

An aerial photograph of a mountain landscape. In the foreground, a dense forest of evergreen trees covers a steep slope. A road is visible at the bottom right, with a small structure or bridge crossing a stream. In the middle ground, a large lake is surrounded by a mix of trees and open land. The background shows rugged mountains with patches of snow and sparse vegetation.

# Putting the **CROSSHAIRS** on **DEADLY** Crossings

*by Christine Paige*

*Which kills more wildlife in America every year, bullets or bumpers? If you guessed the latter, you are, unfortunately, correct. It doesn't have to be this way.*

In the past decade, vehicles surged ahead of hunting as the leading cause of wildlife mortality in the US, indiscriminately killing everything from fox squirrels to Boone & Crockett bulls. Vehicle collisions take a massive toll on un hunted wildlife as well.

If you have ever hit a deer, elk or any other creature—and chances are good you have—you know it's a moment that remains seared in your memory. Yet those moments and the roadkill they produce have become so commonplace as to seem inevitable, a brutal but necessary "cost of doing business" for everyone who climbs behind the wheel. Recent advances in how we design and build roads, though, show that death toll is anything but inevitable.

The past few decades have brought a kind of renaissance in how we look at roads and wildlife. The rapidly growing science of road ecology has deepened our understanding of the impacts of roads on natural communities. More importantly, it is finding solutions to those impacts and changing the shape of highway construction projects around the world.



**WALK OF LIFE**—One of six wildlife overpasses spanning the Trans-Canada Highway in Banff National Park, Alberta.

## Design It Right and They Will Cross

In the early 1960s, hunter associations in France became alarmed at a relatively new development—highways—that were killing off prime game faster than a ring of poachers. They urged local governments to act, which resulted in the world's first wildlife bridges. In the 1980s, Florida began installing underpasses for endangered Florida panthers in the redesign of I-75 through Alligator Alley. This was the first major instance in which landscape connectivity for wildlife was integrated into highway planning in the US. Still, these were early days in road ecology and many of the wildlife crossing structures were basically glorified culverts or concrete tunnels under roadways. There was little understanding of what animals might actually use or why.

We've come a long way. The past two decades of research by engineers and wildlife scientists—some of it funded by the RMEF—have shed a lot of light on wildlife behavior, movements and responses to different structure designs. Today's crossings run the gamut from underpasses beneath the roadbed to bridges spanning streams or draws, and the

granddaddy of them all: massive, soil-covered overpasses that arch across highways and cost millions to construct. Many under- and overpasses are planted with vegetation to provide cover and feel as natural as possible to wildlife. Most motorists zipping by wildlife crossings never even notice all but the most obvious structures.

Each new design attempts to build on the lessons of previous crossings and cater to the unique needs of the local wildlife. Engineers have designed passages over and under roadways for everything from elk, moose and bears to fish, salamanders and tortoises. With human safety in mind, most projects have focused on hotspots for collisions, but an increasing number are also being designed to sustain broader-scale connections for wildlife such as large migration corridors.

## Arizona Highways: Built for Elk

Arizona's Mogollon Rim has a remarkable knack for producing Boone and Crockett bull elk. At the Rim's base, though, State Route 260 lances through the heart of this elk nebula.

## DEADLY DATA

**Crossings not Crosses**—Collisions with large ungulates (deer, elk, moose, domestic cattle and horses) result in more than **200 human fatalities** and **26,000 injuries** in the US every year.

**Crossed Out**—In a 2008 Federal Highway Administration report to Congress, researchers estimated that vehicles collide with at bare minimum **4,000 large animals** every day. That's almost 1.5 million per year.

**Highways to Hell**—Nearly **90 percent** of animal collisions occur on high-speed highways. Highways account for more than three-quarters of all paved routes in our country, some **4 million miles** of pavement. That's the equivalent of eight round trips to the moon.

**Caught in the Web**—There are more than **1.2 miles of road** for every square mile of land in America and over **250 million cars and trucks** on US roads.

Collectively, Americans drove **3 trillion miles** in 2014.

