Natural Environment

IN THIS SECTION

Impacts of Roads provides an overview of the impacts of roads on the natural environment, based on the sentinel article, *Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities* by Stephen Trombulak and Christopher Frissell first published in The Journal of Conservation Biology in April, 2000.

Wildlife introduces you to a variety of mitigation techniques from habitat connectivity linkage analysis to wildlife crossings. Of course, this chapter wouldn't be complete without an overview of potential funding sources for wildlife mitigation measures.

Roadside Vegetation takes you on a tour of our rights of way. You will learn how roadside landscapes are designed and maintained, and what transportation agencies can do to get the most ecological bang for the buck.

Aquatic Resources tells the epic battle between water and roads. Follow the water through bridges, culverts, riprap, fish passage stormwater and road salt.

IMPACTS OF ROADS ON WILDLIFE AND NATURAL RESOURCES

Most conservationists are well aware of the impacts of roads and highways on the natural environment. A massive body of research has documented these impacts and hundreds more studies are in progress. Perhaps the best overview of impacts was the sentinel article, *Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities* by Stephen Trombulak and Christopher Frissell first published in The Journal of Conservation Biology in April, 2000. Trombulak and Frissell group all the impacts of roads on wildlife into seven categories:

1. Mortality from Road Construction
2. Mortality from Collision with Vehicles
3. Modification of Animal Behavior
4. Disruption of the Physical Environment
5. Alteration of the Chemical Environment
6. Spread of Exotic Species
7. Changes in Human Use of Land and Water

The authors note that none of these effects occur in isolation and the presence of a road will ultimately lead to many or even all of these impacts. For instance, by altering the physical and chemical environment, roads facilitate the spread of invasive species. Due to increased human activity, some wildlife species may modify their behavior and avoid otherwise suitable habitat near roads.

Mortality from construction

In the course of clearing the work site in preparation for road construction, any slow moving organisms are killed. Species that nest underground, like gopher tortoise (*Gopherus polyphemus*) are often buried alive or "entombed" when their dens are bulldozed and eventually paved over. Compared to mortality from road collisions, few studies have been done on the direct mortality caused during road construction. The actual clearing and construction may last for only weeks or months and few, if any wildlife agency staff would be on the construction site to witness and record the mortality.

Mortality from road collisions

Perhaps more than any other impact, roadkill is clearly quantifiable and has been very well documented. Vehicle collisions claim individual animals regardless of age, sex or condition of the individual animal, and can have substantial effects on a population's demography.

Modification of animal behavior

The mere presence of a road in wildlife habitat can be enough of a disturbance to alter animal behavior. Roads and highways that bisect habitat can cause wildlife to shift entire home ranges, modify movement patterns and escape responses and change reproductive success and physiological state.

Disruption of the physical environment

Roads destroy and fragment the habitat wherever they are built and transform the environment well beyond the pavement's edge (Forman 2000). At ground level, soil water content and density change leading to altered surface-water flow, run off patterns and sedimentation. By opening the canopy and removing vegetation, the amount of light and heat increases. Additional light invites different plant species, often replacing native communities. Road surfaces store heat, creating heat islands that attract species like birds and snakes. Traffic stirs up dust and other contaminants that settle on plants, blocking necessary processes like photosynthesis and transpiration. In addition, traffic noise can make roadside areas inhospitable to certain nesting songbirds (Forman 2000).

Alteration of the chemical environment

Beyond the road itself, the vehicles that use the road instigate their own problems. Cars and trucks produce carbon dioxide, ozone and heavy metals that quickly contaminate the air, soil, plants, animals and water near roads. Because roads accelerate runoff, they reduce the buffering effects from riparian vegetation and deliver high levels of sediment, nutrients and pollutants to nearby waters. Among the concerns are reduced water quality from chemicals, metals, oil, gasoline, de-icing salts and other contaminants entering water as non-point source runoff from roads and parking lots.

Spread of exotic species

The construction and presence of roads create perfect conditions for non-native, invasive species to move in and ultimately displace native vegetation. Exotics are able to take advantage of the disturbed, altered conditions created when a road is originally built and native species are stressed or removed altogether. Roads also act as vectors for "hitchhiker" seeds that attach themselves to vehicles. Some roadside exotics are no accident. Transportation agencies have historically planted rapidly growing exotic species on bare ground and slopes after construction to control erosion.

Increased human use of an area

Roads are built for many uses—from mere access into remote areas to full blown development—but they are all built for human activities. Roads increase access to formerly remote areas, thus increasing the frequency and intensity of human activity—both legal and illegal.

Trombulak, S.C., and C. Frissell. 2000. "A review of the ecological effects of roads on terrestrial and aquatic ecosystems." *Conservation Biology* 14: 18-30.

WILDLIFE

It took us a while, but after 100 years of road building, we figured out that highways are bad for wildlife and other living things. In the last two decades, our understanding of *how* our highways impact wildlife has grown considerably. This "age of enlightenment" has led to incremental improvements such as the burgeoning science of road ecology, habitat linkage analysis, effective wildlife and fish passage structure designs and innovations in policy that make such measures possible. In some cases, we have even been able to turn back the hands of time and restore some measure of habitat connectivity where it had been severed by a highway decades earlier.

Effective wildlife mitigation techniques should result in a reduction in wildlife-vehicle collisions, hence they are as important to human safety as they are to habitat connectivity. Human deaths and injuries are common when vehicles collide with larger species such as deer, elk and moose. In many rural regions, wildlife-vehicle collisions are the most common cause of highway collisions.

In Banff National Park, a series of 22 underpasses and two overpasses tied together with fencing have decreased total roadkills by 80 percent. Monitoring has documented wildlife using these structures—approximately 75,000 separate uses by a wide range of wildlife, including wolf, grizzly bear, elk, lynx, mountain lion and moose.

This chapter aims to provide conservationists with a better understanding of all the things that are now possible to reduce the impact of existing highways on wildlife. With four million miles of roads and highways out there, we have our work cut out for us. Strategies used to counteract roadkill and habitat fragmentation range from site-specific projects such as underpasses to regional models that combine landscape ecology, conservation biology and human safety concerns with long-range transportation planning. Engineers and biologists are now making a joint effort to design effective wildlife crossing structures that will lessen the effect roads have upon wildlife.

CAUTION: Without question, we have made great strides in mitigating the impacts of roads and highways on wildlife and habitat. But, there's just no substitute for the real thing. Even the best mitigation cannot replace all the values lost when a highway is built in wildlife habitat. Roadkill can be substantially reduced with these measures, but roadkill is only a symptom of a much larger problem. While it is important for us to strive for mitigation projects on existing highways, we need to remain steadfast in opposing continued habitat losses to new highways and development.

WILDLIFE-VEHICLE COLLISIONS

We have all witnessed the carnage, but how many animals are killed on our roadways? We may never know. Some victims are too small to see, some crawl off the road and die elsewhere and others are either eaten by scavengers or taken by motorists. Recent estimates indicate between 725,000 and 1,500,000 animals are struck on our roads annually, but an older study by the Humane Society of the United States and the Urban Wildlife Research Center estimated up to a million vertebrates *every day*. Wildlife-vehicle collisions can take a toll on species at the population level and in some cases, push some rare species closer to extinction. Statistics for human victims are grim as well, with 200 fatalities, 29,000 injuries and more than $1 billion in property damage every year.

Not all transportation agencies record information on roadkill, and those that do vary widely in practice. Some agencies collect and analyze data on all incidents, while others ignore the issue altogether. By collecting and reporting roadkill data, transportation agencies can begin identifying locations for mitigation measures.

In British Colombia, Canada, the Ministry of Transportation pays private contractors to systematically collect wildlife accident data on a daily basis as part of the Wildlife Accident Reporting System (WARS). For each incident, workers record the date, time, location, species, sex and age of the roadkill. This data is used to determine the type and location of warning signs, exclusionary fencing and crossing structures.

Ask your transportation agency if they collect roadkill data. If so, do they analyze the data or report it to the wildlife agencies? Do they use the data to inform their planning, operations or maintenance decisions or processes?

HABITAT CONNECTIVITY LINKAGE PLANNING

Roadkill data is only one factor in determining where wildlife crossings or other mitigation measures are necessary. Transportation agencies can coordinate with resource agencies and conservationists to engage in linkage analyses and develop wildlife habitat connectivity plans. Animals need to move across the landscape for daily, seasonal and life cycle requirements. Climate change likely will force wildlife populations into new and perhaps more critical, movement patterns. They move between core habitat patches via corridors. Habitat connectivity describes the degree to which landscape characteristics (including highways and other development) facilitate or impede the ability of an organism to move within a landscape to acquire resources such as

food, water, cover and mates (Fahrig and Merriam, 1985). As wildlife respond to global warming, these corridors will become even more essential. Preparing statewide or regional plans for habitat connectivity is an essential part of developing a comprehensive system of effective wildlife crossing structures.

"Habitat connectivity across highways is obviously about much more than deer; it helps many species safely negotiate highways that fragment habitat, and from an ecosystem perspective, reconnects habitats that have become isolated by human development. If done well, we can even re-establish genetic connectivity and potentially 'rescue' isolated populations from extirpation." **State wildlife agency biologist**

HALL OF FAME: CORRIDORS OF LIFE

American Wildlands (AWL) has developed two Geographic Information System (GIS) models to locate the highest priority areas for mitigating highways with crossing structures, fencing or other measures in local landscapes. To prioritize work, habitat cores and corridors from AWL's regional *Corridors of Life* model are overlaid with the Statewide Transportation Improvement Plan (STIP) projects. State transportation departments rely on AWL's scientific methodology to justify expenditures of federal appropriations for wildlife mitigation. To date, they have improved five different highway projects in Idaho, Wyoming and Montana, resulting in the commitment to construct seven wildlife underpasses and two bridges for fish passage in the region. So far, this includes more than $2.7 million for wildlife mitigation and $2.2 million in private land conservation adjacent to highway mitigation. (insert map here)

Does your state have a wildlife habitat connectivity plan? If not, contact your state transportation agency and volunteer to spearhead the effort. If your state does have a wildlife habitat connectivity plan, is it being implemented? If not, contact your state transportation agency and volunteer to spearhead the effort.

Elements of a Habitat Connectivity

Aerial photos can be used to identify vegetation patterns, human developments, water bodies, aspect and terrain, and possibly existing trails.

Land ownership maps identify publicly owned lands that can be used as wildlife habitat linkages. Most public lands include wildlife habitat protection in their mission, and are more easily incorporated into a connectivity plan. However, some situations may call for key parcels of private land that may be necessary for successful habitat connectivity.

Vegetation maps that include general vegetation types such as conifer or hardwoods, riparian or upland, marshes or grassland provide sufficient detail for wildlife habitat connectivity planning.

Topographic maps provide important information such as slopes, draws, ridges, saddles, extremely steep lands and flats can often be used to help identify wildlife corridors.

Wildlife habitat or range maps from state wildlife agencies, state heritage programs, federal land management agencies and non-profit conservation organizations can provide valuable information on habitat locations.

Monitoring wildlife behavior—with radio collars, seasonal tracking, or direct observation—can determine where animals attempt to cross.

Roadkill information, available from some state transportation agencies, can provide locations and number of collisions (Ruediger, 2007).

In partnership with transportation and resource agencies, use your completed wildlife habitat linkage plan to develop and prioritize a comprehensive system of effective wildlife crossing structures throughout your state or area of interest.
–Cross-check the linkage plan with your Statewide Transportation Improvement Plan (STIP)
–Identify which pending transportation projects overlap with key linkage areas and move to have wildlife mitigation measures added to the scope of the projects.

HALL OF FAME: ARIZONA'S LINKAGES

The Arizona Wildlife Linkages Workgroup (AWLW) is a collaborative effort between public and private sector organizations to address habitat fragmentation through a comprehensive, systematic approach. Workgroup partners conducted a statewide assessment to identify blocks of protected habitat, the potential wildlife corridors between them, and the factors threatening to disrupt these linkage zones. After four successful workshops and many hours spent coordinating, meeting, mapping and writing, the AWLW presented their initial findings, methodology and recommendations in December 2006—a product that is intended to evolve and ultimately be used as a planning instrument.

SIGNAGE

Perhaps the most common measure to reduce wildlife-vehicle collisions is the ubiquitous "leaping deer" caution sign found on highway rights of way. But until we can teach whitetail deer to read, these signs do very little to prevent wildlife-vehicle collisions. Transportation agencies place the relatively inexpensive signs where wildlife vehicle collisions have occurred or where wildlife are known to cross. But the signs quickly lose their effectiveness as motorists become habituated to their presence. Thus, signs are not recommended as the sole mitigation measure, as they do not deter animals from entering the roadway and have little effect on motorist behavior.

