, Shutterstock

Development north of Salt Lake City, Utah, squeezes between the Wasatch Front foothills and the Great Salt Lake.

In 2016, I entered Utah State University's master's program in bioregional planning. Bioregional planning is an iterative, transparent, community-based method for landscape-scale planning. In collaboration with local stakeholders and community members, bioregional planning takes into account the environmental, social, and economic qualities of a landscape and then initiates public discourse to generate potential alternative futures for a region. The ultimate goal is to generate several different visions for future development that local communities and stakeholders wish to see either realized or avoided. After all, it's as important to understand your goal as it is to understand what should be avoided in the future.

During my introductory courses at Utah State University, I learned how important the Great Salt Lake ecosystem is, and just how imperiled it has become from upstream water diversions and nearby urban development. The more I learned about the importance of the Great Salt Lake to millions of birds, the more I wondered how this natural wonder would fare in the face of a rapidly expanding population and developing urban area; this is what ignited my interest in what would become my thesis project.

As a bioregional planning student, I wanted to know how the nearby urban area was incorporating the Great Salt Lake and Utah's most important wetlands into state, regional, and county master plans. Through this inquiry, I carefully reviewed the planning of new construction projects along the Wasatch Front, including a new major highway—the West Davis Corridor—which is slated to be built along the southeastern edge of the lake around Farmington Bay. I also learned of a regional development plan led by the Wasatch Front Regional Council that would accommodate projected population growth out to 2040: The Wasatch Choices 2040 Regional Vision. Lastly, there were recent news articles featuring debates involving Salt Lake County, Salt Lake City, and the State of Utah over how to develop a quadrant of land directly south of Farmington Bay; this is where the new state prison, new terminal for the international airport, and new inland port are intended to be built.

I noticed the planning documents for these projects did not fully address the potential impacts to the Great Salt Lake wetlands and its wildlife. I saw an opportunity to do a project that fulfilled my thesis degree while simultaneously aiding local planners and government officials by quantitatively assessing those impacts as a preliminary step in the bioregional planning process. I knew it was impractical to complete an entire bioregional plan on my own, so to keep my project feasible, I focused the scope of this project on identifying and assessing the impacts these three major development projects would have on the current migratory bird habitat around Farmington Bay.

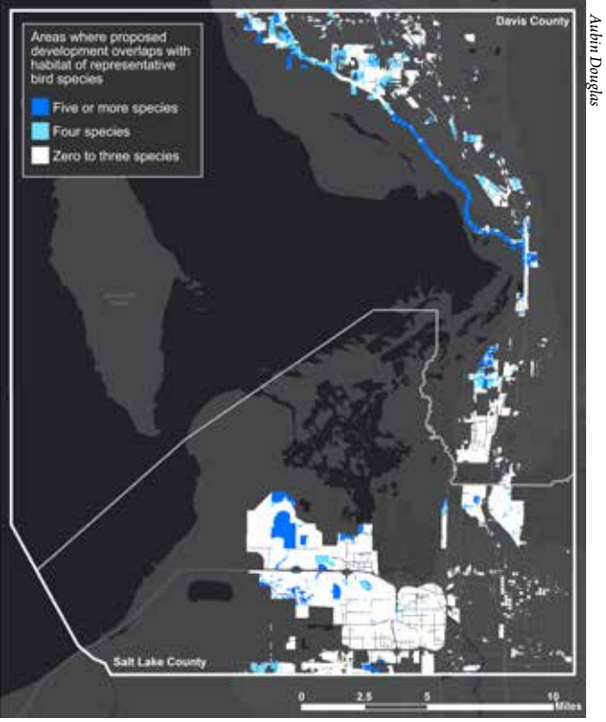
While I began my thesis research, I looked for other places in the West where bioregional planning was being employed to grapple with the issue of rapid population growth. I found that other areas also face the challenge of accommodating more people while managing the beautiful natural areas that surround them and make them unique. So, what cities and regions are working to not only accommodate new development in important natural and recreational areas, but also mitigate the potential negative impacts on local and migrating wildlife?

In a similar 2016 project, local stakeholders in Moab, Utah invited my Bioregional Planning Studio cohort at Utah State University to lead a bioregional planning project to identify alternative potential futures for the region out to 2040. With stakeholder engagement and collaboration, we identified areas amenable to varying types of local land-uses, including new development, agriculture, recreational activity, natural resource extraction, and conservation of water and wildlife resources. After we presented our findings, the local officials, planners, and community members interacted in a Geodesign Workshop to select aspects of the potential futures and create an agreed-upon regional vision to plan for in the coming years.

Bioregional planning has also been implemented by the Crown Managers Partnership, an international partnership among various agencies in Montana, Alberta, and British Columbia. This team is using a planning method that addresses socio-ecological issues and topics spanning the entire Crown of the Continent ecosystem. Using a similar planning method called Landscape Conservation Design, the Crown Managers Partnership, along with interested stakeholders and communities, is bringing the region's existing science and land-use plans into a landscape scale vision that considers not only wildlife and ecosystems, but regional cultural, social, and economic priorities, as well. This is an iterative, ongoing project that will inform and guide planning and development into the future for this international region.

With these project examples in mind, I developed and implemented a bioregional planning-based method that identified and assessed potential future land use conflict between the three proposed major development projects and the critical migratory bird habitat around Farmington Bay. I first mapped the three development projects and then grouped the different types of development into four main categories—highway, commercial, residential, and industrial—to identify and assess how each of these development types were impacting existing migratory bird habitat.

Once I had categorized the spatial data for the three development projects, I collected migratory bird habitat data from the US Geological Survey's Gap Analysis Program. Since there are over 250 species that use the lake and its associated wetlands, I selected habitat data from five representative species for each of the three main bird guilds—shorebirds, waterbirds, and waterfowl—that use the lake and its adjacent wetlands. I combined the habitat data of the five species to make habitat maps for each guild. For example, the shorebird guild's map combined habitat data for American avocet, snowy plover, Wilson's phalarope, willet, and long-billed curlew. After creating the habitat



Aubin Douglas

For her graduate research, author Aubin Douglas selected 15 representative bird species and overlaid their habitat on a map of areas proposed for development under three different regional plans. The West Davis Corridor, a highway project visible as a stripe across the northeast corner of the map, had the most conflict with bird habitat among the three projects.

and development datasets, I looked for spatial overlaps that could indicate potential land use conflict between development and conservation of important bird habitat. I then assessed the percentage of each project in conflict with existing migratory bird habitat within the study area.

I was surprised to find that every development project showed a substantial amount of conflict with all three of the bird guilds I assessed. I realized that it would be infeasible to recommend that the regional planners and developers avoid all areas identified as in-conflict with bird habitat, so I decided to make recommendations based on protecting the most important habitat within the area. I performed a "hotspot analysis" by assessing conflict between the proposed development projects and areas where four or more representative species' habitats overlapped. This revealed the areas where proposed development would displace the most important habitat—habitat used by at least several of the representative bird species—in the study area.

Among the three projects, one stood out: 88 percent of the West Davis Corridor, or 2,090 acres, conflicted with bird habitat. This planned highway will displace agricultural fields, pastures, and wetlands, which are ideal spillover habitats for many of the birds that migrate through the area. In the hotspot analysis, over 1,600 acres of this project were in conflict with habitat for four or more representative bird species. This finding alone should be cause for further research into the potential environmental impacts of this project. The development of a major highway has other negative externalities as well, including decreased air quality (already a major health concern along the Wasatch Front), impacts to water quality, increased urban sprawl and development, and negative impacts to other birds, wildlife, and vegetation around Farmington Bay.

After I submitted my thesis, I developed a short summary of my work and recommendations based on my findings, which I sent to local stakeholders including contacts at the Wasatch Front Regional Council, the Utah Department of Transportation, the Governor's office, and the Salt Lake City Council, among others. In this document, I recommended that local planners and policy makers rethink the location of the West Davis Corridor, or entirely rethink the necessity of constructing a new major highway. Though western cities are typically designed and laid out to accommodate cars, the Wasatch Front could be one of the shining examples of an area that is thoughtfully developed to maintain its natural amenities while promoting modes of public and alternative transportation. I also recommended promoting mixed-use developments (that is, commercial and residential development in close proximity) so people can live closer to where they bank, shop, go to school, eat, and so on. Mixed-use developments are also one of the key principles of the Wasatch Choices 2040 Regional Vision.