**Cross-Examining the Costs**—The average cost per collision with ungulates (in 2007 dollars)—including damage to vehicles, medical and emergency services, law enforcement, carcass disposal and lost hunting revenue—ranges from \$6,600 for a deer to **\$17,500 for an elk** and more than \$30,000 for a moose. In total, with all of the deer, elk, moose and other ungulates hit on our highways, the cost of vehicle collisions with ungulates in the US each year tallies up to a staggering **\$8 billion**.

**Wildlife Savings Time**—Cars collide with wildlife every day, and at all hours, but the highest number of elk and deer are hit **during the rut** in the fall, followed by **spring**, when animals are heading back to summer range. **Calves and fawns** are also extremely vulnerable. As every hunter knows, wildlife rush hour comes at **dawn and dusk**, when traffic densities are often at the maximum.



MARK GOOKE

Biologists long ago identified 260 as a major hazard to this storied herd. As the Arizona Department of Transportation (ADOT) prepared to expand the highway from two lanes to four near Payson, wildlife managers pushed to see it address their concerns that widening 260 would increase collisions and decrease the ability of a host of wildlife to make use of vital habitat on both sides of the road. ADOT proved agreeable, and came back with a major redesign looking to protect elk in particular.



**ANGLE OF REPOSE**—trial and error in Arizona showed elk vastly prefer underpasses with natural dirt slopes (above) and shun those with vertical concrete walls.

Elk here spend much of their time foraging in riparian meadow habitats near the highway corridor. Completed in the early 2000s, the reconstruction included 11 wildlife underpasses, six landscape bridges over canyons and streams, and exclusion fences to funnel animals to crossing structures. Arizona Game and Fish Department (AGFD) biologists were able to track GPS-collared elk and use trail cams to monitor how elk crossed the highway both before and after crossings were installed. Here's what they learned once the crossings were built.

"With the cameras, we documented about 15,000 animal crossings in total, and 7,830 of those were elk," reports Jeff Gagnon, AGFD statewide research biologist. "Eleven thousand were through the wildlife crossings."

The research revealed the importance of exclusion fence blocking off the highway to wildlife. In locations with limited or no elk-proof fence along the

highway, animals ignored the crossing structures, just as you might jaywalk instead of walking up to a safer crosswalk at an intersection. Why bother to go around when you can cut straight across, point A to B? In one reconstructed section with underpasses but no fences, collisions actually increased as the amount and speed of traffic rose after construction. Fences proved key.

"Where 8-foot fence was installed to guide animals to crossings, elk-vehicle collisions dropped almost to zero," says Gagnon. Fencing funneled animals to the underpasses and helped them adapt to using the crossings. Without fencing, the underpasses stood vacant.

AGFD biologists have been applying the lessons from SR-260 elsewhere in the state. As Arizona looks at future highway upgrades, they plan to incorporate crossings in areas with collision hotspots and highly prized wildlife resources.

"We have seven different species we work on with crossings, including mountain lions, Rocky Mountain and desert bighorn, mule deer, white-tailed deer, pronghorn, desert tortoise and flat-tailed horned lizards," says Gagnon. "But elk gather attention more than any other animal."

Biologists are learning to see crossings from different species' perspectives. Gagnon's research, for instance, has shown that elk appear to be more sensitive and wary of certain underpass designs than deer.

"For the most part, elk won't go through smaller structures where deer will," he says. "Elk need an underpass 20 feet high and a minimum of 50 to 100 feet wide."

Structure size is not the only consideration. Two highway bridges of similar size and length were installed on SR-260 to span wildlife passages under the highway. One wildlife passage had vertical concrete retaining walls beneath the highway bridge, while the other passage had natural dirt slopes on either side. Elk avoided the underpass with vertical walls, appearing wary of the ledges atop the walls, but they used the underpass with natural slopes without hesitation. Over four years, elk eventually adapted to using both underpasses, but the one with natural slopes saw twice the use. ADOT took this insight to redesign underpasses in the next phases of highway reconstruction, contouring natural slopes and adding trees and shrubs for cover.