Dynamic signage, however, holds some promise in reducing wildlife-vehicle collisions. Motion sensors are installed on the outer edge of the right of way to determine the presence of wildlife. The sensors then trigger illuminated warning signs next to the roadway, alerting motorists that animals are present and reducing the speed limit. Because the signs are only activated when wildlife are present, drivers are more likely to notice them and be alert.

Suggest reduced speed limits, speed limit enforcement and dynamic signage in areas with high wildlife-vehicle collision rates.

IN THE NEWS: WILDLIFE 'CROSSWALK' TESTED TO PROTECT ANIMALS, DRIVERS

The Associated Press, January 03, 2007

An experimental electronic "crosswalk" designed to keep Arizona's animals and drivers safe will begin operating east of Payson for the first time this month. The high-tech crossing is part of an extensive system of wildlife underpasses and electrified fencing along a three-mile stretch of Arizona 260, about seven miles east of Payson. The fences funnel the creatures to places where they can cross under the road, or to the electronic crossing. The crossing uses infrared cameras and military-grade software to set off large signs and warning lights so that drivers will be prepared for an elk, mule deer or another animal of significant size that may be about to cross the highway. "You don't have to train the animals to use the system. You have to train the drivers," said Norris Dodd, a wildlife biologist for the Arizona Game and Fish Department. "Hopefully, it will convince motorists to slow down." The crossing system and fencing cost about $700,000, most of which is being paid for with a federal grant. Areas where the elk are being funneled through underpasses have seen an 83 percent reduction in such incidents, Dodd said.

Find out how much wildlife-vehicle collisions are costing drivers and taxpayers in your state.

OTHER NONSTRUCTURAL TECHNIQUES

For as long as we've been building roads in wildlife habitat, we've had wildlife-vehicle collisions. And for as long as we have had wildlife-vehicle collisions, someone has been trying to invent a gadget to solve the problem, but with mixed success. Many of these measures, like reflectors and deer whistles have shown little or no effectiveness in reducing collisions.

Every proposed solution falls into one of two categories: changes that affect motorist behavior and changes that affect animal behavior. As it turns out, it's easier to teach animals to change than humans.

Changing motorist behavior

Lower speed limits in areas of high wildlife traffic, and at times of the day (especially dawn and dusk) when animals are more likely to be moving about, result in safer response time and distance, protecting drivers, their passengers and wildlife. However, this technique is only successful with aggressive speed limit enforcement.

Lighting along roadways can improve night visibility for motorists, allowing them to see wildlife and preventing collisions. However, artificial lighting can have negative impacts on wildlife.

Temporary or seasonal road closings allow for safe wildlife movement only during the most important migration periods (sometimes as little as a day) without long-term inconvenience for motorists.

In-vehicle technologies, such as infrared vision or sensors built into cars to detect animals on the road hold promise, but are still only available in a limited number of vehicles.

Reflective collars placed on large ungulates such as elk and moose reflect vehicle headlights at night, helping drivers see them on the road and preventing collisions.

Public and driver education such as seasonal campaigns educating motorists about animal-vehicle collisions raise awareness.

Informed planning should result in fewer new alignments in wildlife habitat; hence, fewer wildlife collisions.

Changing animal behavior

Habitat alteration—such as replacing natural vegetation with unpalatable vegetation—can reduce the attractiveness of roadsides to deer and other herbivores.

Intercept feeding is the practice of using strategically placed feeding stations to lure animals away from roadways.

Hazing animals by harassing them away from the road surface with noise or offensive odors can reduce roadkill, but also limits their ability to move across the landscape.

Herd reduction through hunting, sterilization and relocation has been used to reduce wildlife-vehicle collisions in urban areas.

Mirrors and reflectors mounted on posts along the edge of the highway reflect vehicle headlight beams and create a lighted fence believed to deter animals from entering the roadway. The success of this technique has not been established beyond anecdotal evidence.
Road salt alternatives may reduce the number of deer entering the right of way to lick salt from the road surface.
Ultrasonic deer whistles are mounted on vehicles to deter animals from entering the roadway. Like reflectors, there is little evidence showing the effectiveness of deer whistles.

Discourage mitigation spending on ineffective, unproven measures such as reflectors and whistles. Transportation agencies are less likely to try more effective techniques when they have previously wasted money on ineffective measures. Check out the Countermeasures Toolbox at *http://www.DeerCrash.com* for the latest research on each.

IN THE NEWS: HIGHWAY SHUT FOR BUTTERFLY TRAVEL

BBC News, March 24, 2007
Taiwan is to close one lane of a major highway to protect more than a million butterflies, which cross the road on their seasonal migration. The purple milkweed butterfly, which winters in the south of the island, passes over some 600m of motorway to reach its breeding ground in the north. Many of the 11,500 butterflies that attempt the journey each hour do not reach safety, experts say. Taiwanese officials conceded that the decision to close one lane of the road would cause some traffic congestion, but said it was a price worth paying. "Human beings need to coexist with the other species, even if they are tiny butterflies," Lee Thay-ming, of the National Freeway Bureau, told the AFP news agency. The measures are estimated to have cost $30,000 (£15,200).

WILDLIFE CROSSINGS

Considered by many to be the "holy grail" of mitigation measures, wildlife crossing structures (called ecopassages, ecoducts, overpasses, underpasses or land bridges) have been standard practice in many European countries for decades. Europeans tend to have a stronger land ethic and expect greater government control of land use. Governments respond by including the public in decision-making and incorporating social considerations into the landscape. Contrary to standard practice in the United States, the transportation planning process in European countries is slow, deliberate and transparent with high levels of public participation. As a result, one stretch of Germany's highway B31 has five land bridges. Switzerland has a fully vegetated land bridge with a functioning wetland over a six-lane highway. Early efforts in the United States have been less dramatic, but no less needed.

- (1980) In Montana, two underpasses were built in Glacier National Park to allow mountain goats to cross U.S. 2 on their way to the Flathead River.
- (1987) Massachusetts installed two tunnels in Amherst to allow a local salamander population to cross a two-lane street during its breeding season.
- (1993) Florida installed 24 underpasses under "Slaughter Alley," a stretch of I-75 where several endangered Florida panthers had been killed in collisions.

According to a recent National Cooperative Highway Research Project (NCHRP) study, there are at least 550 terrestrial underpasses for wildlife, six overpasses and more than 10,000 aquatic passages in the United States (Cramer, 2007). Several more crossing structures are currently in design and construction in the United States, including more than 40 crossing structures of all sizes within a 56-mile segment of U.S. 93 in Montana. Washington is planning several crossings as part of widening I-90 through Snoqualmie Pass.

CAUTION: Wildlife crossings are appropriate for retrofitting existing roads that fragment habitat connectivity, but they should never be used to justify building a new road in wildlife habitat. Wildlife crossings are not a panacea, they are merely Band-Aids. Crossings can only address one of the many impacts the highway brings, and only in the exact location of the crossing. The highway is still a major disturbance, source of pollution (air, water, soil, noise, vibration and light), vector for invasives and enabler of extensive loss of habitat through associated development. Even the best designed and most effective wildlife crossing can only restore a fraction of the habitat connectivity that was lost and will never replace the natural conditions that are lost forever when a highway is built.

CROSSING DESIGN

Wildlife crossings are generally designed to mimic the natural environment around them and recreate the natural habitat that was fragmented by the highway. The more naturally a wildlife crossing fits into the surrounding area, the more likely animals will use it. Successful crossing design depends on several factors:

Placement – Crossings should be built in a location where they are most likely to be utilized, generally where animals naturally approach a highway. Often animals choose areas to cross where there is a specific terrain feature, vegetation or narrower right-of-way. Ridges, valley bottoms, stream and river courses and wooded corridors are choice locations. When designing the crossings in Banff National Park, locating the underpasses and overpasses near the animals' natural travel corridors was crucial to the project's success. For carnivores, this meant placing the structures close to stream corridors or drainage areas. For ungulates, it involved doing the opposite—placing the structures far from carnivores (their predators) and with a clear view of the entrances of these structures.

Redundancy – Rarely will one crossing suffice for the full suite of species moving across a large landscape. For small animals, travel distance between crossings can be important. Reptiles and amphibians are unlikely to travel far to reach a crossing before giving up.

Size matters – In most cases, the larger the crossing, the better. Underpasses must be wide enough and tall enough for comfortable passing of various species. However, if crossings are too long, they may create a tunnel effect that is less inviting to certain species.

Openness ratio – For underpasses, the "openness" is determined by the height in relation to the width. In general, the more open the better, as it reduces the "tunnel" effect.

Light – Most species prefer a certain amount of light within a crossing, particularly prey species. Other species are sensitive to human disturbance and reluctant to use structures that are artificially lit. Natural lighting is best.

Moisture – For wet culverts, amphibians may prefer a continuous wet substrate to pass successfully.

Vegetation – Shrubs and other vegetation shield animals from traffic light and noise and provide cover for species that feel vulnerable when using crossings.

Temperature – Depending on the size and air flow within culverts, the temperature inside the crossing may differ from the outside, ambient temperature enough to deter some temperature-sensitive species such as snakes.

Substrate – The substrate within a crossing should replicate ground conditions on either side as much as possible.

Cover – Some small animals feel more secure using a crossing system if it provides sufficient cover. For example, rows of stumps and rootwads in an underpass appear to facilitate use by small mammals such as rabbits and voles.

Noise/Light – Traffic noise and artificial light are additional disturbances for most species, and can deter wildlife from using crossings. Overpasses use high berms and vegetation to reduce traffic noise and headlight glare.

Approaches – Some species prefer well vegetated approaches; others prefer open approaches with good visibility. Vegetation at the entrance of an underpass may deter some mammals that are wary of conditions that provide ambush opportunities for predators.

Line of sight – Structures should be designed as flat and straight as terrain permits. Animals approaching underpasses should be able to see through the structure to suitable habitat on the opposite side.

Fencing – Exclusionary fencing on either side of crossing structures keeps wildlife out of the right of way and guides animals to the structure for safe crossing (Ruediger, 2007).

"The standard response initially by some of the engineers involved was, 'this stuff doesn't work.' I'm still working on getting them to understand that it does work if done properly." **State wildlife agency biologist**

"Engineers are problem solvers. Once they understand the full scope of the problem, they can be creative and effective allies." **Conservation advocate**

Types of Wildlife Crossings

Wildlife crosses OVER the traffic.

Wildlife Overcrossing
A grade separation structure designed to allow wildlife to cross over an intersecting roadway. It is usually covered with vegetation. Also called *ecoduct, wildlife bridge, green bridge, biobridge,* or *wildlife overpass.* The largest overcrossings may be called *landscape connectors*.

Tunnel
The roadway bores through a substantial amount of earth, allowing undisturbed vegetation and soil on top.

Bridge: Wildlife crosses UNDER the traffic.

Wildlife Underpass
Animals pass under an intersecting roadway through a bridge. A bridge forms part of the roadway and is usually at least 20' long.

Single span bridge
The structure rests on abutments with no intermediate support columns. Also called *open span bridge*.

Multiple span bridge
A bridge with one or more intermediate support columns between abutments.

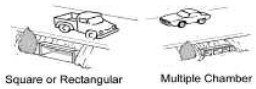
Viaduct
A long, multiple-span bridge

Causeway
Same as viaduct, only often over wetlands.

Culvert: Wildlife crosses UNDER the traffic.

Wildlife Under pass
Animals pass under an intersecting roadway through a culvert. A culvert is a conduit covered with embankment around the entire perimeter. It may or may not convey water. Small conduits for amphibians are sometimes called *tunnels*.

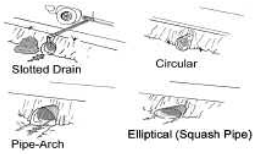
Box Culvert
Culvert has four sides, including bottom. Sometimes square or rectangular corrugated metal pipe culverts without bottoms are called box culverts



Typical Material: Precast concrete, Cast-in-place concrete, Wood

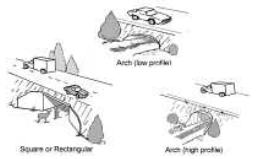
Culvert (Continuous)
Culvert is continuous in circumference. The lower portion may or may not be buried. Sometimes simply called *pipe*. European badger culverts are sometimes called *ecopipes*.

Slotted drain culverts are continuous except for a break in the upper portion.