I never heard back from any planners or policy makers. Last year, I checked in with one of the planners at the Wasatch Front Regional Council about my recommendations. They acknowledged that it would be better for both wildlife and people to invest in alternative and public modes of transportation, but that the majority of Utahns do not currently support that investment. Since my thesis, the Wasatch Choices Regional Vision has been updated and looks to 2050 rather than 2040 and allows for greater urban and suburban development including more roads and other infrastructure to further promote economic growth with less mixed-use developments.

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The result of my thesis is a conflict analysis that serves as a preliminary step in the bioregional planning method. Understanding where vulnerable, valuable resources are—such as groundwater recharge zones, culturally significant areas, or critical habitat for migratory birds—is a critical early step of the process. In the Wasatch Front, conflict analyses could also be used to assess how other significant resources, such as ungulates, furbearers, native or threatened vegetation, other bird guilds, pollinators, and even aquatic species might be impacted by future development projects. The bioregional planning method also calls for pairing resource assessments with analyses to identify areas suitable for other land uses, such as new neighborhoods, roads, or natural resource development. Bioregional planning is all about taking an active approach to creating a data-driven regional future that is 1) economically viable, 2) socially just, 3) environmentally sound, and 4) collaboratively agreed upon by varying social groups (both majorities and minorities). It is an ideal planning method to use in rapidly growing western cities and towns since we have so many unique and wonderful natural amenities to conserve.

Ultimately, the future of the Wasatch Front, and other western communities, is up to those who plan it today. While it may require more forethought, inclusivity, and creativity than the typical method of planning, bioregional planning offers a helpful framework for creating a future that holds true to what not only Utahans, but other westerners prize so highly: a sense of place and community, outdoor recreation, and clean air and water. Future generations of both people and animals will appreciate the steps and efforts we take today to conserve our natural resources and develop in a sustainable and mindful fashion.

Aubin Douglas *is a cartographer for the Division of Realty in the US Fish and Wildlife Service in Lakewood, Colorado. She has an MS in bioregional planning and is completing a second MS in ecology through the Department of Watershed Science at Utah State University.*

The findings and conclusions in this article are those of the author and do not represent the official views of the US Fish and Wildlife Service.

ADDITIONAL READING

Douglas, Aubin A., "Conflicts Abound: How Future Development Along the Wasatch Front Will Replace Critical Migratory Bird Habitat Around Farmington Bay" (2018). *Landscape Architecture and Environmental Planning Student Research*. Paper 1. https://digitalcommons.usu.edu/laep_stures/

Utah State University, "Moab Futures: A Bioregional Planning Analysis" (2017). *Bioregional Planning Studio Reports*. 2. https://digitalcommons.usu.edu/laep_bioregional/2

The Wasatch Choices 2040: A Four-County Land-Use and Transportation Plan. https://wfrc.org/VisionPlans/ArchivedVisions/HelpfulLinksDownloads/wasatchchoices2040report.pdf

Ruckelshaus Day Celebration

In July we held one of our first in-person gatherings since the beginning of the pandemic when we dedicated a Douglas-fir planted next to our building to William D. Ruckelshaus.

Ruckelshaus, who passed away in November 2019, had a long and colorful career in both public service and private industry. He worked tirelessly to advance policy solutions that would benefit both the economy and the environment for issues ranging from water pollution and trash management to salmon fisheries and forests. He was known for his clear-headed integrity, especially after he resigned from the Nixon Administration during what became known as the Saturday Night Massacre. As founding board chair of our Ruckelshaus Institute, he called for bringing collaborative problem solving to the environment and natural resource challenges of Wyoming.

Several people who were instrumental to launching the Ruckelshaus Institute and who worked closely with Bill Ruckelshaus in Wyoming and beyond shared their thoughts and remembrances at the tree dedication. We learned how Senator Alan Simpson asked Bill to come to Wyoming to help launch the Institute of Environment and Natural Resources, how Ruckelshaus read a biography of every US president to prepare his remarks for a speech about trust in government, and where to spot locally growing Douglas-fir trees, a species Bill adored, to get a sense of how big the one we planted may become over the next century. We heard the word "hero" many times and we enjoyed corn on the cob and tomatoes, two of Bill's favorite foods, along with cake to recognize his birthday on July 24.

We plan to celebrate Ruckelshaus Day each July 24 going forward, to remember Bill Ruckelshaus's leadership and to consider ways we can apply his experience and insights to the challenges we and our students will face in the coming years and decades.

> "When concerned citizens take the time to master an issue, when they are able to conduct their deliberations outside the courts or the political fishbowl, they can learn to speak a common language and come up with creative solutions for problems that appear to be frozen in a perpetual contention between narrow interests."
>
> —*William D. Ruckelshaus, 2002*

SPECIAL GUESTS

- Harold Bergman, Director, Ruckelshaus Institute and Haub School of ENR, 1998-2008
- Ann Boelter, Ruckelshaus Institute Research Scientist, 1995-2008
- John Ehrmann, Senior Partner, Meridian Institute
- William Gern, Director, Institute for Environment and Natural Resources, 1995-1998
- Diana Hulme, Assistant Director, Ruckelshaus Institute, 2001-2010
- Rich Innes, Senior Fellow, Meridian Institute
- Michael Kern, Director, William D. Ruckelshaus Center, University of Washington and Washington State University

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AFTER THE ROAD

How to restore sagebrush habitat on decommissioned roads

By Tessa Wittman

In the natural gas fields of western Wyoming, innumerable dirt roads cut through the sagebrush steppe, connecting gas wells and carrying heavy equipment. Sublette County hosts both the Jonah Field and the Pinedale Anticline, two of the most productive gas fields in the continental United States. Mule deer and pronghorn skirt the dusty web of roads, shying away from the noise and activity. Male sage grouse strut and show, struggling to attract hens amidst the cacophony of heavy truck traffic and thumping well pumps. Many studies have shown the negative impacts of active roads on local and migrating wildlife, but what happens when the traffic stops? Is it possible to restore native sagebrush habitat when a road is decommissioned?

"Sagebrush community restoration in itself is not an easy undertaking," says Pete Stahl, "and then it's complicated when you have all the compaction of soil that's caused by roads." Stahl is a soil scientist and the director of the Wyoming Reclamation and Restoration Center at the University of Wyoming where he also teaches restoration ecology. Stahl says restoring sagebrush habitat on decommissioned roads "can definitely be accomplished consistently, if the proper planning and practices are used and time is allowed." There are also preventative measures that can help drive successful road restoration in sagebrush.

Roads are the most extensive and enduring human disturbances across Western landscapes. Colonization of North America established roads that may never be erased. Ruts from wagons carrying nineteenth century travelers on the Oregon Trail are still visible from Wyoming to Oregon. Vast networks of highways and dirt roads now cut across the landscape, and escaping the noise of traffic anywhere in sagebrush is increasingly difficult. Unlike most transportation infrastructure on our landscapes, roads built in gas fields are meant to be decommissioned after the well goes dry. Sometimes that's within a few years of construction, but more often after 20 or more years of use.

Google Earth

A satellite image shows energy development roads crisscrossing a sagebrush basin in southwest Wyoming near Fontenelle Reservoir.

> "A road in itself may not be that harmful or have that many impacts on wildlife habitat. It's the traffic on the road that may be more important than the road itself."
>
> — *Pete Stahl*

Restoring native sagebrush communities on decommissioned roads increases available food, habitat, and resources for wildlife while reducing erosion and restricting the potential for invasive plants like cheatgrass to spread. In an environment of extremes—with high winds, little precipitation, hot summers, and very cold winters—the sagebrush steppe hosts diverse plants and animals. Some animals, including pronghorn, pygmy rabbits, sage grouse, and sagebrush lizards, rely entirely on sagebrush for at least part of their lives. In addition to animals, sagebrush also fosters native grasses and wildflowers, both by providing shelter above ground and supplying water and nutrients below ground. It has a deep tap root that reaches as far as 13 feet below the surface. With this taproot sagebrush can transport water to dry portions of the soil profile through a process known as hydraulic lift. Additionally, sagebrush can create islands of fertility by trapping organic materials near the soil surface, thus retaining water and supplying wildflowers and grasses with nutrients. In return, the grasses and wildflowers

shade the surrounding soil, reduce erosion and evaporation, attract pollinators, trap snow, and help build healthy surface soil.