Another important consideration for many animals, particularly elk and deer, is a clear view to the opposite side of the crossing structure. Prey animals are always on alert for the possibility of ambush. On the SR-260 project, elk were reluctant to use an underpass that crossed the highway at an acute angle where they could not see all the way through. In contrast, they readily crossed a similar underpass with a clear view to habitat on the far side.

## Maple-Leaf Flagship

Conversations about successful wildlife crossings often begin with the landmark project in Banff National Park, Alberta. Between 1982 and 1997, Canada embarked on the largest landscape-scale crossings project ever undertaken. It focused on Canada's busiest transportation corridor, the four-lane divided Trans-Canada Highway that knifes through some of the most spectacular and wildlife-rich country in North America.

The Trans-Canada bisects the park and presented a major hazard to wildlife, with potential for isolating populations on either side. In 1990 researchers predicted that Banff's population of 800 elk would decline to 175 animals by 2010, primarily due to vehicle collisions on the highway. A 1996 report found that the highway accounted for nearly half of all

known ungulate and carnivore mortality in the park.

Along 50 miles of highway, engineers installed 44 crossings, including 38 underpasses and 6 large overpasses planted with native vegetation. Miles of wildlife-proof fence kept animals off the highway right-of-way and directed them to the under- and overpasses. Where fences combined with safe crossings, large wildlife collisions dropped at least 80 percent and in some places by 97 percent. Trail cams have since recorded more than 150,000 critter-crossings on and through these structures and counting. Those cameras show that elk prefer open overpasses three-to-one over underpasses. Deer, moose, grizzlies and wolves display similar tendencies.

"Almost all species prefer larger structures, especially overpasses," says Tony Clevenger, research

## CROSSWALKS FOR ELK

Wildlife underpasses and overpasses are costly and require coordination with planned highway upgrades and redesigns, often taking many years before projects can be completed. Another approach is to try to change the behavior of drivers instead of wildlife at collision hotspots.

On SR-260, Arizona has had some success installing an "elk crosswalk" using an animal detection system to alert drivers to wildlife in the road. Unlike static signs or electronic reader boards warning motorists about the possibility of wildlife in the area, this system uses an infrared sensor to detect the presence of animals—anything coyote-sized or larger. An electronic wildlife warning sign only comes on when animals are actually present, so drivers don't become habituated to the caution sign.

Research has shown that the detection system is effective at getting drivers to brake and slow down at least 10 mph. Before installation of the crosswalk, about a dozen elk were killed in that section of road annually. Since 2007 when the system was installed, only two elk have been hit in total. This system shows potential for low-cost mitigation at collision hotspots, especially for elk and other wildlife that

habitually use a particular corridor to cross a roadway.

Colorado employed a similar setup on the outskirts of Denver after the suburb of Golden built a golf course next to four-lane US Hwy 6. Its greens attracted elk from the dry foothills above to cross a road that sees bumper-to-bumper traffic every rush hour. Following a series of accidents including five with human injuries, highway engineers responded, fencing off the worst section, save for

one gap: a wildlife cross-walk marked by rumble strips and elk-detecting warning lights. The herd soon figured it out. They now pause and wait anywhere from 10 minutes to an astounding three hours for gaps in traffic to cross, says biologist Francesca Tordonato with the Colorado Department of Transportation. Unfortunately cars aren't slowing down as much as designers had hoped, so CDOT may look into investing in a wildlife underpass.

*"It's kind ironic that we're able to change animal behavior that has been around for eons, but people resist changing their ways to slow their speed."*

—Jeff Peterson, CDOT wildlife program manager



**CROSSED UP**—Despite a specially designed wildlife crosswalk on the outskirts of Denver, elk sometimes wait three hours for a gap in traffic to survive US 6.

wildlife biologist with the Western Transportation Institute at Montana State University, which conducted the monitoring studies in Banff. “We haven’t figured out the threshold, but the larger the better. These are the most effective crossings in Banff.

“The learning curve is quicker for elk and deer than for grizzlies, black bears, wolves and wolverine,” Clevenger continued. “Once they find the structures, they use them. Elk even bed down inside them in summer to escape the heat. They don’t tend to find predators nearby, and they adapt to the traffic noise.”