Typical Material: Corrugated metal pipe, Metal plate, Cast-in-place concrete, Precast concrete, Wood

Bottomless Culvert
Culvert is discontinuous in circumference with rounded or square top and natural surface bottom. Also called *open-bottom culvert*.



Typical Material: Corrugated metal pipe, Metal plate, Precast concrete, Cast-in-place concrete, Wood

Barrier

Structures designed to stop movement in a given direction.

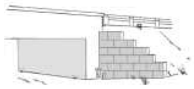
Fence
A barrier or diversion structure usually with some type of material between support structures. Often defined by the material between the support structures.

Typical Material: Diversion fences are sometimes called *drift* or *guide* fences, Wire ,Barbed wire, Woven wire, Chain link, Rail, Plastic mesh

Electric
Electrified strands that give grounded organisms a shock when touched. Shock is typically intense, but not physiologically damaging.

Typical Material: Braided Rope, High-tensile wire

Jersey Barrier
Structures used primarily to affect vehicles direction. Solid or solid with openings.
Typical Material: concrete



Wall
Solid wall

Typical Material: Concrete, Brick, Wood

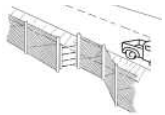
Sound Wall
A solid wall used for absorbing or deflecting sound produced from the highway.

Typical Material: Brick, Wood, Concrete, Sheet Piling

In-roadway Barrier
Support structures for vehicles built over a pit and used to prevent wildlife access across a break in fencing or other barrier. Similar to a cattle guard, but designed for wildlife. Also called *deer guard*.

Escape Structure

A structure designed to allow an animal trapped on the roadway by a diversion fence to exit. They allow passage in only one direction to make it easy to escape the roadway, but difficult to enter it.



One-way Gate
A gate designed to allow passage for the design species in only one direction.

Ramp

Funnel Fence

Graph courtesy of the USDA Forest Service's Wildlife Crossings Toolkit http://www.wildlifecrossings.info

MIXED USE

How would you like to share the sidewalk with a grizzly bear? She doesn't want to share her "crosswalks" with you either. Most wildlife prefer not to share their habitat with humans and wildlife crossings are no different. While some more common species such as deer and coyote can become easily habituated to human presence, sensitive species such as wolves and grizzly bears are disturbed by human activity and will avoid even high quality habitat if humans are near.

Seeking compromise in the face of competing needs and limited dollars, some states have designed mixed-use, human-wildlife crossing structures. But can a crossing structure frequented by humans truly be an effective passage for wildlife? Florida built a 16-meter-wide overpass in 2000 to reconnect the Marjorie Harris Carr Cross-Florida Greenway that crosses I-75 in Marion County. The land bridge was built to accommodate hikers, cyclists and horseback riders during the day and deer, foxes, coyotes, possums and other small mammals at night. Sporadic monitoring has captured images of bobcat and coyote using the bridge and officials have confirmed visual reports of indigo snake and gopher tortoise on the bridge, both of which are listed species in Florida (Thomason, 2007).

In Switzerland, signs are posted near wildlife crossings asking people to respect the purpose of the structures and only use crossings designed for humans.

But other studies have shown that wildlife crossings are less effective when frequented by human visitors. One study measured the use of 14 wildlife underpasses in Banff National Park and concluded that human influence was a factor at all locations. Either a nearby human population or human activity within an underpass consistently ranked high as a significant factor affecting species-performance ratios (Clevenger, 2000). In an effort to increase the low numbers of large carnivores using the structures at Banff, Parks Canada researchers are urging stricter limits on human activity near the crossing structures. According to Anthony Clevenger, wildlife ecologist and research scientist leading the evaluation of wildlife mitigation in Banff National Park, "Distance from humans is the most important consideration in designing crossing structures for large carnivores. The further the better." (Critter Crossings, 2000). The Canadian public supports the wildlife-only crossings. In a recent poll, 89 percent of respondents approved a management plan that would build separate crossings for park visitors, to keep humans from using wildlife crossings (Parks Canada, 2006).

Monitoring

To improve our understanding of how various species respond to different wildlife crossing designs, continued research is needed. It is important to conduct wildlife monitoring both before and after construction, using scientific methodology and publishing all results and recommendations so others benefit from what is learned. On individual highway projects, monitoring can help adjust mitigation measures like fencing, wildlife approaches to structures, and human use levels. Monitoring also helps determine the amount and type of wildlife use structures receive. Due to the learning curve for using crossing structures, more wary species may take years to become accustomed to structures and begin using them successfully.

Monitoring can range from low-cost wildlife track counts and roadkill surveys to medium-cost motion-triggered camera traps and genetic analyses of scat and hair samples. Because it is integral to the success of the structure as it contributes to overall habitat connectivity, monitoring should be included in the planning, design and cost of the project.

If you have existing crossing structures in your state or area of interest, are they being monitored for use and effectiveness? Work with researchers to implement monitoring strategies for crossing structures. Volunteer your organization to help with monitoring.

HALL OF FAME: USING CITIZEN SCIENCE FOR WILDLIFE CROSSINGS

The Southern Rockies Ecosystem Project (SREP), in collaboration with the Denver Zoo and the Gore Range Natural Science School, developed the *Citizen Science Wildlife Monitoring* program to monitor wildlife activity in the area where a wildlife crossing structure has been proposed across Interstate 70 in Colorado. The program engages local residents, educates communities and collects baseline data by monitoring wildlife presence and abundance through the use of motion-triggered cameras. Trained volunteers download images, replace batteries, reposition cameras, record important information on the camera's status, and reprogram the camera for future use. Images downloaded from cameras are compiled in a statewide monitoring database and posted on the Web.

As the program's capacity increases, monitoring efforts will be extended to a greater number of monitoring stations and volunteers will be trained in additional monitoring techniques including scat transects, hair snares and video monitoring. In its first year, the *Citizen Science Wildlife Monitoring* program has proven to be a very successful means for expanding our research capacity while engaging citizens at the local level and fostering knowledge and interest about the Southern Rockies ecosystem.

The Miistakis Institute in Calgary, British Columbia took the citizen science concept to the web with their "Road Watch in the Pass" project. Drivers who use Highway 3 through Crowsnest Pass are encouraged to report sightings of wildlife (dead or alive) on a special website. Users log in and fill out a simple report on the species, location and status. Data collected is analyzed and provided to planners, managers and decision-makers in the Municipality of Crowsnest Pass and beyond.

Where wildlife crossings are planned or needed, volunteer your organization to help with pre-project monitoring and citizen science.

SAFETEA-LU contains Section 6001, a planning provision that requires long-range transportation plans to be developed in consultation with agencies responsible for land use management, natural resources, conservation and environmental protection. The provision also requires that the consultation involve a "discussion of potential environmental mitigation activities and potential areas to carry out these activities, including activities that may have the greatest potential to restore and maintain the environmental functions affected by the plan." These early consultations are great opportunities to begin discussing wildlife mitigation measures such as crossing structures. For more information on Section 6001, see Planning.

Take advantage of the Section 6001 consultation process.
–Ask someone from your state planning division if there are opportunities for public participation in the Section 6001 consultation.
–Bring your State Wildlife Action Plan and wildlife habitat linkage plan. Suggest that they be used as a basis for the mitigation discussion required under Section 6001. Find opportunities for wildlife mitigation in upcoming projects.

COSTS

Perhaps the most common questions related to wildlife crossings are "how much do they cost?" and "where does the money come from?" Like all aspects of highway building, wildlife mitigation techniques range in price from very inexpensive (warning signs) to very expensive (overpasses). Because each project is unique and because construction and materials costs are constantly fluctuating, it is nearly impossible to develop firm cost guidelines. However, we were able to collect the following estimates from various sources.

Crossing type	Cost	Source
Elliptical metal culvert	$150,000-170,000	The Use of Highway Underpasses by Large Mammals in Virginia and Factors Influencing their Effectiveness (cited in Donaldson, 2005)
Corrugated metal pipe bottomless arch culvert	$150,000	The Use of Highway Underpasses by Large Mammals in Virginia and Factors Influencing their Effectiveness (cited in Donaldson, 2005)
Arch culvert 13' x 23'	$250,000	Safe Passage: A User's Guide to Developing Effective High-way Crossings for Carnivores and Other Wildlife (Ruediger, 2007)
Concrete box	$120,000	Road Ecology (Forman, et al.)
Box culvert	$870,000	The Use of Highway Underpasses by Large Mammals in Virginia and Factors Influencing their Effectiveness (cited in Donaldson, 2005)
Bridge extension	$433,000 (extension only)	The Use of Highway Underpasses by Large Mammals in Virginia and Factors Influencing their Effectiveness (cited in Donaldson, 2005)
Open-span bridge–over land	$470,000–670,000	Road Ecology (Forman, et al.)
Open-span bridge–over waterway	Minimal added cost	Road Ecology (Forman, et al.)
Overpass	$1.15 million	Road Ecology (Forman, et al.)
Open span underpass	$1 million	Safe Passage: A User's Guide to Developing Effective Highway Crossings for Carnivores and Other Wildlife (Ruediger, 2007)
Combination over and under passes (FDOT is building 2 crossings, each with two bridges: one to bridge over the Barron Canal; one to allow passage under SR 29.)	$1,581,325.60 Cost of entire project: $7, 149,846.61	Personal communication with project engineer, Bill Franklin, March 27, 2007 Project: 407940-1-52-01, SR 70 Wildlife Crossings (SR 29)
Double span bridge	$3 to 4 million Cost of entire project: $14 million	Personal communication with Deborah Wambach of Montana Department of Transportation, April 5, 2007
Vegetated overpass	$5 million or more	Safe Passage: A User's Guide to Developing Effective Highway Crossings for Carnivores and Other Wildlife (Ruediger, 2007)
Elevated roadway	$8.5 million	Road Ecology (Forman, et al.)
Tunnel	$16 million	Road Ecology (Forman, et al.)

We know that habitat connectivity is critical to ecosystem health and we now have more than sufficient evidence that properly designed crossing structures are effective. Yet, with no specific funding mechanisms for wildlife crossings and no regulatory directives to build them, transportation agencies are often reluctant to spend highway dollars on crossing structures.

Regardless of the price tag, it is important to remember that—as with any other safety measure—wildlife mitigation measures should be seen within the context of the entire transportation project, and the costs should be seen within the context of the entire project budget. Cost alone should never be the sole factor in determining which mitigation techniques are used. Rather, the proposed measures should be evaluated based on cost-effectiveness, overall benefits and savings, and long-term return on the investment.

CAUTION: Don't fall for the "Jedi mind tricks" of wildlife mitigation. When discussing the high costs of wildlife crossings, inevitably someone will suggest that because they benefit wildlife, resource agencies and conservationists should pay for them. Nice try, Obi-Wan. Crossings are used by wildlife, but are still a part of our transportation infrastructure. They are only necessary because a highway was built through wildlife habitat. Efforts by transportation agencies to restore lost connectivity are highly commendable, but they are not charity. If a highway is built in an avalanche zone, is the weather bureau expected to pay for avalanche sheds?

BENEFITS OF EFFECTIVE WILDLIFE CROSSING STRUCTURES

Ecology: restoration of wildlife corridors, reduced effects of fragmentation, reduced road mortality

Human safety: reduction in wildlife-vehicle collisions means a reduction in deaths and injuries

Cost savings: reduction in property damage, hospital costs and lost wages

SAFETEA-LU contained a provision requiring the USDOT to commission a study of methods to reduce collisions between motor vehicles and wildlife. The study will include an assessment of causes, solutions and best practices for reducing wildlife vehicle collisions—including wildlife crossings and other mitigation measures. The results of the study will inform the development of a best practices manual to serve as a guide for developing

statewide action plans to reduce wildlife-vehicle collisions. The manual will become the basis for a training course for transportation professionals.

CAN WE AFFORD *NOT* TO BUILD CROSSINGS?

Wildlife crossing structures can be expensive, especially when they are done carefully and correctly—meaning predesign research is done, the size and number are adequate, they connect protected and quality habitat on either side, and they are maintained and monitored for the most efficient use. But consider the alternative.

With fewer than 100 cats remaining, vehicle collisions area a major threat to the endangered Florida pather.