Soil is foundational to successful restoration. Restoration ecology is the science of assisting the reassembly of native communities of plants and animals. It is a young science, and sagebrush community restoration is not well understood. Sagebrush itself is notoriously difficult to cultivate. Further, many native plants in sagebrush are perennials which grow from well-established roots year after year. The roots allow these plants to survive years of drought, wildfire, and other disturbances, but too much disturbance—such as heavy traffic—can kill the plant. Re-establishment can be very difficult because seedlings struggle to germinate and survive in the harsh climate. Additionally, few seed sources exist for many native sagebrush steppe plants. For some plants, no known cultivated or collected seeds exist, and collection requires precise timing. Even if restoration ecologists can find seeds to plant, it may take years of expensive and time-consuming reseeding until the right set of conditions allows these perennial plants to reestablish. Planners generally allot a two- to five-year window for assessing the success of a restoration project, but it can take longer to reestablish diverse sagebrush communities.

Planning is critical to restoration. Stahl says, "With a little forethought you can avoid a lot of problems." Factors to consider in planning road construction include salvaging appropriate layers of topsoil. Stahl advocates for including a soil scientist on the construction team, indicating equipment operators can become adept at saving important soil layers when they collaborate with a soil scientist. Planners should avoid steep slopes wherever possible to reduce erosion during use and facilitate seeding during restoration. Stahl also advises against disturbing sensitive habitats where there may not be a seed source for some of the native plants.

Once a road is decommissioned, deep ripping or tilling that reaches under the compacted soil is critical to allow roots and water to penetrate. That ripping can also make a decommissioned road impassable, thus preventing recreational traffic. Land movers can then replace the salvaged topsoil in a way that replicates the pre-disturbance topography that was shaped by regional climate. Seed mixes should be sourced from nearby seed companies so the plants are adapted to local conditions, and the mix should reflect the pre-disturbance plant diversity in representative proportions. Many considerations in road restoration are specific to the location, and the weather is always a gamble. Restoration should plan for the possibility that seeding may fail due to unpredictable weather and that it may take repeated applications before plants establish.

When asked if he sees any common misconceptions around roads, Stahl says people's perceptions of roads may be part of the problem. "A road in itself may not be that harmful or have that many impacts on wildlife habitat. It's the traffic on the road that may be more important than the road itself." But traffic does not necessarily stop when gas production ceases. In the sagebrush steppe, anything resembling a two-track is considered fair game for motor vehicles like ATVs. That traffic disturbs wildlife, prevents seedling establishment, and hampers restoration.

Thanks to the Surface Mine Control and Reclamation Act of 1977, which mandates extensive pre-disturbance ecological surveys and bonded restoration plans, coal mines have pioneered restoration ecology in the sagebrush steppe. Oil and gas extraction is not regulated under such comprehensive restoration legislation. However, with Environmental Impact Assessments increasingly mandating restoration plans and some companies voluntarily undertaking restoration to maintain a good relationship with the surrounding communities, oil and gas sites might be able to replicate coal mine restoration efforts.

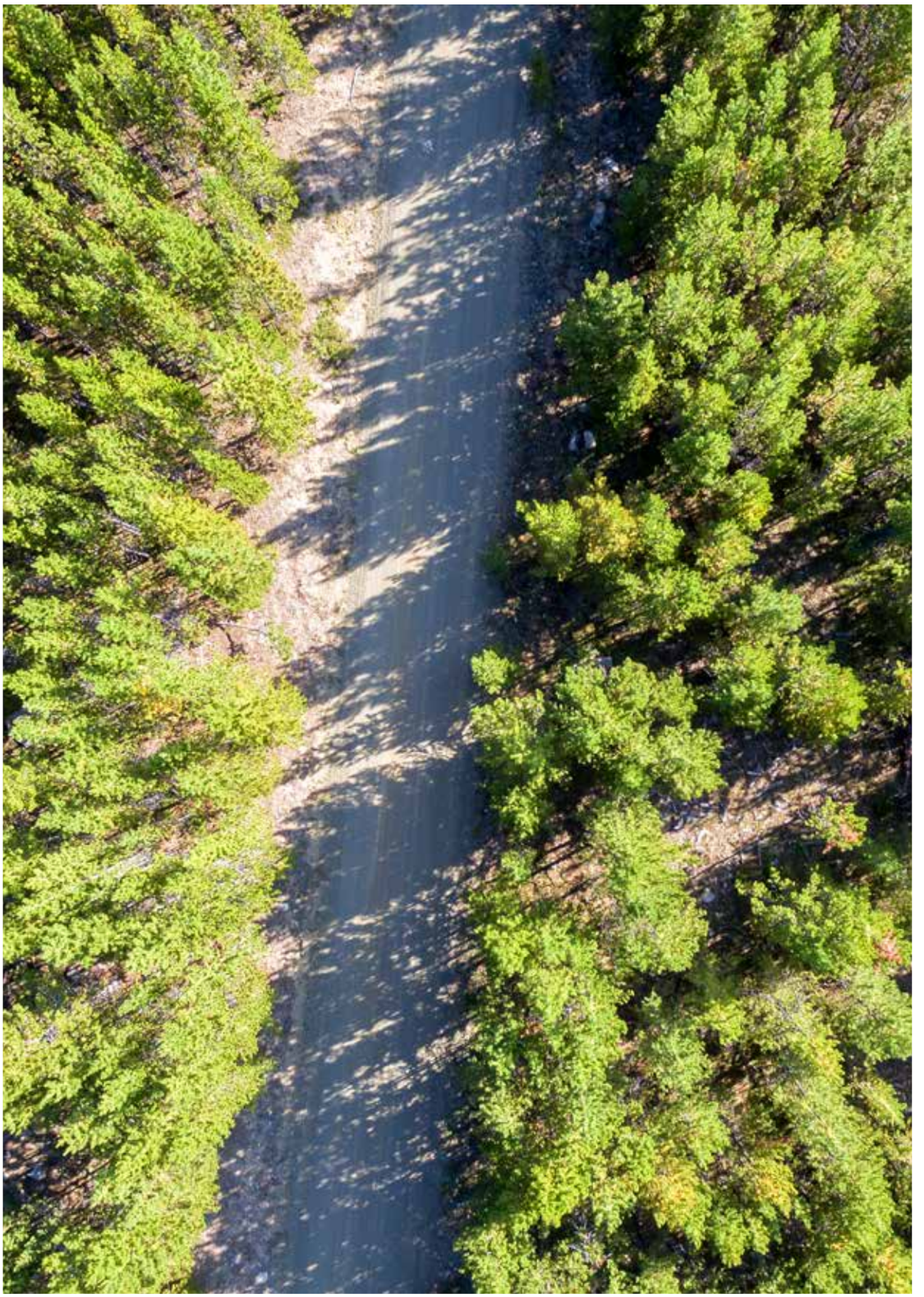
The Dave Johnston coal mine, just east of Casper, Wyoming, provides one example of successful road restoration. After the mine was retired, soils were replaced, topography rebuilt, and sagebrush was seeded on late winter snow to replicate natural conditions. In his early visits to the mine, Stahl travelled along retired mine haul roads with substantial soil erosion and compaction issues. He returned years later to find little or no evidence of the reclaimed roads. This site presents one of the only successful large-scale sagebrush restoration projects in the West and offers tested methods that can improve restoration efforts elsewhere. "With good planning, good ripping, and good practices, roads can virtually disappear," Stahl says.

UW Photo

Soil scientist Pete Stahl directs the Wyoming Reclamation and Restoration Center at the University of Wyoming where he also teaches restoration ecology.