Bears took several years to adapt, but recent DNA analysis from hair-snares verified that grizzly and black bears of both sexes now make regular use of the passages en route to seeking food, shelter and mates on both sides of the Trans-Canada. This helped ease biologists’ concerns that the busy highway was separating bears genetically. DNA tests confirm sufficient gene flow to keep Banff’s bear populations healthy over the long haul.

### *Migrating through the Meat Grinder*

Just north of Craig, Colorado, Highway 13 traverses what is likely the busiest elk migration corridor on earth. Every fall as many as 20,000 elk pour forth from the Elkhead Mountains onto a sage-covered plateau west of the highway known as the Great Divide. A narrow two-lane road with a 65-mph limit, 13 is the main connector to I-80 across the border in Wyoming.

“If you were to walk from Craig to Baggs, Wyoming, I don’t think you could go 25 feet without coming on bones,” says Jamie Skidmore, a fifth-generation native of the area. The highway offers

no shoulders and barely room for the frequent coal trucks to pass one another.

“In the spring and fall the road is literally littered with elk and deer corpses, and bald eagles are all over the roadkill,” Skidmore says. “It sounds gruesome, and it is. In the spring you can smell the stench. It’s a tragedy, especially when a third of our economy depends on hunting and you realize how much those animals contribute.”

A Colorado Parks and Wildlife study found that hunters inject \$26 million every year into the coffers of Moffat County, where Craig is county seat. Elk hunters are the main cash cow.

Michael Vanderhoof, planning and environmental manager for Colorado Department of Transportation, says CDOT is currently evaluating several projects to improve safety on various stretches of Highway 13, but they’re still in the planning stage.

“We fully recognize the value of wildlife in

Colorado,” Vanderhoof says.

“Unfortunately, in the area of heavy elk migration [north of Craig], the highway has already been reconstructed and there is no additional work proposed for the foreseeable future. We’re aware of the problems, and in a world of unlimited funding we would have addressed things differently.”

Vanderhoof emphasizes the importance of local involvement in the planning process. That can translate into showing up at a bunch of fairly bureaucratic meetings, but it can also make a huge difference on the ground. He stresses the value of private-public funding partnerships to demonstrate commitment, leverage federal funding and spur more innovative solutions, saying, “Any outside the box thinking would be welcome.”

*“If you were to walk from Craig to Baggs, Wyoming, I don’t think you could go 25 feet without coming on bones.”*

—Jamie Skidmore



GARY KRANIER

Meanwhile, south of Craig on 13 between Rifle and Meeker, CDOT aims to reconstruct the highway with wildlife exclusion fence and four underpasses. And to the east near Kremmling, CDOT is launching its most ambitious wildlife-friendly highway renovation yet. On two-lane State Highway 9, the state is installing 7-foot wildlife fences, five underpasses and Colorado's first wildlife overpasses—two of them. The project will also widen highway shoulders and improve the roadway for driver safety.

through. By the third year, passage rates were up to 92 percent as deer gained confidence and adapted to the culverts. Elk were caught on camera using the passes as well. Meanwhile, vehicle collisions with deer dropped 81 percent.

"The underpasses effectively solved the problem," says Sawyer. "This was essentially the first wildlife crossing success story for Wyoming."

Completed in 2007, it paved the way for more ambitious projects. Thousands of mule deer and



**TUNNEL OF LOVE—With 7-foot roadside fencing acting as a funnel, underpasses have proven incredibly effective at allowing everything from alligators to otters to elk to cross busy roads unscathed.**

"This is our crown jewel right now," says Jeff Peterson, CDOT wildlife program manager. "The project is primarily for mule deer, but also definitely elk and pronghorn."

### *Poster Child to Success Story*

In the past two decades, Wyoming has invested tens of millions in wildlife crossing structures. The turning point came on a 13-mile stretch of Hwy 30 through Nugget Canyon west of Kemmerer. The area overlaps with winter range and a migration route used by thousands of mule deer. In the 1990s an average of 130 deer were killed along the stretch each year.

