



Wildlife Impacts and Conservation Solutions

Large Mammals

EFFECTS OF HIGHWAYS ON ELK (*CERVUS ELAPHUS*) HABITAT IN THE WESTERN UNITED STATES AND PROPOSED MITIGATION APPROACHES

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Why Elk?

Elk are an excellent species to use as a “terrestrial wildlife indicator” for highway impacts. First, they are widespread and exist in all western states as well as several midwestern and eastern states. They are prevalent on many National Forest lands, Bureau of Land Management lands, USDI Fish and Wildlife Service and National Park Service lands. Much elk habitat is on public lands in the western United States (Flathers and Hoekstra 1989, Peek undated, Thomas and Toweill 1982).

Elk are also one of the best studied animals in North America. This is particularly true in respect to the effects of roads on elk. Very few wildlife species have as much scientific literature directed at them. Information such as food habits, density, behavior, fecundity, migration patterns, home range sizes and other important scientific data also abounds.



Figure 1. Elk are important socially and economically in the western U.S. Billions of dollars have been expended to ensure their conservation and management. They also present dangerous highway hazards to motorists.
(Photo by Alex Levy)

Socially, elk are almost universally accepted as important native wildlife. They are generally not controversial, and their presence is usually accepted or even cherished. Economically, elk are one of the most important wildlife species in the western US. The economics of elk includes revenues to state wildlife agencies, motels, restaurants, airlines, and sporting goods manufacturers and retailers. Elk are enjoyed by the public for hunting, for food value, for viewing, and other aesthetic purposes.

How Elk are Affected by Highways

Before transportation and other agencies can apply appropriate highway mitigation measures, they first must understand how highways affect elk. From these impacts, appropriate and effective mitigation measures can be applied, often benefiting many wildlife species. Figure 2 provides a map showing elk habitat and highways in the western United States. It is obvious from this map that elk habitat is affected by highways.

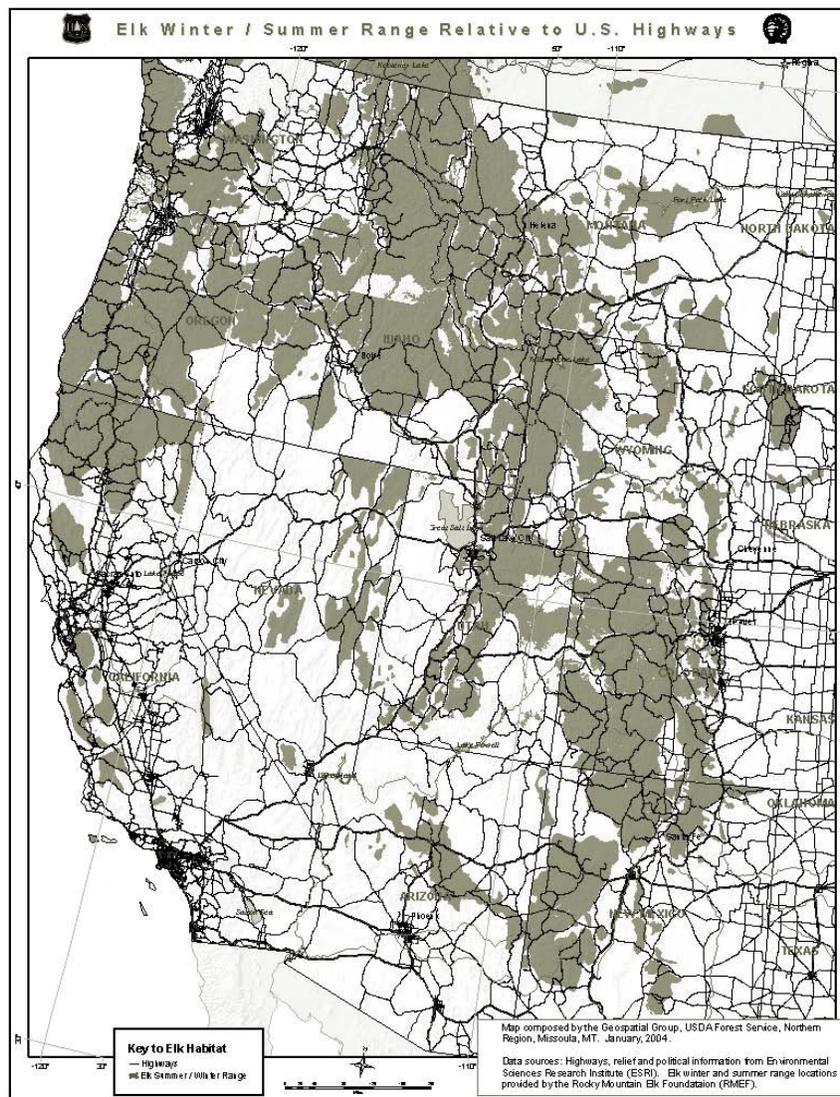


Figure 2. Overview of highway system with elk habitat in the western U.S.