***Tessa Wittman** earned her bachelor of science in wildlife biology and environment and natural resources from the University of Wyoming. She currently works as a research scientist in the Ruckelshaus Institute assessing wildlife-livestock conflict on public lands in the American West.*

ROAD WAGER



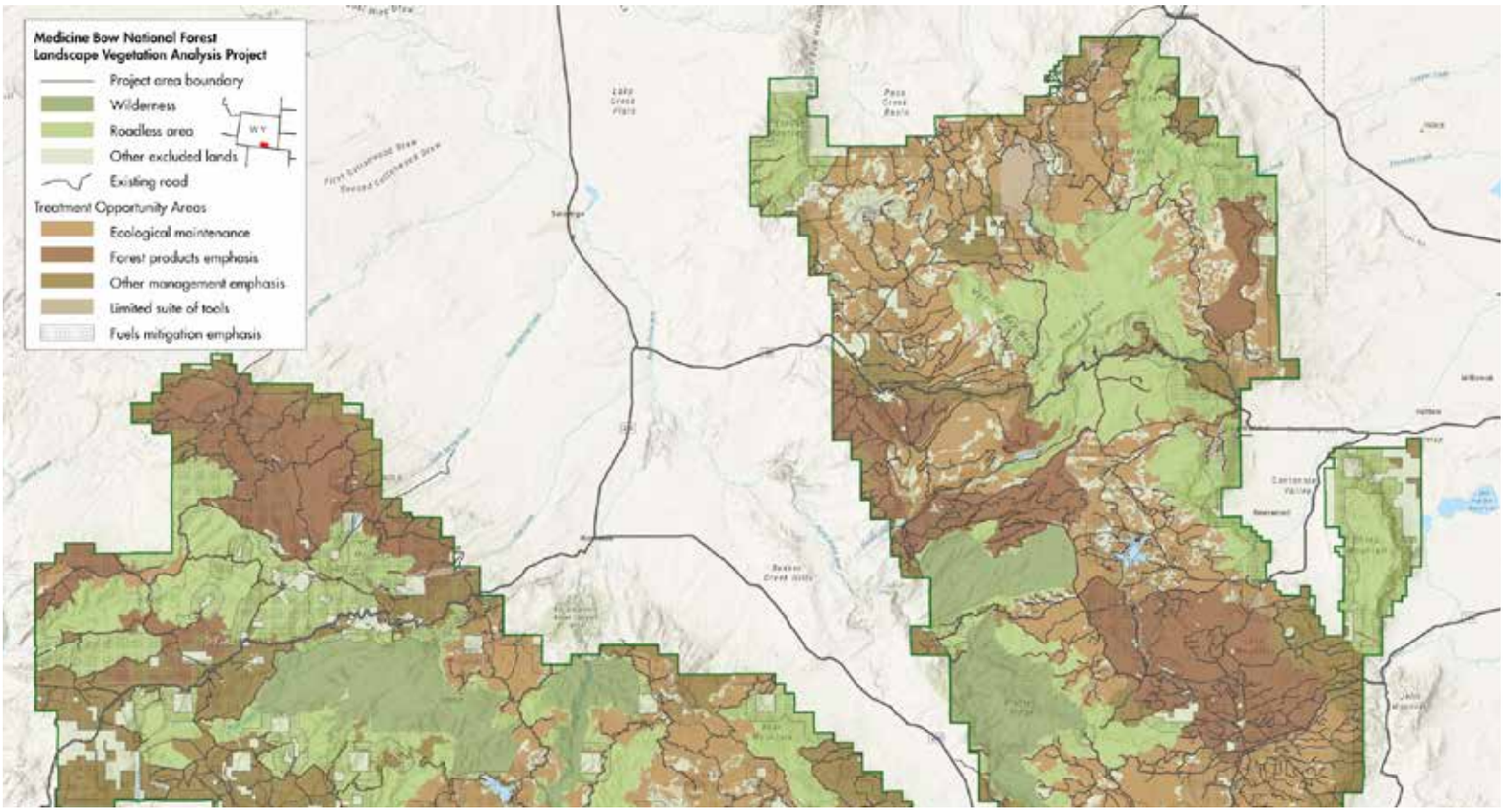
Jess Kraft, Shutterstock

Agencies bet that hundreds of miles of temporary new roads can help a forest

By Nathan C. Martin

The Medicine Bow National Forest is the most densely roaded forest in Wyoming. Interstate 80 borders it to the north, and winding byways bisect its major mountain ranges—the Sierra Madre and the Snowy Range. From these and other paved access points, networks of gravel and dirt roads spiderweb across the territory. Summer brings legions of side-by-sides buzzing along the major arteries and pickup trucks crawling to the end of each bumpy two-track. Cars overflow from the pullouts along the Snowy Range Scenic Byway. Come winter, snowmobile trailers line the highways at the seasonal closure gates, their noisy cargo plowing through the powdery white wonderlands beyond.

Roads are far from the only element reshaping the Medicine Bow National Forest. Warming temperatures have allowed native pine beetles to recently proliferate at unforeseen rates, ravaging the



The Medicine Bow Landscape Vegetation Analysis Project authorizes forest treatments such as prescribed burns, mechanical thinning, and clear cutting during the next 15 years on up to 288,000 acres of the Sierra Madre and Snowy Range portions of the Medicine Bow National Forest to address beetle killed trees and minimize potential for large-scale, high-intensity wildfires. Up to 600 miles of temporary roads may be constructed in this already densely roaded forest to accomplish the project.

timber. Meanwhile, decades of drought combined with warmer weather have turned the forest into a tinderbox—live and dead trees alike burn infernally when it's hot, dry, and windy. Wildfire and beetle kill are natural processes, but they are increasing in frequency and scope.

In the fall of 2020, the Mullen Fire ripped across the Snowy Range, torching 176,000 acres of living and beetle-killed trees, along with dozens of structures. It was the largest fire in Wyoming's recent history. Around that same time, the US Forest Service launched what could become its largest-ever management project in the state, an ambitious effort to confront the new hazards that face the Medicine Bow National Forest.

The "Landscape Vegetation Analysis" (LaVA) Project calls for a suite of commercial logging, prescribed burns, and other treatments for up to 288,000 acres of forest over the course of 15 years. It aims to remove beetle killed trees and reduce the threat of wildfires to private property and public infrastructure, including the aqueducts that furnish drinking water for the city of Cheyenne.

With the approval of the LaVA project, the Forest Service gained wide latitude to conduct these treatments within a 490,000-acre footprint. That's more than half of the Sierra Madre and Snowy Range portions of the Medicine Bow National Forest. In order for crews and equipment to reach the far-flung nooks and crannies of the landscape, forest managers also gained approval to build up to 600 miles of temporary new roads.

For conservation groups and concerned locals, these proposed roads are among the LaVA project's most worrisome aspects. Six hundred miles is the distance the crow flies from these mountains in southern Wyoming to the deserts of southern New Mexico. Sierra Club Chapter Director Connie Wilbert said that, already, "There are a few places you can go and hike and get away from motorized use in the rough, rough terrain. But the idea of adding another hundreds of miles of roads just blows me away. I don't know where they think they're going to put them."

The LaVA project will demand balance: Treatments meant to benefit the forest require roads that potentially inflict harm. The forest managers in charge of LaVA face intense scrutiny, while stakeholders have reason to be vigilant. The LaVA project will significantly shape the Medicine Bow National Forest's near-term future, for better or for worse.

Roads can annoy humans seeking untrammeled wilderness. They can have far graver consequences for wildlife. The Wyoming Game and Fish Department is an official collaborator on the LaVA project, and one of its main aims is to improve wildlife habitat. Treatments like burns and logging can help achieve this goal. But building the roads required to execute them presents a complex cost-benefit analysis.

According to Embere Hall, the WGFD's Laramie Region wildlife coordinator, old-growth timber that covers much of the Snowy Range and Sierra Madre provides little in the way of forage for some of the region's most iconic species. Hall describes the vegetation in these areas as having reached an "apex," beyond which succession from one stage of plant life to another ceases. Once that succession stops, so, too, does the vegetation's capacity to nourish big game.

Disturbances like wildfire, beetle kill, and commercial logging have accelerated plant succession in some parts of the Medicine Bow National Forest in recent years. But overall, the cycle forest-wide has slowed. As mule deer populations in particular wane, Hall hopes removing some of the older conifer stands will help spur

aspen growth, a critical food source for many ungulates.

"We're specifically focused on being able to regenerate certain aspen communities," Hall said. "Aspen are an early successional species, whereby if succession proceeds undisturbed, we'll start to lose those aspen pockets and therefore the wildlife that depend on them. So, making sure we're regenerating aspen, that's a key piece."

While new aspen stands are good for wildlife, new roads cut by bulldozers and traversed by logging trucks are not. Hall said ensuring the roads' harms do not outweigh the treatments' benefits will be an ongoing challenge.

Roads can fragment wildlife habitat, she said, threatening species that need large tracts of unbroken land in which to roam and hide. In addition, they can spoil stream ecology and provide invasion points for noxious weeds like cheatgrass that displace native forage. A road left untraveled is essentially harmless. But heavy traffic can displace animals from their home ranges or natural locations, issuing negative ripple effects through the herd or population.

The best solution, Hall said, will be to build no more new roads than are absolutely needed, allow the bare minimum of motorized use, and then return the roads to their former state as thoroughly as possible.

The tricky part, however, will be monitoring to see whether the treatments are meeting the wildlife habitat improvement targets the WGFD has laid out, and if not, determining whether it's worthwhile to proceed.