- A recent study by the Western Transportation Institute calculated the average total costs associated with an animal-vehicle collision for three species: $7,890 per collision for deer, $17,100 for elk, and $28,100 for moose (Huijser 2006).
- The British Columbia Ministry of Transportation and Highways analyzed the various costs of wildlife vehicle collisions, including the obvious property damage and human injuries, as well as costs of accident clean up and the loss of the value of the animals in terms of tourism and hunting revenue. Between 1997 and 2000, a Canadian insurance provider paid out more than $67 million in wildlife-related motor vehicle accident claims. Between 1991 and 2000, Ministry Maintenance Contractors spent more than $5.2 million on wildlife-related accident clean-up and disposal. If every wild game animal reported killed on provincial highways represented an opportunity to sell a hunting license, the Province of British Columbia lost between $80,000 and $400,000 in hunting license revenues in 2000 (British Columbia Ministry of Transportation and Highways, 2000).
- Virginia Transportation Research Council recently conducted a cost-benefit analysis of two underpasses and concluded that an effective structure with fencing is cost-effective in terms of savings in property damage alone when it prevents just 2.6 collisions per year (Donaldson, 2005).
- Jerry Booth sued the state of Arizona for $3 million after he was severely injured in a collision with an elk lying in the roadway. A jury found that the state failed to guard against foreseeable collisions between motor vehicles and elk or deer (Booth v. State of Arizona, 2004). It should be noted that Arizona does have crossings for elk and other wildlife and is implementing several more mitigation measures.
- Endangered species are priceless and managing them is very expensive. Certain taxa like herpetofauna and carnivores are particularly susceptible to impacts from roads and highways. If existing road impacts aren't addressed through mitigation measures, highly vulnerable species could quickly be relegated to endangered status.

"There is such a demand for transportation dollars; the biggest hurdle is convincing people that wildlife crossings are truly needed and justifiable. This ultimately means changing the mindset of people."
Conservation advocate

SOURCES OF FUNDING FOR WILDLIFE MITIGATION MEASURES

Transportation funding for wildlife mitigation can come from several different pots, depending on the circumstance. This is by no means a complete list and conservationists should continue exploring new sources and creative ways to leverage all of our resources.

1. Project Budget

Crossing structures may ultimately benefit wildlife by restoring some fraction of habitat connectivity that was lost when the highway was built, but they are still part of our transportation infrastructure. Wildlife-vehicle collisions are a serious safety hazard on many highways because they were built through wildlife habitat. As such, any measure to reduce the risk of accidents is a legitimate transportation expense. The Washington Department of Transportation is not only including the cost of crossings in their pending widening of I-90 through Snoqualmie Pass, they have included the restoration of habitat connectivity in the purpose and need of the project.

"The politicians don't really want to spend money on highway amenities for wildlife unless forced to do so. People start getting nervous when you raise taxes for things like wildlife crossings."
Retired FHWA biologist

2. Retroactive Mitigation

Pssst—this may be one of the best kept secrets in the business. In December 2000, FHWA released a final rule on the eligibility of federal-aid transportation funding of mitigation activities. The final rule broadened the existing regulation to allow use of federal highway funds to mitigate for impacts to wetlands and *natural habitat* caused by current *or past* highway projects. Yes, you read that right. federal transportation funds can be used to mitigate impacts for nonwetland habitat that was impacted "due to already-completed projects which were not mitigated when the projects were built."

For the purposes of this rule, natural habitat is defined as "a complex of natural, primarily native or indigenous vegetation, not currently subject to cultivation or current artificial landscaping, a primary purpose of which is to provide habitat for wildlife, either

terrestrial or aquatic." Actions eligible for federal funding include restoration, enhancement or improvements of degraded wetlands or natural habitats and other measures to protect, enhance or restore the wetland or natural habitat character of the site. Federal-aid funds may be used for acquisition of proprietary interests in replacement wetlands or natural habitat, and the state transportation agency may acquire privately owned lands in cooperation with another public agency. Federal-aid funds may not be used unless the area will be maintained in the intended state as a wetland or natural habitat.

Ask a friend at your transportation agency about using retroactive mitigation for nonwetland habitat in your state or area of interest. Brainstorm a list of potential projects and make suggestions. Keep in mind that this mitigation is not required, but this rule does make federal funding eligible.

3. Federal Lands Highway Program

The Federal Lands Highway Program (FLHP) is an adjunct to the Federal-Aid Highway Program, created in 1982 to fund a coordinated roads program for transportation needs of federal and Indian lands which are not the responsibility of a state or local government. Often referred to as "the DOT for federal lands", FLHP's purpose is to:

1. ensure effective and efficient funding and administration for a coordinated program of public roads and bridges serving Federal and Indian lands
2. provide needed transportation access for Native Americans
3. protect and enhance our Nation's resources.

FLHP funds are distributed to each category, where project selection is delegated to users (federal land management agencies, Indian tribes and states) according to three-year transportation improvement plans (TIP). Roads owned by the Bureau of Land Management, Bureau of Reclamation and the U.S. Army Corps of Engineers and other Department of Defense agencies do not receive dedicated funding and have to compete for funds under a discretionary category. FLHP funds are 100 percent eligible for wildlife mitigation measures. **For more information on FLHP, see Public Lands.**

SAFETEA-LU provides $4.5 billion for the Federal Lands Highway Program through 2009, which is eligible for wildlife mitigation measures on highways within or serving our public lands system.

Contact your FLHP regional office and ask if they have any wildlife mitigation projects planned. Check the FLHP project list in your state or area of interest for opportunities to incorporate wildlife mitigation measures into pending projects.

"It's common sense to many people to make our roadways safer for people and wildlife and reduce the impact of our roadways on clean water. The divisive issues often center around how we pay for those improvements and making it clear to folks that this is a holistic transportation issue." **Conservation advocate**

HALL OF FAME: COLORADO'S FIRST VEGETATED OVERPASS

Heavily developed resort areas, recreational use and streams of passenger and freight traffic severely constrict wildlife movement in the Vail area. Conservationists teamed up with Colorado Department of Transportation (CDOT) and others to explore building a wildlife bridge just west of Vail Pass on I-70. The location was recognized as a high-priority habitat linkage for a diversity of species by an interagency group called "A Landscape Level Inventory of Valued Ecosystem Components" (ALIVE). When finished, the bridge will reconnect critical wildlife habitat fragmented by the interstate and restore one of the last remaining forested connections for wildlife moving north-south through the heart of the Rocky Mountains.

In 2005, Congress appropriated $500,000 through FLHP's Public Lands Highway Discretionary Program to conduct preliminary studies and planning and additional funds are expected. The project brings highway dollars into the state without bringing more highways and because it is funded under the PLHD program, no match is required from CDOT or local governments.

4. Safety

Because wildlife-vehicle collisions are now more widely recognized as a serious safety hazard for the traveling public, safety funding can be used to build wildlife crossings or any other mitigation measure.

SAFETEA-LU clarified the eligibility of safety funds with a provision in the Highway Safety Improvement Program (HSIP). "The addition or retrofitting of structures or other measures to eliminate or reduce accidents involving vehicles and wildlife" is

now considered a highway safety improvement project and therefore eligible for safety funding.

Contact your transportation agency and ask about using safety funds to reduce wildlife-vehicle collisions. Use accident data to make a list of collision hot-spots.

5. Transportation Enhancements

Beginning with ISTEA, the Transportation Enhancements (TE) program set aside 10 percent of all Surface Transportation Program dollars for community-based projects that expand travel choices and enhance the transportation experience by improving the cultural, historic, aesthetic and environmental aspects of our transportation infrastructure.

TE is a federal aid reimbursement program, whereby the federal government pays 80 percent of the project cost and the project sponsor pays the nonfederal match of 20 percent.

While TE uses federal funding, state transportation agencies retain most of the responsibility for implementing the program, and each state does so in its own way. Each state devises its own application, selection process and selection criteria but they all have some characteristics in common, such as eligibility, advisory committees, project implementation, innovative financing and streamlined project development. To qualify for consideration, projects do not have to be associated with a specific highway project, but they must be within the acceptable categories and must relate to surface transportation.

While wildlife mitigation measures have always been eligible for transportation dollars, TEA-21 was the first federal transportation bill that explicitly stated that highway dollars could be used for wildlife crossing structures and other mitigation measures. In 1998, Congress included Activity 11, known in law as "e*nvironmental mitigation to address water pollution due to highway runoff or reduce vehicle-caused wildlife mortality while maintaining habitat connectivity*." The provision provides communities with funding to decrease the negative impacts of roads on the natural environment—including water pollution and habitat fragmentation. To reduce water pollution from stormwater runoff, TE funds can be used for pollution studies, soil erosion control or river clean-ups. To address wildlife passage and habitat connectivity, TE funds can be used for crossing structures and monitoring and data collection on habitat fragmentation and vehicle-caused wildlife mortality.

CAUTION: Transportation Enhancement funds are not allowed to be used for standard environmental mitigation related to a current highway project, routine maintenance or the preservation of transportation corridors for future highway development. M

Since the inception of Transportation Enhancements in 1992 approximately $72 million (just 1 percent of all TE program dollars) has been programmed for Activity 11, environmental mitigation projects. Of that $72 million, only $19 million has been spent on wildlife habitat connectivity projects (National Transportation Enhancements Clearinghouse, 2007).

Get in there and take advantage of the TE program to address wildlife habitat connectivity needs in your state or area of interest.
–Read the Guide to Transportation Enhancements by the National Transportation Enhancements Clearinghouse.
–Contact your state TE coordinator to introduce yourself and your organization. Ask for information on eligibility requirements. Find out when the next selection cycle begins and ask to be added to the mailing list.
–Meet with other stakeholders (wildlife and resource agencies, other conservation organizations) and make a "wish list" of potential TE projects.
–Find a sponsor (must be a public entity such as a state agency) and apply for a TE project.
–Keep in mind that TE funds are not eligible for standard environmental mitigation related to a current highway project or routine maintenance. These funds are best used where mitigation measures are needed but no relative transportation projects are pending.

6. Bridge Construction

Along with constant maintenance and upkeep of highways, your transportation agency is fastidiously checking and rechecking all the bridges and culverts in your state. They keep records of the conditions and schedule them for maintenance, restoration and full reconstruction when necessary. Bridge reconstructions are an excellent time to rethink the opportunities for better aquatic and terrestrial passage under the bridge. Sometimes, just extending the bridge's footprint by a few feet on either side makes a world of difference.

HALL OF FAME: "BRIDGING" BETWEEN FUNDING SOURCES FOR PANTHERS

In 2006, Defenders of Wildlife's Florida office applied for a TE project to improve a small bridge on US 41 in the Big Cypress National Preserve for wildlife passage. Despite lowered speed limits, seven Florida panthers had been killed within 2.5 miles of the bridge. Florida Department of Transportation checked their records and discovered that the bridge was already scheduled for

reconstruction. As a result, they will use bridge replacement funds for the project, supplemented with $425,000 in TE funds for preconstruction monitoring and design.

7. Intelligent Transportation Systems

We've all seen traffic surveillance cameras, travel advisory radio signs and electronic toll collection systems on highways. These and all the communications-based information and electronics technologies used on our highways are called Intelligent Transportation Systems (ITS). When integrated into our infrastructure and in vehicles themselves, ITS can improve safety and mobility—but can we put them to use for wildlife? Absolutely! A federal program began in 1991 to research, develop, and test ITS technologies, funded at $110 million annually. The program is divided into 16 application categories, three of which hold promise for preventing wildlife-vehicle collisions:

Crash Prevention and Safety applications include animal warning systems such as infrared or other detection technologies to identify large animals are approaching the roadway and warn drivers with flashing warning signs.

Roadway Operations and Maintenance applications include information dissemination via dynamic message signs that can be also be used to warn drivers about approaching wildlife.

Driver Assistance Systems applications include in-vehicle vision enhancement technologies such as dashboard infrared to help drivers see wildlife on the road at night.

Take advantage of the ITS program for wildlife. As of 2004, only six states had implemented ITS animal warning systems.

8. Transportation, Community and System Preservation Program

TEA-21 gave birth to the Transportation, Community and System Preservation (TCSP) program, a research and grants program to fund innovative transportation strategies that enhance community preservation, environmental protection and social equity. Big job, little program. Total funding for TCSP is $61 million per year, divided among all states. Nevertheless, one of the factors for eligibility is to "reduce the impacts of transportation on the environment." State, tribal, regional and local governments can apply, and priority is given to applications that meet certain criteria, including "environmental mitigation."

9. Ballot Measures

In the United States, ballot measures have recently been proposed for everything from legalizing marijuana to funding stem cell research. Conservationists have been using ballot measures for years to protect open space and bring much-needed funding for habitat acquisition. Now, ballot measures are being used to raise money for wildlife crossings. Typically, ballot measures are created when a threshold number of signatures is gathered on a petition to express public support. Once the signature threshold is met,, the measure is certified for the election and then presented to the public on a ballot for the voters' final decision. Ballot measures commonly require a simple majority of the public's vote to be enacted.