Direct habitat loss

Direct habitat loss results from paving and fencing highway rights of way. This elk habitat is permanently lost as long as the highway is active. The direct loss of habitat in the highway right of way is easily assessed, but rarely mitigated. The significance of habitat loss is explained in the GIS assessment of this paper and is astounding. For a two-lane highway with a width of 150 feet (Basting 2005), the number of acres of elk habitat directly lost per mile of highway is 18.18 acres. For a four-lane divided highway with an average 300-foot pavement and right-of-way distance (Basting 2005), the number of acres of elk habitat lost is 36.36. For analysis purposes the authors call the habitat loss from direct loss of the pavement and right of way as Zone 1.

A 2005 geographic information system (GIS) analysis done by the authors indicates there are 21,285 miles of highways in mapped elk habitat and that over 387,000 acres of elk habitat have been lost to these highway developments. This estimate assumes a 150-foot right-of-way distance, which is common for two-lane highways. Undoubtedly, many four-lane highways exist in elk habitat and would increase the number of acres affected. Previous GIS analysis done in 2004 by the authors suggests that a majority (58%) of existing highways cross winter range habitat, generally the most critical range for elk.

Figure 3 provides a graphic estimate of the number of acres of elk habitat by state directly lost to highways in the western United States. The miles of highways in elk habitat by state can be found in table 3. Oregon leads the western states in both the number of miles of highways in elk habitat and the relative direct impact, with over 65,000 acres impacted. Colorado, Idaho, New Mexico, and Montana have all lost between 42,000 to slightly more than 50,000 acres of elk habitat to highways. California, Washington, Utah, and Wyoming have similar impacts of highways on elk habitat, ranging from nearly 26,000 acres to 33,000 acres.

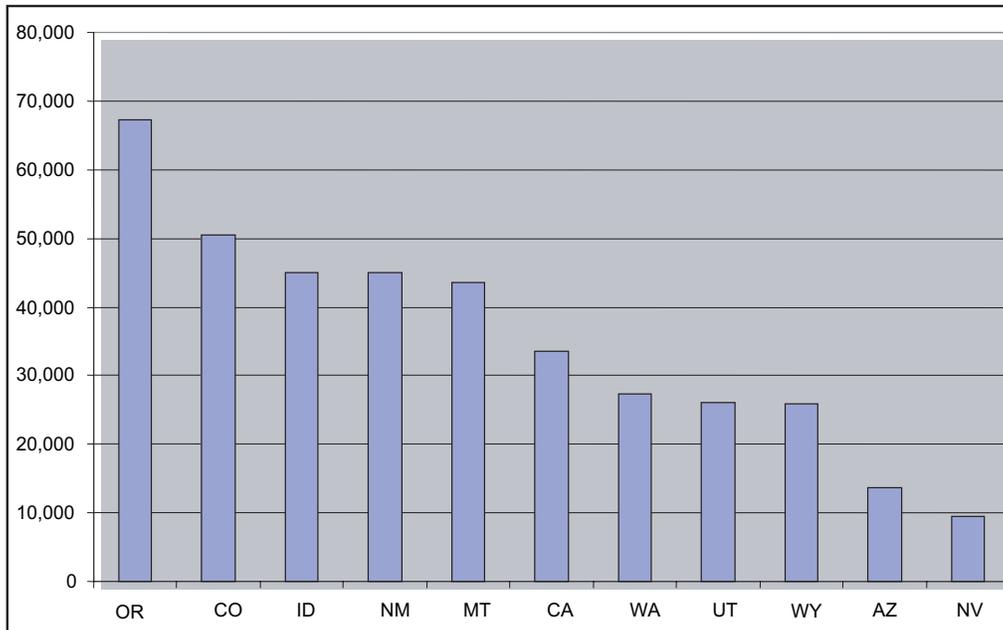


Figure 3. Estimated direct acres of elk habitat lost to highways by state.