"If we're not seeing aspen regeneration, or we're not seeing improvement in the shrub stands, or whatever the specific goal is of the treatment, or we're not seeing the acres impacted that we expected to see for the benefit of wildlife, and we're simultaneously seeing additional roads put on the landscape, that balance starts to shift," she said.

For species such as mule deer, LaVA's benefits will depend in part on whether the aspen grow more robustly than the road network.

LaVA officials are cognizant that road-related issues could counter their progress, and they are keenly aware of public concern over the roads. So, people like Medicine Bow National Forest supervisor Russ Bacon take great pains to stress that the LaVA project's roads will, for the most part, be temporary—ideally like footprints to sweep away when the job is complete.

Bacon said LaVA will rely on the 2,258 miles of existing roads within the project's target area whenever possible. If loggers or burn crews cannot reach a treatment site without a new road—say, a slope to be logged is in a drainage where a two-track exists, but it's on the wrong ridge—a team of engineers, foresters, and biologists will devise the least intrusive path to it.

These teams will consider the disruptive impacts of road construction on the forest's hydrology, avoiding stream crossings, sensitive wetlands, and the addition of sediment to watersheds. They will steer clear of fragile slopes and sensitive plants. The roads themselves will be large enough to accommodate 30-foot logging trucks, but they'll still be narrower than typical roads in the Forest Service's system. These temporary roads will be closed to conventional traffic, so motorists won't grow accustomed to the new routes.

Upon a treatment's completion, the roads will be returned to the earth. "Each road gets its own recipe for decommissioning, depending on the situation and the location," Bacon said. "It's a site-specific exercise from a menu of methods to ensure that we've effectively decommissioned that road."

What's on that menu? Common ingredients include removing culverts, blading roadbeds, installing berms and boulders, concealing road entrances, and using heavy equipment to de-compact the soil, like rototilling a garden. Botanists will use tailor-made seed mixes to revegetate former road areas with native grasses that spread quickly to prevent invasive weeds, as well as forbs and shrubs that establish over time and diversify the ground cover.

A road stretches between beetle-killed trees in the Medicine Bow National Forest.

Under the LaVA plan, no more than 75 miles of new, temporary roads can exist at any given time, and each temporary road should be decommissioned within three years once its treatment is complete.

Unless it's not.

During his half-century teaching, researching, and recreating in the Medicine Bow National Forest, ecologist Dennis Knight has seen "temporary" roads built for a single project, only for the Forest Service to subsequently decide that those roads might serve some longer-term use.

"These are 'temporary' roads—but roads that it turns out will be used for fighting fires well on into the future. So are they 'temporary'?" Knight said.

The LaVA plan includes safeguards against too much mind-changing like this. If more than 5 percent of the project's roads are not rehabilitated within three years, the Forest Service will conduct a formal review. Ten percent triggers a full-blown stop to new road construction.

But other factors—namely, the four-wheel-drive variety—can extend a temporary road's life as well.

Duane Keown, a retired University of Wyoming science educator, questioned whether the perpetually underfunded Forest Service has the resources to keep overzealous motorists off the new roads, before or after they're decommissioned.

Robert Apple, Shutterstock

Hundreds of miles of new roads might be a necessary evil in the effort to cull beetle kill, reduce wildfire impacts, and restore big game habitat. But critics remain uncertain whether the damage of even temporary roads will be worth it.

"They cannot patrol the roads they have. They close off a road and you can see tracks going around the gate. And they plan to patrol 600 more miles of road?" Keown said. "Those new roads are going to be nothing but a challenge for off-road vehicles."

Bacon, the forest supervisor, acknowledged that his agency struggles to keep motorists from establishing new roads around gates and elsewhere through the forest.

"It's pretty amazing how fast those can turn into well-traveled routes," he said. "People come along and they see a four-wheeler track and they go, 'Oh, somebody else went there. I'll drive down that!' The next thing you know you've got an unauthorized road."

Most of the LaVA project's roads will likely, indeed, be temporary. But some, like invasive weeds, could grab hold and persist

Hundreds of miles of new roads might be a necessary evil in the effort to cull beetle kill, reduce wildfire impacts, and restore big game habitat. But critics remain uncertain whether the damage of even temporary roads will be worth it, because they question whether the LaVA project will yield benefits as advertised.

For one thing, significant uncertainty exists as to what, precisely, the LaVA project will entail. Wilbert, from the Sierra Club, said she has a hard time trusting the process when the Forest Service has not outlined where treatments will take place, and what roads will be required to reach them.

"One of our biggest concerns about the LaVA project from day one has been that the Forest Service will not identify where the different parts and pieces of the project will occur," Wilbert said. "They will not say where those potential 600 miles of roads will be built. They will not say where the nearly 100,000 acres of clear-cut logging that they would authorize under this project are going to occur. We just don't know." (The plan approves up to 86,119 acres for clear-cutting.)

The LaVA project will not adhere to the traditional protocols that typically guide stakeholders through the process of vetting proposed Forest Service projects like prescribed burns or timber sales, outlined in the 1969 National Environmental Protection Act (NEPA). Instead, LaVA will operate under a "condition-based" permit, which allows Bacon and his team the ability to identify areas that need treatment and, within parameters, simply act.

Bacon said this new approach is a response to the amount of time required by traditional NEPA processes—time his agency does not have to adapt to rapidly changing conditions on the landscape. The Mullen Fire, he said, which burned a huge portion of LaVA's proposed footprint just weeks after the project was approved, is a prime example of how quickly the forest can transform.

"It's really an acknowledgement of how frustrating it can be to spend years developing a project and make all of these assumptions, only to have things change by the time you get out to implement [the treatment]," Bacon said. "All of those assumptions you made don't apply anymore, you've lost all that effort, and you've lost ground on the need to treat."

Wilbert argues that this approach, while potentially making things easier on project managers, gives the Forest Service blanket authority to greenlight—without due process—logging clear-cuts, disruptive roads, and whatever else it sees fit.

Others maintain that LaVA's nimble approach to individual treatments acknowledges one aspect of the new and variable conditions in the forest resulting from climate change, but it misses the bigger picture. Keown, the retired educator, points to a growing body of research that indicates forests in the Mountain West, already stressed by drought and heat, face increased difficulty recovering from fires. The LaVA project's assumptions that prescribed burns and timber harvest will result in rejuvenation might not be correct.

"What I really fear is that the forest won't come back, hundreds of thousands of acres won't come back," he said.

As LaVA's collaborators prepare to roll out treatments during the coming years, Bacon, the forest supervisor, said his agency is committed to engaging the public, even without the standard NEPA protocols. He encourages people to check the Forest Service's LaVA website, which includes a "StoryMap" with updates about the project's proceedings, as well as notifications about public workshops and project site visits.