HALL OF FAME

In May 2006, voters in Pima County, Arizona, voted to pass a half-cent sales tax increase to fund their Regional Transportation Authority's (RTA) $2.1 billion regional transportation plan. The RTA plan was developed with input from a diverse, 35-member Citizens Advisory Committee and a 22-member Technical/ Management Committee. The plan included several highway and transit projects, but also set aside $45 million for a "Critical Landscape Linkages" category that will fund wildlife crossing structures and amenities in transportation projects. The crossings are critical to accomplishing the vision of a much larger effort under the Sonoran Desert Conservation Plan. Crossings will complement land acquisitions purchased with a 2004 open space bond, with more planned in the future.

HALL OF FAME

In 2005, the Washington State Legislature passed a transportation bill that included $387 million for the Snoqualmie Pass East I-90 Project, which includes several wildlife passages. Members from both sides of the aisle and the state worked to pass this bill, and make sure that I-90 remained on the project list. This package was challenged by an initiative to repeal the gas tax funding for the transportation bill, but was upheld by statewide voters in the fall of 2005. Since that time, the governor has requested further funding for the project as transportation costs in the state increase.

10. Impact or User Fees

Wildlife mitigation measures should always be paid for with transportation funds, but under special circumstances, conservationists could also consider creative, supplemental sources of funding such as bonds, specialized license plates and fees on recreation equipment. Impact fees could be assessed as an increase in sales tax on vehicles sales, or a flat-rate surcharge tacked on to vehicle registration fees. Assessing an additional one dollar per vehicle registration could generate millions per year, depending on the state. California's state constitution allows gasoline tax dollars to be used for environmental mitigation related to construction and operation of roads and highways.

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Simulation of overpass to be built for the Snoqualmie Pass East I-90 Project in Washington

WILDLIFE RESOURCES

WILDLIFE VEHICLE COLLISIONS

SAFETEA-LU Wildlife Vehicle Collision Study
http://safety.fhwa.dot.gov/safetealu/factsheet1119n.htm

Deer-Vehicle Crash Information Clearinghouse (DVCIC) and Countermeasure Toolbox
http://www.deercrash.com/
http://www.deercrash.com/Toolbox/index.htm

British Columbia Conservation Foundation's Wildlife Collision Prevention Program
http://www.wildlifeaccidents.ca/

HABITAT CONNECTIVITY

Highways and Habitat: Managing Habitat Connectivity and Landscape Permeability for Wildlife
http://www.fs.fed.us/pnw/sciencef/scifi79.pdf

Corridors of Life: Wildlife and Wild Places in the U.S. Northern Rockies
American Wildlands
http://www.wildlands.org/land.html
http://www.wildlands.org/highwaywildlife.pdf

Restoration of Carnivore Habitat Connectivity in the Northern Rocky Mountains
Bill Ruediger
http://www.defenders.org/habitat/highways/new/sub/library/bill's%20carnivore%20paper.pdf

WILDLIFE CROSSINGS

Wildlife and Roads
http://www.wildlifeandroads.org/

The Wildlife Crossings Toolkit
http://www.wildlifecrossings.info/

FHWA's Critter Crossings
http://www.fhwa.dot.gov/environment/wildlifecrossings/

Safe Passage: A User's Guide to Developing Effective Highway Crossings for Carnivores and Other Wildlife
Bill Ruediger and Monique DiGiorgio
http://www.carnivoresafepassage.org/

Wildlife Habitat Connectivity Across European Highways
http://international.fhwa.dot.gov/Pdfs/wildlife_web.pdf
http://international.fhwa.dot.gov/wildlife_web.htm

Guidelines for Bridge and Culvert Construction to Accommodate Fish & Wildlife Movement and Passage
Arizona Game and Fish Department, Habitat Branch
http://www.azgfd.gov/hgis/pdfs/BridgeGuidelines.pdf
http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

Evaluation of Wildlife Crossing Structures: Their Use and Effectiveness
Maureen Hartmann, for Wildlands CPR
http://www.wildlandscpr.org/resourcelibrary/reports/EvaluationByMaureenHartmann.htm

SOURCES OF FUNDING

Retroactive Mitigation
Mitigation of Impacts to Wetlands and Natural Habitat
Federal Register / Vol. 65, No. 251 / Friday, December 29, 2000 / Rules and Regulations
http://www.fhwa.dot.gov/environment/fr29de00.pdf

Federal Lands Highway Program
http://www.fhwa.dot.gov/flh/index.htm

Safety
http://safety.fhwa.dot.gov/

Transportation Enhancements
http://www.enhancements.org/misc/TEGuide2002.pdf
http://www.fhwa.dot.gov/environment/te/principles_pt1.htm
http://www.fws.gov/refuges/roads/transenhancements.html

Intelligent Transportation Systems (ITS)
http://www.itsoverview.its.dot.gov/Options.asp?System=CPS&SubSystem=AWSc&Tech=Animal
Transportation Community System Preservation (TCSP)
http://www.fhwa.dot.gov/safetealu/factsheets/tcsp.htm

ROADSIDE VEGETATION

Have you ever been to Yellowstone National Park? Yosemite? The Grand Canyon? Imagine all three of them put together and multiply that by four. That's how much land we have in our public rights of way! Seventeen million acres of land—an area roughly the size of Ireland—are found next to our roads and highways. Like it or not, that makes our transportation agencies land managers on a grand scale. Granted, our roadsides may not be high quality habitat like Yellowstone, but in many places roadsides provide some of the last vestiges of highly imperiled native habitat such as prairies and grasslands. Conservationists can't afford to overlook any opportunities for stewardship, much less a shot at 17 million acres. By partnering with transportation agencies, we can take advantage of new trends in ecologically sensitive roadside vegetation management.

AMERICA'S FRONT YARD

We live in our cars, so that makes our roadsides "America's front yard." And just like our own lawn care, early roadside vegetation managers were looking for something inexpensive, low-maintenance and attractive. If native flora failed to meet these objectives, non-native species such as kudzu and grasses were used. Some of these invasives spread beyond the right of way, onto adjoining private and public property, further degrading habitat and reducing biodiversity.

By the 1990s, the paradigm shifted from "do it fast" to "do it right." A new aesthetic began to take hold, suggesting that our country's roadsides reflect the natural beauty and biodiversity of each region, rather than the look of a manicured lawn. Can roadsides be more ecologically diverse, provide habitat for wildlife, showcase local character, control erosion, use less water, fertilizer and other chemicals, and require less maintenance?

FUNCTIONS OF ROADSIDE VEGETATION

- Traffic calming
- Stress reduction
- Buffer or shade for pedestrian or park-and-ride facilities
- Stream bank stabilization
- Wetland mitigation
- Water quality improvement
- Stormwater retention
- Air pollution mitigation
- Fire prevention
- Windbreak
- Noise abatement
- Wildlife habitat
- Enclose, screen, expose or blend the roadway with adjacent land uses
- Visual quality, quality of life
- Corridor continuity

Guest Column:

HOLISTIC SOLUTIONS FOR ROADSIDE VEGETATION

Bonnie Harper Lore, FHWA

ROADSIDES, The Front Yard of the Nation was written by J. M. Bennett in 1936. Apparently the book defined roadside development as we know it today, although it was not based on federal standards. Bennett wrote, "The necessity and popularity of grass cannot be questioned and its use along the roadsides invites little criticism." And with that comment, the idea of roadsides looking like front yards became the unwritten public policy and the expectation of the traveling public.

Grass does indeed fulfill the needs and constraints of modern roadsides across the nation. However, we can no longer afford—ecologically or economically—the costs of non-native grasses, fertilizers, irrigation or the fossil fuels used to maintain them. Every region has native grasses that can provide the ground cover, erosion control, aesthetics, small animal habitat and vehicle soft landings required by most highway engineers. Once native perennial grasses are established, they take care of themselves.

Bennett also said, "What is really desired, however, is attractive and useful roadsides which can be obtained by preserving or creating a natural or an approach to a natural condition in keeping with the adjacent or surrounding country. And the significant thing about this is that to follow a natural development is outright economy in road maintenance." Unfortunately it was the title of his book that caught on, not the practical substance of it. Four decades later, his counterparts were faced with the energy crisis of the 1970s and began looking for more holistic solutions to roadside development. This is when an ecological approach replaced the front yard approach to our nation's highways.

Partner with your transportation agency, garden clubs, community and civic organizations to develop educational programs and provide informational materials to the general public, landowners and other government agencies on the value of roadside vegetation.

"There is of course more to the wish to preserve our roadside vegetation than even such esthetic considerations. In the economy of nature, the natural vegetation has its essential place. Hedgerows along country roads and bordering fields provide food, cover, and nesting areas for birds and homes for many small animals. Of some 70 species of shrubs and vines that are typical roadside species in the eastern states alone, about 65 are important to wildlife as food."
—Rachel Carson

TYPES OF VEGETATION ON ROADSIDES

Some states have inventoried their roadsides in order to improve and prioritize management efforts, but for the most part we don't have an accurate picture of what is hiding (or lurking) in our public rights of way. From a highway operations perspective, roadside vegetation typically falls into one or more of these categories:

Desirable vegetation – species, preferably native, that complement the function of the road and are inexpensive, self-sustaining, attractive and fast growing.

Hazard vegetation – plants that are obscuring visibility, growing over guardrails, creating obstacles to signage or vehicular movement, posing windfall hazard over vehicles or pedestrians or creating persistent winter shade leading to prolonged icing conditions.

Detrimental vegetation – grasses and woody plants that are destructive to or compromise the function of highway structures, including grasses in pavement and bridge joints, medians, barriers, traffic islands and drainage structures.

Nuisance vegetation – plants with potential to cause problems to the general public or maintenance staff such as poison ivy and ragweed.

Invasive vegetation – exotic or non-native vegetation that displaces indigenous habitat and may compromise efforts to control soil erosion or reduce fire hazards. Certain species can even become entangled in and damage roadside mowing equipment.

Contact your local universities about conducting necessary research and monitoring of roadside vegetation.

ROADSIDE VEGETATION IN DESIGN AND CONSTRUCTION

Prior to roadway construction, the project area is clear-cut, scoured of all vegetation and grubbed to remove rooted material in the soil surface. Occasionally, desirable or valuable species may be salvaged prior to clearing, to be used after construction in the revegetation. Vegetation and topsoil are cleared from the future roadbed and shoulders. At curves, the area cleared may be wider to provide optimum visibility for drivers traveling in both directions. In colder climates, trees are removed that may contribute to snow drifting or shade the roadbed from sunlight needed to melt ice.

During the final design phase, engineers or landscape architects develop a landscaping plan. Landscape designers and engineers may conduct a preliminary field review, or "scoping," to identify conceptual locations for particular landscaping elements. Prior to construction, the design team settles on detailed landscape plans, conducts final field reviews and drafts maintenance agreements for the final roadside landscaping. Initial roadside landscape planning, design and development are generally considered part of highway construction projects, so the cost is included in the overall project budget. If plants are chosen based on their ability to be self-sustaining (requiring minimal water, fertilizer, pesticide, mowing) they will require less maintenance and resources in the future.

Landscape design should incorporate several existing and desired conditions, including:

- aesthetics
- erosion control
- minimizing maintenance requirements and costs
- screening undesirable views
- preserving desirable views
- shielding headlight glare
- preserving/enhancing the natural environment
- reducing noise volume.

Encourage your transportation agencies to coordinate and compile roadside vegetation inventories and classification systems. Volunteer to assist in data collection. You can also train volunteer "citizen scientists" to help with the inventory and future monitoring. The inventory data can then be used to establish a statewide invasives clearinghouse to provide data, information and technical assistance to land and resource managers, transportation agencies and developers.

VEGETATION MAINTENANCE

Maintenance crews have many responsibilities, including road resurfacing, shoulder maintenance, curb, gutter and sidewalk repair and replacement and snow removal. They also manage both planted and naturalized vegetation in the rights of way. Some typical maintenance practices are harmful to roadside vegetation and resident wildlife, such as mowing, herbicides and road-salt runoff. Emerging best practices can reduce these impacts and actually reduce maintenance costs. **For more information, see Maintenance and Operations.**

Many transportation agencies have developed comprehensive vegetation management plans, which include the full array of vegetation-related maintenance measures. Massachusetts' Highway Vegetation Management Plan states the objective as follows: "…to provide a safe, unobstructed roadway corridor and preserve the integrity of the highway infrastructure. Left uncontrolled, roadside vegetation can impede normal maintenance operations, obstruct motorists' line of vision, threaten pedestrian safety and cause damage to structures such as median barrier, pavements, guard posts, drainage lines and waterways. Other objectives include development of an aesthetically pleasing roadside, pest control, provisions of habitat, and stabilization of embankments and other areas prone to erosion."