"It was a poster child of deer collisions," explains Hall Sawyer, research biologist with Western Ecosystems Technology, Inc. "Wyoming Department of Transportation went through years of different mitigation efforts to slow traffic." Finally, WDOT installed seven underpasses at collision hotspots where deer traditionally attempted to cross and linked them with wildlife-proof fence.

Over three years of monitoring, deer steadily increased use of the underpasses. In the first year, 54 percent of deer that approached the crossings went

pronghorns winter in the sagebrush of the Green River Basin near Pinedale before migrating north to summer range in the Gros Ventres and Wind Rivers. Unfortunately, US Highway 191 slices directly across that corridor, forcing thousands of animals to cross the highway come spring and fall. With the input of biologists, WDOT constructed six wildlife underpasses and two large overpasses along 12 miles of highway from Bondurant to Pinedale, flanked by 13 miles of wildlife-proof fence with jumpouts. The overpasses sit at key crossing hotspots, 150 feet wide and planted with native forage plants. Berms help to block animals' view of traffic below.

Motion-triggered cameras showed in the first year more than 36,000 animals —9,228 pronghorn and 26,843 mule deer—used the structures, not only during migration but throughout the winter months. There was also a striking division between the species. Eighty percent of the mule deer used the underpasses, while 90 percent of the pronghorn stuck to the great wide open of the overpasses. Elk and moose have also taken to the crossings, and in perhaps a first, sage grouse hens were caught on camera ushering their broods through an underpass.

# WORLD-RECORD ROADKILL



**THE LATE GREAT**—one of the last photos taken of the new #1 bighorn before its demise.

Alberta Highway 40 recently killed the new Boone and Crockett world's record rocky mountain bighorn sheep. Actually, an unidentified driver dealt the fatal blow. The massive ram was able to leave the blacktop, but a ranch foreman found the bighorn's carcass not far from the highway southwest of Calgary. He then got a possession permit from Alberta Fish & Wildlife before sharing it with B&C to be scored.

The ram's official score of 209  $\frac{3}{8}$  tops the previous record by more than an inch. That ram was killed by a hunter in 2000 on Luscar Mountain west of Edmonton, Alberta. Boone and Crockett accepts legally obtained "picked up" or found trophies, including not only those that die of natural causes but animals struck on highways, and occasionally, poached game confiscated by wildlife agencies.

Alberta has produced all of the top six B&C bighorns. Not surprisingly, the Alberta Minister's Special Bighorn Sheep Permit, which allows a hunter to hunt anywhere within the province during any season, has auctioned for as much as \$405,000 (US). The magnificent ram that recently became the new world record had lived 14 years before being hit on the highway. He was well known in the area.

"This ram and a younger ram had lived on the ranch where I worked since 2009," the rancher told Boone and Crockett. "The older ram would go down to the highway a couple times a month, but the younger ram would rarely follow. We always wondered if one of these trips to the highway would be his last."

—Bugle staff

## *The Balance Sheet*

A well-designed animal overpass that spans a two-lane highway can cost \$4-5 million and twice that amount to bridge a four-lane. Underpasses are far cheaper, but still run several hundred thousand dollars, depending on their dimensions. Combine that with fencing costs and you have a huge investment. Are they worth it?

Rob Ament, road ecology program manager with the Western Transportation Institute (WTI) at Montana State University, is convinced they are. And he backs his claim with compelling numbers.

"Crossings can justify their cost to society," says Ament. "There's a net savings to the public, and it gets paid back fast."

Wildlife crossings across the West have cut wildlife collisions by 70 to 90 percent in the areas where they have been installed and those results are well-documented. A 2009 cost-benefit analysis published by the WTI at Montana State University found that the cost of the optimum combination of elk-proof fences, jump-outs, overpasses and underpasses breaks even if a stretch of road kills three or more elk per mile per year. That estimate takes into account the full cost of the crossing structures along with their maintenance and replacement over 75 years, balanced against the cost of collisions to drivers, insurance companies and the public. Highways that kill seven deer or more per mile every year break even as well.

Marcel Huijser, a research ecologist at WTI, says these analyses are based on the costs/benefits for human safety and are extremely conservative. They do not take into account the economic value of having healthy wildlife populations on the landscape, including trophy animals such as large bull elk or bighorn rams. The economic values of threatened and endangered species aren't factored into these analyses, either.