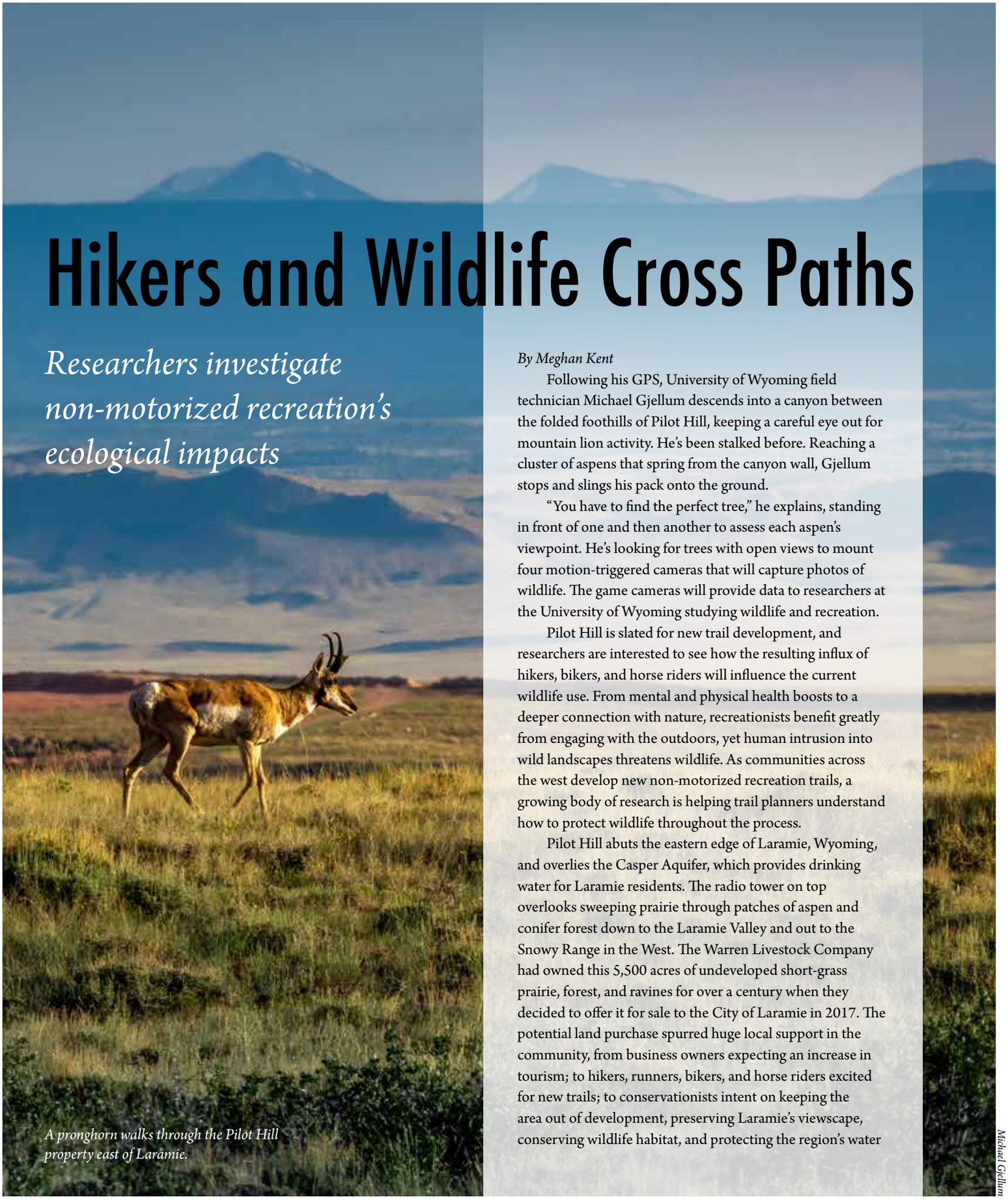
Knight, the ecologist, said he objected to the LaVA project as it was being developed. But he also understands why forest managers are eager to adopt new processes to confront unprecedented challenges. Now that LaVA is underway, Knight encourages anyone who is concerned about the future of the Medicine Bow National Forest to stay productively engaged.

"I think the public should be watching now and be willing to participate," Knight said. "Now that it's a done deal, the public needs to participate in evaluating what the managers think needs to be done and helping them with the process. We need to think of ourselves as partners more than we ever have before."

Nathan C. Martin *is a writer, nonprofit director, and public school board trustee in Laramie, Wyoming.*

Hikers and Wildlife Cross Paths

Researchers investigate non-motorized recreation's ecological impacts



A pronghorn walks through the Pilot Hill property east of Laramie.

Michael Gjellum

By Meghan Kent

Following his GPS, University of Wyoming field technician Michael Gjellum descends into a canyon between the folded foothills of Pilot Hill, keeping a careful eye out for mountain lion activity. He's been stalked before. Reaching a cluster of aspens that spring from the canyon wall, Gjellum stops and slings his pack onto the ground.

"You have to find the perfect tree," he explains, standing in front of one and then another to assess each aspen's viewpoint. He's looking for trees with open views to mount four motion-triggered cameras that will capture photos of wildlife. The game cameras will provide data to researchers at the University of Wyoming studying wildlife and recreation.

Pilot Hill is slated for new trail development, and researchers are interested to see how the resulting influx of hikers, bikers, and horse riders will influence the current wildlife use. From mental and physical health boosts to a deeper connection with nature, recreationists benefit greatly from engaging with the outdoors, yet human intrusion into wild landscapes threatens wildlife. As communities across the west develop new non-motorized recreation trails, a growing body of research is helping trail planners understand how to protect wildlife throughout the process.

Pilot Hill abuts the eastern edge of Laramie, Wyoming, and overlies the Casper Aquifer, which provides drinking water for Laramie residents. The radio tower on top overlooks sweeping prairie through patches of aspen and conifer forest down to the Laramie Valley and out to the Snowy Range in the West. The Warren Livestock Company had owned this 5,500 acres of undeveloped short-grass prairie, forest, and ravines for over a century when they decided to offer it for sale to the City of Laramie in 2017. The potential land purchase spurred huge local support in the community, from business owners expecting an increase in tourism; to hikers, runners, bikers, and horse riders excited for new trails; to conservationists intent on keeping the area out of development, preserving Laramie's viewscape, conserving wildlife habitat, and protecting the region's water

Pilot Hill Research Team, University of Wyoming

Pilot Hill Research Team, University of Wyoming

Research cameras captured images of many different species using the Pilot Hill property.

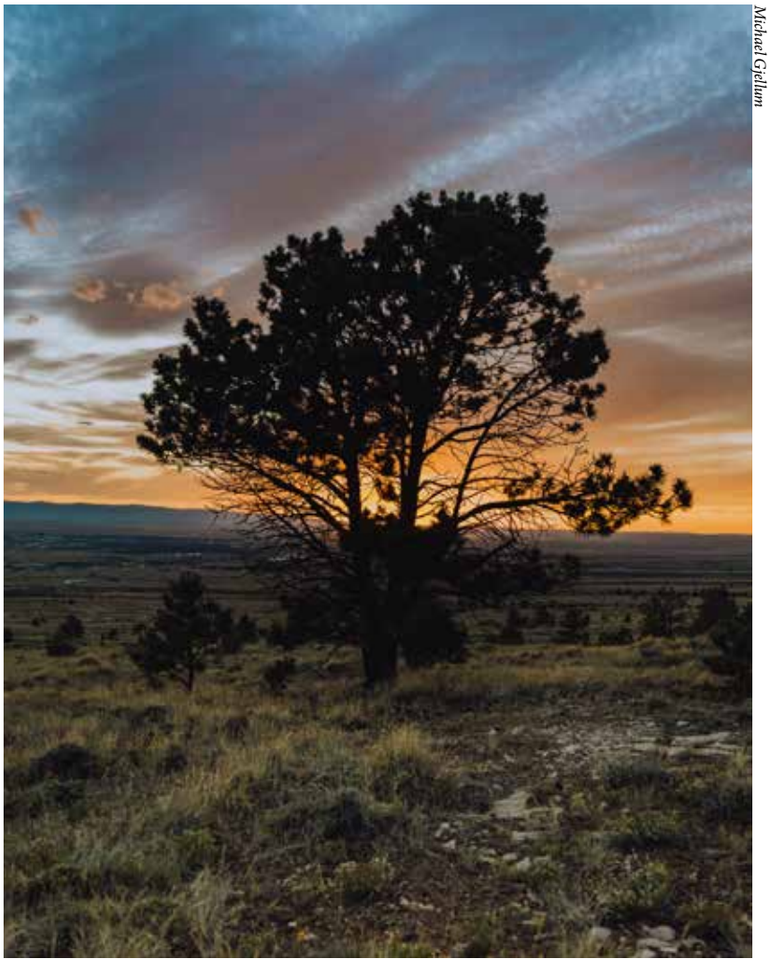
quality. In 2020, the state legislature approved the land exchange that made Pilot Hill public. Over the next few years, the community will build a new 43.9-mile trail network on Pilot Hill connecting to even more trails in the Medicine Bow National Forest.

"If we are strategic about it, we can create an open space corridor for wildlife and for recreation users... and create a huge Central Park, Western style," says Sarah Brown Mathews, executive director for Pilot Hill, Inc., the nonprofit organization behind the land exchange. Mathews highlighted the role of the project in preserving open space as Laramie and the surrounding region grows, benefiting both residents and wildlife.

Laramie is not the only western town building new trails. While total new mileage is difficult to quantify, communities across the country are building new trails on open space, greenways, and other previously private or undeveloped land. Nationally, the Rails to Trails Conservancy has active trail-building projects in almost every state. In 2018, the Verde Valley Cyclists Coalition in Sedona broke ground on a new 29-mile trail system. Salt Lake City plans to build over 40 miles of trail in its northern foothills in the coming years. The "Colorado the Beautiful" project has created 16 new trails traversing hundreds of miles across Colorado. Harnessing volunteer power, the Sheridan Community Land Trust is constructing 22 miles of trail to add to its Red Grade trail system in northern Wyoming. And these are just a few examples.

While communities are embracing new trail development, increasing human activity in wildlife habitat has consequences.