Vegetation control consists of both mechanical and chemical control measures (i.e. mowing and spraying). To reduce wildfire hazards and promote healthy roadside ecosystems, some states also practice prescribed burning on roadsides where appropriate.

If your transportation agency has made great strides in improving roadside vegetation management for conservation, publicly recognize them for their efforts. Send a letter to your governor and transportation agency secretary with words of praise and encouragement for their efforts. And don't forget to send a copy to the maintenance division!

Mowing

How would you like to have to mow 17 million acres? Maintenance crews use several types and sizes of mowers; some specially designed for this purpose as well as ride-on and push mowers like the ones you might have at home. Mowing is typically used in all areas where it is safe and efficient to use the equipment. Weed whackers, trimmers and brush saws can also be used where mowing is impossible or impractical due to terrain, site size or sensitivity. In some instances, the cut vegetation may be "hayed" or baled for agricultural use. Mowing may be done by transportation agency staff or contracted out to a private landscape company.

When developing a mowing regime or policy, transportation agencies consider such factors as blade height, swath size, slope, frequency, timing, safety and cost. Vegetation is cut short enough to provide visibility for drivers, but not so short to "scalp" the plants and soils. The width of the mowed area depends on the type of highway and whether the area is a median or shoulder. Special attention is always given at intersections to create greater sight distance for motorists.

Depending on the weather and vegetation growth rates, maintenance crews may mow roadsides several times per year or only once every few years. Nebraska mows once before Memorial Day, once during summer and once more after Labor Day. Texas DOT warns against excessive mowing, which "leads to loss of desirable vegetation, fills drainage ways with silt and accelerates erosion." Mowing may be scheduled based on the growth, time of year and height of certain vegetation types and may be prohibited during certain times of the year to avoid disturbing sensitive species.

SAFETEA-LU's new research program will spend $50,000 to look into the economic and ecological benefits of reduced mowing. Minnesota and Michigan have already legislated reduced mowing and the idea is gaining ground. The final result of this research will be a published, peer-reviewed study that will affect state transportation agencies' mowing policies across the country. If the economic and ecological benefits exist as hypothesized, more environmentally sensitive vegetation management will become common practice.

HALL OF FAME: NEW YORK CONSERVES THROUGH MOWING PLANS

New York State DOT implemented Conservation Alternative Mowing Plans (CAMPs) designed to maintain existing standards for safety, aesthetics and routine maintenance yet do the following:

- Conserve staff hours spent mowing
- Conserve fuel usage and costs
- Conserve air quality through reduced spent fuel emissions
- Conserve habitat for protected and declining populations of ground nesting birds
- Conserve required equipment maintenance
- Conserve habitats through reduced fragmentation.

HALL OF FAME: NEBRASKA WON'T MOW DOWN PHEASANTS

Nebraska has taken steps to alter its mowing practices in order to protect pheasants. A Memorandum of Understanding between the Nebraska Game and Parks Commission and the Nebraska Department of Roads reads as follows:

Whereas, as research has shown that 25 percent of the pheasants are hatched in roadsides, and;

Whereas, the right of ways along Nebraska's road systems managed by the Department of Roads are of significant importance as wildlife habitat, and;

Now, therefore, That total roadside mowing be done on a scheduled rotational basis and that no more than one-third of a district

shall be mowed out in any one year. The term "total roadside mowing" is defined as mowing all areas within the right of way, including, but not limited to, the median and the road shoulder.

"Once it had been a joy to follow those roads through the evergreen forests, roads lined with bayberry and sweet fern, alder and huckleberry. Now all was brown desolation." **—Rachel Carson**

Herbicides

Chemical herbicides are used to control vegetation on roadsides, and can be used at different strengths to kill unwanted vegetation or simply retard growth rates. Generally, these chemicals are sprayed onto vegetation using truck-mounted spray booms, pressure sprayers, portable pressurized canisters, squirt bottles, paintbrushes or sponges. Droplet size can be controlled to keep spray drift to a minimum. Herbicides can either be sprayed over the entire plant when fully grown or applied to cut stumps immediately following a cutting operation to prevent re-sprouting.

To reduce the amount of herbicide use, spraying can be limited to areas where mowing is deemed unsafe or difficult. Using mowing equipment near roadways with higher speeds and traffic volume can put both motorists and maintenance personnel in danger. Herbicides are often used around guardrails and signs where mowers cannot reach.

"To date, there is no environmentally, economically feasible and safe right of way management program that eliminates the use of herbicides altogether. In particular, guardrails, medians and traffic islands on high-speed, high-volume roads present conditions unsafe for personnel hand-cutting operations." **MASS HIGHWAY Vegetation Management Plan 2003-2007**

Controlled Burning

Fire is a natural and essential part of ecology and controlled burning is an increasingly accepted practice used to manage natural areas such as prairie, oak savanna, wetlands and oak woodlands. Rights of way contain important remnant native grasslands, best managed through a strong fire regime.

Prescribed burns offer numerous ecological and cultural benefits, such as:

- Controlling weeds and woody invasive species
- Stimulating seed generation and growth of many native plants
- Removing thatch and heavy accumulation of leaf litter
- Recycling nutrients
- Warming the soil and giving warm-season plants an earlier start
- Control biting and disease carrying insect populations

To bee or not to bee: Roadside Management for Pollinators

Roadside restoration creates valuable refugia for bees and other pollinators. Marginal linear habitats (roadsides, crop margins) may provide valuable habitat for bees by supplying foraging and nesting opportunities in landscapes in which resources are otherwise scarce. Recent trends in roadside management practices—reduced use of pesticides, altered mowing regimes, reseeding with native prairie plants and abundant floral resources—are providing potential sites for ground-nesting bees (Hopwood, 2006).

Tree Maintenance

Trees, shrubs and other woody vegetation found in rights of way are often pruned, trimmed, burned or sprayed with herbicides to maintain sight distances for drivers, to widen roadway clearance, improve visibility of signage or to protect utilities and adjacent property from falling limbs. In colder climates, thick shrubs contribute to snow drifting on roads and trees can shade the road surface, reducing the amount of sunlight needed to melt ice on roads. "Brush control" involves mechanical mowing, trimming, spraying and removal.

YOU MAKE THE CALL: KILLER TREES?

Trees have become unwelcome residents on roadsides. In the name of safety and in fear of lawsuits, maintenance divisions often remove everything taller than grass from roadsides. Many communities have had to fight to preserve trees as historic and scenic resources during the construction and reconstruction of highways. Meanwhile, transportation agencies continue waging war on what they consider "killer trees," removing any tree larger than four inches in diameter from the rights of way.

The American Association of State Highway and Transportation Official's (AASHTO) Strategic Highway Safety Plan, Goal 15 is *Keeping Vehicles on the Roadway,* and Goal 16 is *Minimizing the Consequences of Leaving the Road.* Subsequently, three emphasis areas evolved from these two goals:
-Run-off-road crashes
-Head-on crashes and
-Crashes with trees in hazardous locations.

According to Ohio Department of Transportation's design guidelines, "While it is a policy within ODOT to increase the amount of aesthetics on the state highway system, and these guidelines attempt to encourage that end, it cannot be understated: trees are proven killers when placed by the roadside."

What is the risk of a tree accident? The U.S. accident count is about 6 billion annually, and more than 43,000 people die on roads each year. About 80 percent of accidents are car-to-car collisions, while collisions with roadside fixed objects (including trees) account for about 10 percent of these accidents. Of those, collisions with poles and signs (2.1 percent) outnumber tree crashes (1.9 percent).

Design guidelines and standards for safe roadside design should take into account the full range of tree benefits. Tree-lined streets have been shown to calm traffic, reduce motorist stress, reduce accidents, boost pedestrian use and increase shopping. Context Sensitive Design (CSD) encourages transportation designers to regard the AASHTO "Green Book" as a set of design guidelines rather than as standards.

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Study reports and information at:
www.cfr.washington.edu/research.envmind/transportation.html

INTEGRATED ROADSIDE VEGETATION MANAGEMENT PROGRAMS

Sometimes being cheap and lazy really pays off. In searching for ways to cut costs and save time, maintenance departments discovered that Mother Nature just might be onto something. By preventing disturbance in the first place, self-sustaining native plant communities can naturally discourage the establishment of unwanted plant species. This new philosophy came to be known as Integrated Vegetation Management or Integrated Roadside Vegetation Management (IRVM). The approach employs manual activities, mechanical tools and chemical applications combined with cultural and biological methods to develop a vegetation community that requires minimal maintenance and benefits wildlife and its habitat.

If your transportation agency has not yet adopted an IRVM plan, encourage them to do so. Explain the benefits to them, to citizens and to wildlife. Ask how you or your organization can help them achieve this goal. Perhaps you can lobby for additional funding or send letters of encouragement to leadership. AASHTO's Center for Environmental Excellence has guidance for IRVM planning and implementation.

–Not all IRVM plans are created equally. Does yours adequately and appropriately incorporate conservation? If not, suggest improvements.

INVASIVE SPECIES

Invasive species are like the in-laws of vegetation. They're somehow related, but they're irritating, they move in where they're not wanted and they're almost impossible to uproot. Our rights of way have been inundated with non-native species—mostly by accident, some times by design, and often in well-intentioned but harmful attempts to "beautify" the roadside. Because they disturb natural habitats, road systems can facilitate the spread of plant and animal species. Roads transport "hitchhiker" seeds and make it easier for foreigners to lay roots by disturbing the ground or importing soil that holds water. Invasives also sneak in via mulches, seed mixes, contaminated soils and construction equipment. A recent study by the University of California at Davis and the U.S. Geological Survey found that invasive species were more likely to be found near roads and that their spread was wider with each improvement to the roadway, such as grading and paving (Gelbard, 2003).

The real problem with roadside invasives is they don't stay on the roadside—hence the name. They invade adjacent properties, wreaking havoc on agriculture and habitat. Introduced species are a significant threat to biodiversity, contributing to the decline of 42 percent of U.S. endangered and threatened species. At least

three of the 24 known extinctions of species listed under the Endangered Species Act were wholly or partially caused by hybridization between closely related exotic and native species. Invasive species degrade habitats and threaten natives through predation, disease, competition and hybridization (Schmitz, 1997).

Roadside maintenance is the domain of state transportation agencies with very little federal oversight. However, because invasive species have gone from a nuisance to a very expensive ecological crisis, Congress considered measures to address the use of invasives in roadside vegetation management in crafting SAFETEA-LU. Bowing to pressure from the seed industry and property rights advocates, Congress fell short of naming or defining invasive species in the bill. Early drafts of the bill included restrictions on the use of invasives on roadsides that drew fire from the seed industry that objects to any restrictions on what their clients (like transportation agencies) can purchase. Private property advocates saw the draft provision as a threat to their right to use or own non-native species on privately owned land. Together, they successfully defeated the provision. In the final bill, SAFETEA-LU contained a provision that makes transportation funds available to control "noxious weeds" and establish native vegetation as part of any transportation project.

SAFETEA-LU allows transportation funds to be used for "establishment of plants selected by state and local transportation authorities to perform one or more of the following functions: abatement of stormwater runoff, stabilization of soil, and aesthetic enhancement," and "management of plants which impair or impede the establishment, maintenance, or safe use of a transportation system."

In 1999, President Bill Clinton signed Executive Order 13112 "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause." Soon after, FHWA developed a framework for preventing the introduction of new invasives on rights of way and controlling those invasives that already existed.

Encourage your transportation agencies to provide additional training in removing invasive species and re-establishing native flora on rights of way for maintenance crews, contractors and landowners. Offer logistical support for training including use of facilities or providing copies of training documents.

–Partner with your transportation agency on a pilot project to remove and prevent roadside invasives and to restore native species.

YOU MAKE THE CALL: ARE ROADSIDES CONSIDERED HABITAT?