"Wildlife mitigation measures are not only good for human safety and biological conservation, but also make economic sense," Huijser says. "Even if you do not care about human safety, even if you do not care about biological conservation, but if you only care about your wallet, mitigation measures can still be a wise investment. They do not necessarily 'cost' money, but can be regarded as a cost saving, when compared to doing nothing."

However convincing the data might be, though, the expense of such projects remains the fundamental hurdle. Ament says getting over that bar in more places across elk country hinges on partnerships.

"Who is responsible?" he asks.

Federal and state highway departments have no directive to address wildlife, but they are charged with public safety. Wildlife departments and hunters

have the most to gain. But insurance companies stand to realize major savings by cutting wildlife collisions as well. What gets most projects approved is a collective push from local communities and multiple other interests that all stand to gain by taking a share of the responsibility.

“When partnerships come together, we get more conservation projects for wildlife,” Ament says.

The federal government helps fund both state and federal highway improvement projects. These dollars have the potential to be invested in efforts that address wildlife collision hotspots for public safety. But wildlife crossings are usually an add-on, folded in when a highway is due for other major upgrades. Although crossing projects can take years to come to fruition, local communities play a crucial role in lobbying for wildlife crossings, and taking part throughout the planning stages to see that highway reconstruction is designed with wildlife in mind.

In 2012, Congress passed the first national transportation bill to directly address the impacts of roads on wildlife. The “Moving Ahead for Progress in the 21st Century Act” (MAP-21) gives authority for state, federal and tribal managers to make efforts to reduce wildlife vehicle collisions and improve habitat connectivity in road projects. In effect, it’s a green light to take into consideration wildlife and landscape connectivity in addition to human safety on highway projects. Combine that with a growing push to rejuvenate our nation’s aging highway and bridge infrastructure, and this may well present the best opportunity to integrate wildlife-friendly modifications America has ever seen.

“This issue is nonpartisan,” stresses Ament. “Everyone gets this: we have to protect wildlife and people.”

*Christine Paige is a wildlife biologist and writer who wanders the wilds from her home in Driggs, Idaho.*

## RMEF CROSSING WORK

In 1986 when RMEF was only two years old, the organization put its first dollars down to help elk cross roads more safely. The project placed experimental reflectors that help warn wildlife of approaching vehicles along a one-mile stretch of I-17 south of Flagstaff, Arizona. Since then, projects have ranged from funding flashing signs that warn drivers of nearby radio-collared elk in Wisconsin to studying which locations are most effective for wildlife crossings.

In 2007, RMEF purchased motion-triggered cameras to help the Colorado Department of Transportation collect data supporting construction of an overpass across I-70 on Vail Pass, notorious for its roadside carnage and a gangway to thousands of hunters headed for elk camp.

Last year, near Idaho’s Boise Wildlife Management Area, RMEF funds helped aid the travels of elk moving from summer to winter range along the Boise River. “They didn’t ask us for millions of dollars,” says Tom Toman, RMEF Director of Science and Planning. “They asked us for materials and labor to build wing fences, and that was a good role for us.”



**LIFE SUPPORT**—RMEF is helping to sponsor highway crossing projects all across elk country, including fence wings for this underpass just outside Boise, Idaho, on Highway 2 at a spot that has claimed 200 mule deer and elk in recent years.

The fact is, fully funding just two wildlife overpasses could swallow up the majority of RMEF’s annual habitat stewardship budget nationwide, so Toman and RMEF’s other conservation staff look instead to support this cause in targeted ways across multiple locations. These funds are raised at banquets throughout the year, and allocated by state Project Advisory Committees (PAC). Most RMEF projects involving roads have

focused on the front end, funding research such as radio collars to identify and monitor elk migration patterns and pinpoint places where they most frequently cross highways. RMEF has so far funded 190 radio-collar studies of elk movements in 22 states, says Toman. The foundation will continue to fund projects enhancing and protecting habitat for all wildlife in elk country, especially if a road crosses it.

—Jess Field, Bugle Intern