"As we started looking at the ecosystem more broadly, we realized non-motorized recreation impacts pretty much every part of the ecological system" says Abby Sisneros-Kidd, assistant professor at the University of Wyoming. As a recreation ecologist, Sisneros-Kidd explores the interactions between humans and environment when people recreate. Non-motorized recreation spans all sorts of activities, from hiking, biking, and skiing to riding horses, hunting, and fishing. As understanding about recreationist-environment interaction evolves, researchers are turning attention to the nuanced ways recreation affects wildlife.



Michael Gjellum

The sun sets over the Laramie Valley as seen from the upper end of the Pilot Hill property.

"We talk about wildlife as this one collective unit, but different species respond to human disturbance very differently" says Sam Dwinnell, former wildlife research scientist at the University of Wyoming.

For example, researchers at Colorado State University linked the presence of hikers at Vail Pass to elk calf deaths by monitoring radio-collared elk's movements in response to hikers. The researchers found that even seven encounters between elk and hikers during calving season resulted in 30 percent more calf deaths than for elk in areas without human disturbance. Elk may respond to human presence by fleeing, which reduces their foraging time as well as putting increased stress on the newly born calf. Increased fatality is just one way recreation affects wildlife.

In the Appalachian Mountains, researchers used game cameras to monitor how wildlife responded to trail construction. They found that deer and coyotes avoided construction and changed what time of day they accessed nearby habitat after the trail was established to avoid encountering

Pilot Hill Research Team, University of Wyoming

Pilot Hill Research Team, University of Wyoming

humans. Conversely, raccoons used the area more during construction because the exposed soil made it easier for them to catch and eat invertebrates. In this study, squirrels stopped using areas near trails after construction, possibly due to the removal of dense understory making it harder for them to hide from predators.

A 2015 study in eastern Canada found hiker, mountain biker, and dog walker use of trails disturbed birds that nest or forage primarily on the ground. Recreation caused possible interference with breeding behavior, reduced foraging time, altered vegetation near trails, introduced invasive species, and increased presence of nest predators. In this study, the birds did not habituate to human presence even after trail construction ended.

"People tend to be more conscientious of their effects on the mega-fauna on the landscape and just aren't aware of their effects on the small mammals and the less visible species," says Dwinnell.

Thanks to recent research, including the studies above, land managers can better plan for wildlife in trail development and usage.

In Vail, managers now close trails during calving season to prevent hikers from disturbing elk. The Appalachian study suggests shortening trail construction periods and restricting construction to avoid sensitive times like denning or calving seasons to help animals adjust to changing conditions. For species like ground birds and squirrels, leaving more area between trails conserves intact habitat. But it's not all on the land managers. Recreationists must do their part in being wildlife friendly.

"The best thing recreationists can do is to stay on the trail," Sisneros-Kidd says. Staying on the trail concentrates impacts and is more predictable for wildlife, as they can continue to access habitat away from trails without disruption.

As trail development begins on Pilot Hill, "One of the biggest potential impacts is going to be to wildlife," says Sisneros-Kidd. A survey found the community to be evenly split between their interests of recreation development and wildlife protection.

The Pilot Hill organization is aware of the potential to affect wildlife populations. They plan to concentrate trails on the northern half of the property and space them to provide undisturbed habitat as well as improve user experience in the largely open landscape. The southern portion of Pilot Hill is designated as critical wildlife habitat and will remain virtually undisturbed but for a single trail. While undisturbed habitat may be best, "We want to honor that people want to be in that area and plan to establish a trail suited for people who want to be in there and not just have people out creating user trails on their own," says Mathews.

In addition, the Pilot Hill Project will benefit from real-time feedback thanks to Gjellum's game cameras, which are providing critical data to researchers assessing recreation development impacts on wildlife.

> "If we are strategic about it, we can create an open space corridor for wildlife and for recreation users… and create a huge Central Park, Western style."
>
> *Sarah Brown Mathews*

"We have a really unique opportunity to both add to the scientific literature and help sustainably manage this space," says Sisneros-Kidd, one of the faculty members leading the study.

Sisneros-Kidd and colleagues Drew Bennett and Joe Holbrook are conducting a three- to five-year study to track how wildlife respond to Pilot Hill recreation. The researchers hope to determine whether the new trails displace animals or if the animals can adapt. Using game cameras, the researchers are tracking habitat use by animals including elk, mountain lions, pronghorn, and others before, during, and after trail development. In addition to the game cameras on Pilot Hill, researchers are using a nearby private parcel as a control to compare the developed and non-developed areas. Once trails open, researchers will monitor recreational use to assess how animals respond to human presence. Because trail building is expected to come in multiple phases, developers can revise the plan if the research shows trails are disturbing wildlife. With careful planning, land managers aim to create high-quality trails while maintaining wildlife habitat.

After setting the last camera, Gjellum climbs out of the canyon and hikes to a cluster of cameras he mounted months ago on the edge of a conifer forest. He removes the memory cards and downloads the pictures to his laptop. The pictures reveal pronghorn, elk, moose, deer, foxes, coyotes, mountain lions, bobcats, bears… and the occasional dirt biker or hiker trespassing before the land exchange was final.

"The reality of it is, you can have responsible recreation and you can have responsible development that takes into account more of these nuances of how animals respond to humans," says Dwinnell, "We have these creative solutions at our fingertips that we rarely talk about. We need to talk about them more and implement them in how we design trails."

Meghan Kent *was the summer 2020 Science Journalism Intern for the Ruckelshaus Institute. She is a master's student in the Department of Ecosystem Science and Management and the Haub School of Environment and Natural Resources at the University of Wyoming.*

Reclaimed Wildness

Riding Coal Basin's closed mining roads

Doug Stenclik

Author Manasseh Franklin pedals into Coal Basin.

By Manasseh Franklin

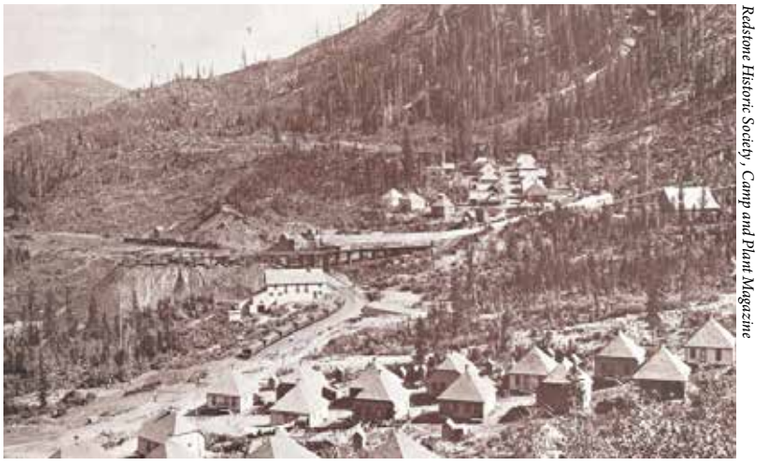
While quietly pedaling a narrow, paved road near Redstone, Colorado, I rounded a corner and came face-to-face with a small black bear. The bear leapt in surprise when it saw me and crashed up the steep roadside through scratchy brush. I was alone, 16 miles from cell service, and no one knew that I was heading into the old Coal Basin mine site.

I had never been to Coal Basin. The tight, slate-rimmed feature on the eastern edge of Colorado's Grand Hogback is home to a closed coal mine that was once an economic driver in the Crystal Valley. During its years in operation, 1900–1909 and then 1956–1991, more than 29 million tons of coal were extracted from the mine. It was a major employer of nearby Redstone and Carbondale. In fact, the cute boulevard of Redstone, now a prosperous enclave of second homeowners and eccentrics, was originally built as a company village to house mine workers.

Despite its substantial contributions to the valley, I'd heard bad things about the mine. A ranch manager I knew who'd worked there as a teen called it "awful." Newspaper articles from the 1970s and '80s reported that the mine violated numerous environmental regulations. And in 1980, 15 miners died in an underground explosion. Following a series of additional explosions in 1991, the mine came to a shuddering halt.

An extensive $4 million reclamation project followed the closure. Over the course of ten years, 15 miles of haul roads were regraded, widened, and replanted; five primary mine entries were filled in; buildings were dismantled and removed; and concrete slabs and culverts were implanted to return diverted streams to their original courses. Under the jurisdiction of the US Forest Service, the land was then left to rewild itself. But to say it still had an eerie air around it is an understatement.