Rights of way have traditionally been managed for safety and aesthetics, with little or no consideration for wildlife. Recent trends in roadside vegetation management can restore and create habitat for wildlife. But is creating habitat adjacent to roads and highways a good idea? Some people believe that we can't afford to overlook the potential for 17 million acres of land. In highly disturbed landscapes, the roadsides may hold the last remaining vestiges of important ecosystems such as prairies. On the other side, many biologists argue that creating habitat near roads can do more harm than good. Animals near roadsides are exposed to pollutants, increased predation and human interaction and are more likely to be involved in vehicle collisions

YES

Roadsides if managed properly can provide habitat for various wildlife species. Development of these areas is relatively inexpensive and requires very little maintenance. Wild turkeys will use these areas for nesting, brood rearing and foraging. Deer will be attracted to the increase in forage production. To further enhance and diversify roadsides, food plots and mast-producing trees can be planted along portions of the roads.
Roadside Management For Wildlife
Claude Jenkins, Wildlife Biologist Alabama Wildlife Federation

"Wildlife benefits are not the primary goal of roadside vegetation but they could be," according to Leslie Ries of Northern Arizona University. Restoring prairie along roads has great conservation potential. Iowa alone has more than 600,000 acres of roadside vegetation and there are millions more nationwide.
Retrieved from:
http://www.eurekalert.org/pub_releases/1999-06/SfCB-Btir-280699.php

NO

"Roadsides are death traps," says Ron Mumme of the Department of Biology at Allegheny College in Meadville, Pennsylvania. Florida scrub jays that nest along a highway die in greater numbers than they reproduce. Three times as many fledglings die on road territories than on non-road territories. "I think the best of the politically acceptable alternatives would be, oddly enough, clearing all vegetation of the right of way and keeping it mowed," says Mumme.
Journal of Conservation Biology, April 2000

"Although roadsides provide some benefits to some species, those benefits must be balanced against ecological effects of roadsides. For example, in Banff National Park, the increased habitat quality for bears along roads must be weighed against the increased probabilities of bears being road killed or (as threats to visitors) removed from the park."
Richard T.T. Forman, et al
Road Ecology: Science and Solutions, page 129

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INTEGRATED ROADSIDE VEGETATION MANAGEMENT

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http://www.nrvma.org/

INVASIVE SPECIES

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AQUATIC RESOURCES

Roads and water don't mix. Period. In fact, the history of road building can be told as a battle between roads and water. Our early dirt roads were no match for water; a good rain could reduce them to mud pits or wash them out altogether. Water was clearly winning the war. But eventually, roads gained the upper hand with the advent of pavement. Networks of paved roads increased the amount of impervious surfaces, disrupting the natural flow and circulation of water. But water does not give up so easily. Groundwater strikes back by destabilizing roadbeds from below and ice uses freeze-thaw cycles to deteriorate road surfaces. In counter-attacks, roads choke streams, block fish passage and deliver harmful pollutants into watersheds. Not to be outdone, water attacks roads with flooding, erosion and landslides. It's a classic man vs. nature struggle and both sides are losing the battle. Our aquatic resources are severely degraded by roads and roads continue to take a beating from water. With advances in science and technology, transportation agencies plan, design, build and maintain roads with water in mind. This chapter examines the many ways transportation agencies protect roads from water and vice versa.

ROADS vs.	WATER
Disrupt natural flow and circulation	Flooding
Affect material transportation	Destroy bridges and culverts
Cause sedimentation	Erosion
Transport pollution	Landslides
Block absorption in soil with impervious surfaces	Deteriorate road surface with freeze-thaw cycle
Choke off fish passage	Destabilize roadbed by discharging groundwater
Accelerate water flow	

IMPACT OF ROADS ON AQUATIC ECOSYSTEMS

- Loss or degradation of habitat
- Erosion and sedimentation
- Stormwater runoff contamination
- Altered hydrology—pooling, scouring, excessive velocity and turbulence
- Restricted passage of debris and deflectors
- Impeded movement of animals
- Disruption, fragmentation and isolation of populations
- Reduced access to vital habitats
- Altered abundance and diversity of aquatic organisms (Jackson, 2003):

BRIDGES AND CULVERTS

There are only three ways that roads cross water—they either bridge over the water or they go through it, and in a few urban settings, roads are tunneled under water. In many places, entire streams have been moved to make room for a road. The most common methods of crossing streams and rivers are bridges, culverts and fords. Bridges are more expensive to build and maintain, but are considered the least detrimental to the surrounding aquatic ecosystem.

Rather than spanning over the natural flow of rivers and streams, many roads are built through the water and culverts are put in place to allow for water flow. Culverts are less expensive so are used whenever conditions permit. Fords are generally only used as temporary measures during construction.

Bridges

Bridges come in all shapes and sizes and have been built to cross over water bodies as small as a meander and as large as an ocean channel. There are four main types of bridges: beam bridges, cantilever bridges, arch bridges and suspension bridges. Because of the expense, bridges are generally considered an option only over wider streams and rivers, or if water is too deep to accommodate culverts. Though not totally benign, bridges are considered the most ecologically sensitive method for roads to cross streams and rivers. In some regions, bridges serve as habitat for certain migratory birds and bats. Aesthetically, bridges can also be the distinguishing feature in a landscape; contributing to the scenic and cultural value of the community.

There are no minimum size standards for bridges. When deciding between a bridge and a culvert, designers and engineers consider cost, topography, navigation and the presence/absence of endangered species. When designing a bridge, engineers consider the following factors:

- Length of the span (How long is it from one side to the other?)
- Width of the deck (How many lanes will it support?)
- Functional classification
- Average daily traffic volume
- Vehicle weight and size
- Scale
- Surroundings and context
- Topography
- Weather
- Cost

There are 591,707 bridges more than 20 feet in length located on public roads in the United States, carrying nearly four billion vehicles per day. Bridges provide special opportunities for wildlife habitat connectivity. Riverine systems serve as movement corridors and habitat linkages for many species of terrestrial wildlife, and they provide essential habitat functions in and of themselves. Bridges are often built to span the water but not the adjacent land, thwarting any attempts by terrestrial species to pass below them. The movement and flow of the water continues, yet the movement and flow of the terrestrial animal community along the riverbanks is abruptly constricted. When bridges are being replaced or rehabilitated, they should be extended to span enough unsubmerged land to provide habitat and a movement corridor for terrestrial wildlife. Lengthening existing bridge spans also costs far less than building separate wildlife crossings under existing roadways.

Survey the bridges in your area of interest. Do they span beyond the water's edge to allow terrestrial wildlife species to use them as crossings? Contact the bridge division in your state transportation agency and ask about the status of the bridges. Ask if, and when, they plan to replace the bridges. Suggest they consider building a wider span to allow for terrestrial passage.

Pile driving, Bioacoustics and Barotrauma

Bridges are often built on concrete or steel foundations driven into the surface with pile drivers. The noise (bioacoustics) and sound impulses (barotrauma) generated from pile driving have profoundly adverse effects on fish, marine mammals and diving sea birds. Fish kills, disruption of foraging behavior and altered migratory patterns are among the documented concerns.

Because pile driving impacts endangered salmon, the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries have implemented terms and conditions for pile driving. Transportation agencies are experimenting with cofferdams and bubble curtains to reduce impacts of pile driving on aquatic species.

Culverts

Because culverts are less expensive to build and maintain than bridges, they are the preferred method of crossing water when conditions permit. Culverts are designed with the principal objective of moving water under a road alignment; they are not intended to simulate a natural waterway or provide habitat for aquatic organisms. In fact, streams are often straightened and deepened near a culvert to increase water flow speed so the culvert can be self-cleaning. Until recently, hydrology, sediment

transport, movement of woody debris, and fish and wildlife passage were given little consideration. As a result, more than half of the culverts assessed on U.S. Forest Service and Bureau of Land Management (BLM) lands in Oregon and Washington are considered barriers to juvenile salmonid fish passage (U.S. Government Accountability Office, 2001).

From a conservation perspective, all water crossing are not created equal. The ecological hierarchy of preferable structure types is as follows:

1. Bridge (with no approach embankment into the main channel)
2. Streambed simulation using a bottomless arch or embedded culvert design
3. Streambed simulation using an embedded round metal or concrete box culvert design
4. Nonembedded culvert, placed at less than 0.5 percent slope
5. Baffled culvert (various designs); placed at 0.5 percent to 12 percent slope or a structure with a fishway.

Survey the culverts in your area of interest. Are they functional? If not, contact your transportation agency and ask if, and when, they plan to retrofit the culverts for fish and aquatic organism passage.

FISH PASSAGE

We've all pondered the question, "Why did the chicken cross the road?" But have you ever thought about how a fish crosses a road? According to the U.S. Fish and Wildlife Service, an estimated 2.5 million culverts, dikes and dams exist throughout the country. All of them, from small culverts to massive dams have altered the features and hydrology of our waterways, blocking the migration of fish and other aquatic organisms. The issue of fish passage is certainly much larger than just transportation—many wildlife and resource organizations are working to restore adequate fish passage where it has been lost. For its part, the transportation sector has recently begun accepting responsibility and taking action.

Suboptimal culverts have taken their toll on migratory fish in rivers and streams. High water velocity, shallow water depth within culverts, excessive vertical drop at the culvert outlet, and debris blockages are the most common causes of fish passage problems at culverts. Fisheries have always been important economic and recreational resources, and some species (salmonids) are now federally listed as threatened or endangered, bringing a sharper focus to the issue of fish passage for migratory species. Transportation agencies are now spending a considerable amount of time and money undoing the damage created by a century of poorly designed culverts, while also creating better design standards for new and replacement culverts.

To assist fish passage, transportation agencies can make the following modifications to existing culverts:

- Increase culvert size to decrease water velocity.
- Use a different shape culvert to accommodate fish passage.
- Lower the invert level to allow natural substrate on the culvert bottom.
- Increase "roughness" within culverts to slow water velocity.
- Install gradient controls or "resting areas" upstream and downstream of culverts.

For new structures, the following culvert designs are used to reduce the impacts to fish passage:

- Active Channel Design Method uses a culvert size large enough and embedded deep enough into the channel to allow the natural movement of debris and formation of a stable bed inside the culvert.
- Stream Simulation Design Method uses bottomless culverts placed over a natural streambed, and makes them wide enough to include banks on either side. By not restricting flow, this method mimics the natural stream processes within a culvert.
- Hydraulic Design Method tailors the hydraulic performance of the culvert to the swimming abilities of target species of fish.

SAFETEA-LU provides $10 million per year to the U.S. Forest Service to "pay the costs of facilitating the passage of aquatic species beneath roads in the National Forest System, including the costs of constructing, maintaining, replacing, or removing culverts and bridges, as appropriate."

HALL OF FAME: MAINE DEPARTMENT OF TRANSPORTATION'S FISH PASSAGE POLICY AND DESIGN GUIDE

Maine DOT issued guidance in 2002 that established a policy, process and design guide for fish passage on all projects with bridges, culverts, pipes or pipe arches. The guidance was developed in coordination with resource agencies and established a clear protocol for addressing fish passage.

STREAMBANK STABILIZATION: RIPRAP

Wherever you see bridges and culverts, you're sure to see the dreaded riprap: a permanent cover of rocks intended to control erosion, stabilize streambanks and protect them from high velocity water flow. This streambank stabilization process requires heavy equipment to clear vegetation and smooth the banks before a blanket of boulders is poured onto the slope—a process that is

also called "armoring." The large, jagged rocks used for riprap slow down the flow of stormwater runoff, reducing streambank cutting and decreasing sediment loads. Riprap can be fieldstone, quarry stone, scree or broken concrete. Complex mathematical formulas are used to determine stone size and feature dimensions. If stones are not available or are too expensive, fabricated alternatives can be used, such as articulated concrete block mats. To prevent water from removing underlying soil, a layer of geotextile or a stone filter must be placed beneath the riprap. The use of riprap is limited by steepness of slope; slopes steeper than 2:1 tend to lose l riprap to erosion and sliding.

IMPACTS OF STABILIZATION MEASURES

1. Hinder morphologic evolution–the natural changes in stream characteristics, energy processes and riparian succession that occur in healthy stream and riparian ecosystems.
2. Alters the hydrologic balance of a river by changing resistance, altering channel geometry and modifying water exchange and hydrodynamic character.
3. Reduce or eliminates sediment yield and tends to generate local scour, usually at the toe or immediately downstream.
4. Alter the channel geometry, flow field, riparian vegetation conditions and a host of other habitat elements, creating preferential habitat for some organisms at the expense of others.
5. Impact chemical and biological processes provided by natural stream channels and their associated riparian zones, such as soil and water quality, nutrient cycles and source and sink areas for maintaining population equilibrium of some plant and animal species.

Effects of Riprap on Riverine and Riparian Ecosystems
U.S. Army Corps of Engineers

Did You Know? Water flowing at the rate of two feet per second can move a cobblestone weighing half a pound, but an increase in velocity to 10 feet per second can move a rock that weighs 150 pounds (Ohio Department of Natural Resources, 2007).

What's wrong with Riprap?