And it was—at least by conventional standards of pristine natural beauty—damaged goods. The mine's dark history of human carelessness, greed, and environmental degradation stood in direct contrast to the wild beauty of the nearby Elk and West Elk mountain ranges. Since the mining days, Carbondale has become a rarified recreation hub thanks to its easy access to endless wilderness, flowy polished mountain bike trails, and wild undammed rivers.



Redstone Historic Society, Camp and Plant Magazine

A town in Coal Basin housed 265 miners during the mine's early active years.

The most notable human imprints in those spaces are occasional gates for roaming cattle. Just as miners once came to the area for work, residents and tourists alike now flock there for its untrammeled open spaces, its calendar worthy scenery.

I too had been drawn to the area by its access to unfettered mountain

History Colorado, Accession 87.41.5

A boiler plant spewed steam in Coal Basin sometime between 1890 and 1910.

Coal Basin, I discovered, was not its history of destruction and greed; it was a portal to a new kind of experience in nature, one that dismantled conventional definitions of wildness and made them anew.

beauty. In more than a decade of living in the valley, I'd steered clear of Coal Basin because I considered it the antithesis of the wilderness experience I sought and valued. But in recent years my perspective had begun to shift: Weren't machine-cut mountain bike trails also a sign of human impact? Was "pristine" beauty real or a manufactured ideal? Could "used" nature could be just as beautiful as conventional, coveted "wildness"? I ventured into Coal Basin in search of answers.

Undeterred by the bear encounter, I continued pedaling. Around each bend in the road, the basin grew larger, the silvery layers of its shale mountainsides steeper. Pavement ended at a large dirt lot and a USFS gate bearing a NO MOTORIZED VEHICLES sign. I gazed at imposing ridgelines that rose 3,000 feet above, seeming to form an impenetrable wall between me and the rolling subalpine terrain beyond. The mountainsides were not in fact impenetrable, though. Long diagonal scars were etched across them—old road cuts.

I ducked under the gate and pedaled up the gravel road to where it forked at a derelict concrete structure—the former wash plant for the mine. A stiff breeze stirred the sharp autumn air, rattling a loose metal flap on the abandoned building roof. I eyed the building warily before choosing the right fork and crossing a shallow creek lined with thick black plastic. Later, I would learn it was one of the creeks that had been re-routed for the wash plant.

The wide road had been crudely sliced into the silvery crumbling mountainside and led into shadowy steep ridges reminiscent of Mordor. Shaley gravel crunched under my tires with each timid pedal stroke. My senses tingled, made alert by the strangeness of the derelict wash plant and the imposing walls of the basin I ascended toward. Metallic clouds clustered on the high ridgelines. The wind gusted with short, erratic bursts. This place is wild, I thought, my neck hairs prickling.

The next gust blew a wave of cold rain that prompted me to tug on my rain shell. I paused and gazed through rain-streaked glasses into a maze of road cuts that riddled the surrounding slopes. Alarmed by the turning weather, the fact that I had only encountered one bear and no humans over the past several hours, and an inexplicably odd feeling, I retreated and vowed to return again.

A winter passed. Spring slowly emerged in lime green aspen shoots and shy yellow glacier lilies. Once the high elevation snow had receded, I embarked into the basin again, this time with a bike partner and a map. The shallow stream was not so shallow; we soaked our bike shoes crossing it. The road cut was flush with orchard grass, timothy, and mountain brome so high it brushed our elbows. This time Coal Creek emerged from the basin's heights as a pulsing waterfall that plunged into the valley below.

We turned at a high fork and followed yet another wide road cut that traversed a broad mountainside before climbing steeply. It disappeared suddenly around 10,000 feet elevation at what I guessed had been the entrance to one of the mines. We retreated.

Over the subsequent summer, enticed by the mystery and strangeness of the basin, I returned again and again. The chunky, wide roadcuts were a far cry from groomed mountain bike trails, and that somehow made them more interesting. Some roads climbed as high as 11,000 feet, leaving me panting and pushing my bike through rock rubble that had crumbled off the mountainsides. I encountered rusted machinery, warped edges of giant culverts sticking out of the ground, clusters of wandering cows, and one day a herd of at least 100 sheep under the watch of a single small border collie.

I noticed also that I was not the first to explore the roads by bike; others had made trails off of them. A road would give way to single track that led to high points with sweeping views I would otherwise never have seen.

On the many rides into the basin, I encountered more black bears than I had during all of my years wandering established wilderness trails in the area. I came upon dense clusters of columbine and rosy paintbrush to rival any high mountain meadow. I explored miles of primitive trails that I often lost and had to backtrack to find again. Coal Basin, I discovered, was not its history of destruction and greed; it was a portal to a new kind of experience in nature, one that dismantled conventional definitions of wildness and made them anew.

Manasseh Franklin *has an MFA in creative nonfiction writing and environment and natural resources from the University of Wyoming and is editor of the online ski publication WildSnow.com. She lives in Redstone, Colorado.*

Intersecting Roads

The need to value and safeguard wildlife movements

Perspective from Corinna Riginos

Roads may well be humankind's greatest source of metaphors, inspiration for a plethora of phrases about journeys and all the bumps, bends, twists, and turns along them. Even the word *metaphor* here is a play on words, because a metaphor means, literally, a transportation. Roads are, indeed, our greatest source of transportation, conduits for the movement of goods, the physical movement of people and culture, and the journeys within our souls they so often bring about.

Now let's imagine that other species have roads just as important to them as ours are to us, only we can't easily see them. Let's re-visualize a map of the West that has not just our human interstates and highways, but also the scores of regular animal movement paths overlapping and intersecting them. Recent studies using GPS collars show us the deer and pronghorn highways that entire herds use to migrate from their winter to summer ranges and back. Their highways intersect ours and continue on through landscapes most of us will never see, because our human roads do not go there. We may not see these paths, but for deer they are just as vital as our roads are to us.

When we visualize it this way, it begs us to ask: how do we manage the flow of traffic at these junctions? This is the question we need to answer in order to address the problem of roads for animals and people.

Roads have two major impacts on wildlife. The first is easy to see and understand: vehicles hit wildlife on roads, killing them, injuring people, and damaging vehicles. We have estimates of the costs of these collisions: $50 million per year in Wyoming, alone.

Yet, it is the second problem, more difficult to measure and see, that is a greater concern for our wildlife: roads create a connection challenge for entire networks of animal paths. In a study I recently completed, I found that mule deer need at least 30 seconds between consecutive vehicles to get across highways. When there are too many vehicles, too close together, deer give up their attempts to cross. That means that for many hours of the day, on many roads in the West, animals cannot get to their habitat on the other side. Major highways can even be a total barrier; we see this in animal movement paths, as hundred-mile journeys abruptly dead end when they reach the most heavily trafficked roads.

Here in Wyoming, we are starting to make some progress on the problem. Scientists are working extensively to map big game movement routes and share the stories of the animals that traverse them. This storytelling makes animals' journeys, with all their twists and bends in the road (real or metaphoric), relatable to people. We have mapped the areas with high numbers of wildlife-vehicle collisions and used economic analyses to show the monetary benefits of fixing those spots with wildlife crossing structures. We have built a number of these highway under- and overpasses and seen that they dramatically reduce collisions, allow animals to move back and forth across roads, and save more money—in terms of collisions avoided—than they cost to build. We have used the science and stories of migration and collisions to bring together diverse stakeholders, leading to a statewide strategy on roads and wildlife and millions of dollars in new funding to ensure safer passages.

Yet, there is more we could do. We place high cultural and economic value on keeping abundant herds of big game in the West, but we lack a way to express the value of the free movement that sustains these herds—or, conversely, what we lose in animals and dollars by cutting off their movements with obstructions like roads. Putting numbers to these ideas is difficult and even controversial, but it could open opportunities to further justify the benefits of crossing structures, or other fixes, to humans and wildlife. My hunch is that the economic value of sustaining migrations is substantial, and that defining this value would increase the range of funding options and tools for keeping these wildlife highways open.

Even without hard quantification, we could do a better job of valuing animal movements and the role they play in keeping our wildlife healthy and abundant. Imagine our human world without roads and travel. The pandemic has given us a glimpse of this, and we don't like it. Our lives are less rich—literally and metaphorically—without our roads. The same can be said for our wildlife. Let's ensure we can all continue our journeys, on all of our roads.

***Corinna Riginos** is the Director of Science for The Nature Conservancy in Wyoming and an adjunct associate professor at the University of Wyoming. She has been studying roads and wildlife and working with agencies on this issue since 2012.*

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Daniel J. Rao, Shutterstock

Highway across the Shoshone River near Cody, Wyoming.