Make no mistake, most stabilization measures are intended to protect the built environment from the natural environment, not the other way around. Healthy aquatic systems *are* dynamic and unstable, wrought with erosion, deposition, flooding and drought. In a natural state, rivers will regularly overflow banks to move within the floodplain, creating new channels, distributing seeds and stems, leaving behind ghost channels, wetlands and oxbows that nourish a variety of species. It's an incredibly complex system. But confined, the river has only two places to go: scour down its own channel or deliver the water faster downstream. The floodplain loses connectivity to the river itself; becoming smaller and drier as wetlands disappear and side channels go dry.

Stabilization measures have been used in the United States for more than a century now, largely unregulated and without recognition of potential ecological impacts. Consequently, thousands of miles of stream have been stabilized with riprap and the cumulative impact to our aquatic ecosystems has yet to be calculated or mitigated. Moratoriums on the use of riprap have been pursued by the National Marine Fisheries Service, the U.S. Fish and Wildlife Service and some state departments of environmental quality.

"Soft" techniques, like the use of trees and rootwads, provide a good alternative to riprap by helping to slow the erosion rather than stop it completely. The challenge is to successfully stabilize the streambank without significant impacts to the natural functions of the river itself.

"It is yet another of the paradoxes of living in the modern West. We move to places like…Montana, drawn by the lure of a wild river. We build our homes close to what we love. But for us to stay there, through year after year of spring flood, the river must be controlled. And a river like the Yellowstone, like any force of wild nature, cannot be controlled and remain that which attracted us, and thousands of others, in the first place." **Wild Rivers and Riprap: The Case of the Yellowstone Hal Herring**

Survey the streambank stabilization measures used in your area of interest. Is riprap the primary measure used? Contact the appropriate authority and suggest the less harmful alternatives listed in this chapter. Volunteer your organization to help remove the old riprap and replace it with less harmful alternatives.
-Check on the land use or zoning restrictions in floodplains and riverbanks. Support restrictions on development in floodplains that lead to riprap and other habitat alterations used to protect human structures from natural processes.

STORMWATER RUNOFF

What goes up must come down, but where does all that water go? Water from rain or melting snow that enters waterways rather than soaking into the ground is called stormwater runoff. Impervious surfaces like roads and parking lots decrease the amount of water absorbed by the ground and increase the amount and velocity of stormwater runoff that is directed into storm drains that carry the water far from its place of origin. As stormwater flows, it collects and transports debris, chemicals, sediment, excess nutrients, pathogens and other pollutants into either a storm sewer system or directly into streams, lakes, wetlands or coastal water. Untreated, polluted stormwater threatens drinking water supplies for humans and degrades aquatic habitat for fish and wildlife. Nonpoint source pollution accounts for 80 percent of the degradation of waters in the United States (Smoot, 1997).

Federal environmental regulations under on the Clean Water Act require the control of pollutants from municipal separate storm sewer systems, construction sites and industrial activities. Contaminants come from a variety of origins called point and nonpoint sources. Stormwater runoff and discharge can be both point and nonpoint sources, so transportation agencies must go through the general permit process of the Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES). Also, each state has an environmental agency with water quality oversight (often called the Department of Environmental Quality) and state health departments oversee drinking water issues. In addition, state wildlife agencies have jurisdiction over water quality issues relating to aquatic ecosystems.

As such, addressing stormwater runoff is serious business for transportation agencies. Almost every state transportation agency has developed guidance and uses best management practices (BMPs) on stormwater management, and many states have sophisticated programs with full-time staff devoted to addressing stormwater issues. California has four department-wide Stormwater Advisory Teams or SWATs to evaluate new and improved BMPs and to develop procedures and guidance for implementing their statewide stormwater management plan. All districts have designated NPDES Storm Water Coordinators to facilitate implementation of a Storm Water Management Program.

The most common contaminants in highway runoff are heavy metals, inorganic salts, aromatic hydrocarbons and suspended solids that accumulate on the road surface. Salting and sanding practices leave chloride, sodium and calcium on the roadway surface. Our cars leave behind grease, rust, hydrocarbons, rubber particles and other solid materials. These materials are often washed off the highway during rain or snow storm events.

Stormwater BMPs can be incorporated into the planning, design and construction of new projects or reconstruction of existing facilities. In planning and design, the project engineer can consider proactive, technology-based, nontreatment controls to reduce pollutant discharges. Stormwater run-on at the project site can be calculated using the peak flow rate, runoff velocities and erosive characteristics of the soils in the area, so that appropriate control measures can be implemented.

"Highway runoff is generally not harmful."
Federal Highway Administration

Contact your transportation agency and ask if they are currently using stormwater best management practices.

Roads are built in such a way to direct stormwater from the roadway surface into drainage systems within or adjacent to the right of way. Drainage systems discharge either to municipal drain systems or directly into receiving waters such as creeks, streams, lakes, estuaries, wetlands and coastal waters. To minimize adverse impacts of highway runoff, transportation agencies can take measures to clean the water as it comes off the roadway surface and before it reaches creeks and streams and other receiving waters. Structural measures such as filtering systems and porous pavements trap runoff until the contaminants settle out or are filtered through the underlying soils. Detention/retention ponds and wetlands are used to temporarily store runoff and remove contaminants but are considered expensive and require annual maintenance. Vegetated swales are wide, shallow ditches with thick vegetation designed to trap pollutants and slow the flow of stormwater. Nonstructural measures such as street sweeping and vegetated buffers control contaminants at the source and reduce the pollution concentration in runoff.

SAFETEA-LU includes funding eligibility for environmental restoration and pollution abatement, including retrofitting and construction of stormwater treatment systems.

DEICING SALT

If you have ever had to drive in snow or icy conditions, you may welcome the sight of the salt trucks. But that excess salt is not welcome in the surrounding environment. Transportation agencies use salt and other chemicals to melt snow and ice on roadways either prior to storms (anti-icing) or after storms (de-icing) to melt ice. The two most commonly applied salts are sodium chloride (NaCl, rock salt) and calcium chloride (CaCl2), which are often mixed with abrasives like sand, ash or sawdust to improve traction. Deicing chemicals are often combined with other substances to prevent caking and inhibit corrosion. Calcium chloride is more effective at melting ice but sodium chloride is more widely used because it costs less.

Did You Know? Deicing chemicals work by lowering the freezing point of water. A 23.3 percent concentration of salt water freezes at minus 6 F, while a 29.8 percent solution of calcium chloride freezes at minus 67 F.

What's wrong with salt?

Ironically, the salt used to protect motorists from hazardous driving conditions is the very substance that rusts automobiles and corrodes the rebar used to reinforce concrete bridges. Salt also wreaks havoc on the surrounding environment, including aquatic ecosystems.

Salt is highly soluble and quickly washes from the road surface to the roadside where it eventually finds either groundwater or surface water. Increased salinity can have a detrimental effect on drinking water supplies in reservoirs and aquifers and on wildlife.

Beyond the salt itself, the additives have detrimental impacts as well. Sodium ferrocyanide, added to prevent caking, releases cyanide ions that are extremely toxic to fish. Rust inhibitors contain phosphorus compounds that stimulate the growth of undesirable aquatic plants, weeds and algae in freshwater lakes. Abrasives (sand, cinders, gravel and sawdust) can accumulate along roadways and clog stormwater inlets and sewers. And all these materials may wash downstream and end up in streams and lakes.

Contact your transportation agency and ask what kind of deicing chemicals they use and how much they use. Suggest less harmful alternatives. Volunteer your organization to help plant a living snow fence.

SALT ALTERNATIVES

Transportation agencies are getting the message: Road salt is costly. Some communities use salt only in ice-related emergencies and adjust spreading equipment so less salt is used. Trees can be planted to establish a "living snow fence," to keep snow from blowing onto the road. In Minnesota, farmers leave corn stalks standing through the winter in fields along the highway to hold blowing snow. Other proposed methods to remove snow include the use of external melting systems, pavement that stores solar energy for melting, and improved tire/vehicle design.

The most common chemical alternatives are calcium magnesium acetate (CMA) and potassium acetate (KAc). Verglimit is a mixture of deicing chemicals that are bonded with asphalt during paving, allowing very little runoff and maintaining effectiveness even in very cold temperatures. Unfortunately, these alternatives are often deemed cost prohibitive. CMA is approximately 20 times more expensive than salt and Verglimit installation doubles the cost of surfacing a road.

Some reports have estimated that the damage to automobiles done by salt ranges from six to 30 times the initial cost of the salt, with 90 percent of the damage due to corrosion. With the corrosive damage to bridges, highways and vehicles factored in, one study concluded that the actual cost of salt may be close to $775/ton.
Michigan Department of Environmental Quality

IN THE NEWS: STUDY: SALT IN NORTHEAST STREAMS SHOWS SHARP INCREASE

(AP) WASHINGTON, Sept. 5, 2005 The amount of salt dissolved in streams in the Northeast is rising and chemicals used to clear snow and ice from the roads are being blamed. "We're basically hardening the watersheds and feeding them a high-salt diet. There is a direct connection between the number of driveways and parking lots we have and the quality of our water," said Sujay Kaushal of the University of Maryland Center for Environmental Science in Frostburg, Maryland.

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AQUATIC RESOURCES

BRIDGES

Bridge and Road Construction Guidelines for Wetland and Riparian Areas New Mexico Department of Game and Fish
http://www.wildlife.state.nm.us/conservation/habitat_handbook/documents/BridgeandRoadConstructionGuidelines.pdf

TRB Committee AFH40: Construction of Bridges and Structures
http://www.trb.org/directory/comm_detail.asp?id=1406

CULVERTS_AND FISH PASSAGE

USFWS National Fish Passage Program
http://www.fws.gov/fisheries/FWSMA/FishPassage/
http://library.fws.gov/Pubs9/fishpassage.pdf

USFS National Inventory and Assessment Procedure For Identifying Barriers to Aquatic Organism Passage at Road-Stream Crossings
http://www.stream.fs.fed.us/publications/PDFs/NIAP.pdf
http://www.stream.fs.fed.us/fishxing/index.html

USGAO *Restoring Fish Passage Through Culverts on Forest Service and BLM Lands in Oregon and Washington Could Take Decades*
http://www.gao.gov/new.items/d02136.pdf

Washington State Highway System Fish Passage Program
http://www.wsdot.wa.gov/environment/fishpass/state_highways.htm

RIPRAP

Effects of Riprap on Riverine and Riparian Ecosystems
J. Craig Fischenich, U.S. Army Engineer Research and Development Center
http://el.erdc.usace.army.mil/wrap/pdf/trel03-4.pdf

Michigan Department of Environmental Quality, Riprap Fact Sheet
http://www.deq.state.mi.us/documents/deq-swq-nps-rip.pdf

Mats, Concrete, Blocks and Rocks: The Lowdown on Riprap
http://www.forester.net/ecm_0207_mats.html

STORMWATER

EPA, National Pollutant Discharge Elimination System (NPDES)
http://cfpub1.epa.gov/npdes/home.cfm?program_id=6
VII. Management Measure for Roads, Highways, and Bridges
http://www.epa.gov/OWOW/NPS/MMGI/Chapter4/ch4-7a.html

American Rivers Stormwater Systems Toolkit
http://www.americanrivers.org/site/PageServer?pagename=AMR_content_39bf

Alternative Practices to Manage Highway Runoff, Webcast Series – Resources and Links
The Izaak Walton League of America
http://www.iwla.org/index.php?id=223

Is Highway Runoff a Serious Problem?
http://www.tfhrc.gov/hnr20/runoff/runoff.htm

CalTrans Stormwater Management Plan
http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-02-008.pdf

NCHRP 25-30 Temporary Bridging to Avoid or Minimize Impacts to Waters and Wetlands During Highway Construction
http://www.trb.org/trbnet/projectdisplay.asp?projectid=765

DEICING SALT

De-Icing Salt is here to stay, but can be used more wisely
Todd Paddock and Cynthia Lister, Academy of Natural Sciences
http://www.saltinstitute.org/nas.html

Using Salt and Sand for Winter Road Maintenance
Wisconsin Transportation Bulletin No. 6: Using Salt and Sand for Winter Road Maintenance
http://www.usroads.com/journals/p/rmj/9712/rm971202.htm

Michigan Department of Environmental Quality, Winter Road Management
http://www.deq.state.mi.us/documents/deq-swq-nps-wrm.pdf

Advocacy

Your most valuable tool for advocacy is knowledge. Now that you have a better understanding of how highways happen, this chapter compiles some good advice on how to put your newfound knowledge to work. If you find yourself in a situation where it is no longer appropriate to chain yourself to a tree, this information will help.