Habitat fragmentation

Habitat fragmentation is one of the most serious impacts of highway development on elk and other wildlife. Habitat fragmentation of wildlife habitat is often a complicated issue with many causes and effects. Many of the effects of habitat fragmentation are poorly understood, such as the effects that noise and activity have on species' use of habitat near highways. Habitat fragmentation affects elk populations more profoundly than some other species because many elk herds are migratory, elk have relatively large home ranges, and elk dispersals can be long. Highways often limit how elk can move to and from summer and winter habitats; can separate cows from calves; and can affect breeding, water and food availability, mortality, and other biological factors. Recent expansions of highways from two to four lanes can increase fragmentation by making highways more difficult for elk to cross, by increasing elk mortality and by placement of cement rail, rip-rap, steep slopes, and other measures that encumber elk movements.

Although elk are economically and socially important to many western states, the issues with habitat fragmentation have been poorly studied with this species. Most impacts of habitat fragmentation have addressed carnivores and other species (Harris 1984, Noss et al. 1996, Noss 1987, Noss and Harris 1986, Noss 1983, Paquet and Hackman 1995, Quigely et al. 1996).

Displacement due to human disturbances

Elk responses to highways and roads vary by a number of factors, such as topography, vegetation, traffic volumes, how the highway is designed, and whether or not elk are hunted. Elk have been shown to use habitat adjacent to roads less frequently than similar habitat that is not affected by roads (Rowland et al. 2004, Wisdom 1998, Johnson et al. 2000, Ager et al. 2003, Perry and Overly 1977, Lyon 1979). Generally, elk use of habitat decreases as the proximity of that habitat to roads and highways increases. Rowland et al. (2000) found there was a measurable decline in elk use up to 1.8 kilometers (5,500 ft) from roads. Roloff (1998) and Rowland et al. (2000) suggest assessing using distance band approaches. Using distance band approaches from the Roloff (1998) and Rowland et al. (2000) and habitat effectiveness (HE) equations from Hitchcock and Ager (1992), the Wallow-Whitman National Forest calculated values of 0.17 to 0.83 for five distance bands of habitat moving from the roadside outward. Each of the five bands was 1,182 feet wide (394 yards) and exists on each side of the highway (Rowland et al. 2004). The authors of this paper simplified the Wallow-Whitman elk HE information into three zones as follows. Zone 1, highway right of way with HE = 0; Zone 2, roadside to 0.45 miles with HE = 0.25; and Zone 3, 0.45 - 1.1 mile with HE = .67. (Note: Zones 2 and 3 extend on both sides of the highway, so the total corridor of highway effects to elk is approximately 2.26 miles for a four-lane road, slightly less for a two-lane road. See table 1.)

Table 1. Acres of Lost Elk Habitat for Direct and Displacement Effects per Mile of Highway* for Two-Lane Highway

ZONE	SIZE*	HAB. EFFECT.	AC. HAB LOST/MI
Zone 1	150 ft* (.03 mile)	0	18.18 acres/mile/hwy*
Zone 2	0.45 mile (each side of hwy)	.25	432.0 acres/mile/hwy
Zone 3	0.65 mile (each side of hwy)	.67	282.0 acres/mile/hwy
Total*	2.23 miles*		732.18 acres/mile/hwy*

What are the strengths and weakness of assessing highway impacts and mitigation to elk habitat using such a system? The strengths include recognition that highways have a significant effect, even outside of the right of way. Current elk research is clear that the displacement effects to elk due to roads are significant. The weakness is that the research used to calculate the effects were based on forest roads and not highways in Oregon. When asked about how the effects of displacement for highways might compare to forest roads, some of the authors of the Rowland paper felt displacement effects would be more serious on highways. The only way to determine this definitively would be to do appropriate research.

The effects of displacement on elk and other wildlife are rarely displayed in highway environmental assessment documents, yet the displacement impacts may be the most important, or one of the most important, adverse effects of highways. The authors have taken the best available information and applied it on a broad-scale basis to look at how highways may be affecting elk and other terrestrial wildlife. Even if the approach only approximates the impacts of highways on terrestrial species, it indicates there are some large impacts that are currently not being assessed or mitigated.

Elk highway mortality

Highway mortality of elk has been studied very little. The extent that highway mortality adversely affects elk populations is minimal in most situations. Along with the other factors discussed in the paper, the long-term impacts are significant and increasing every year. The following is an estimate of known elk mortality by state. The estimate is low based on the responses provided. Almost all respondents mention that the actual number of elk killed on highways may be two to three times that reported. Better information about elk and other wildlife mortality on highways would greatly benefit wildlife effects analysis, wildlife mitigation, and highway safety.

Table 2. Reported Number of Vehicle Collisions with Elk (NA = Not Available)

<u>STATE</u>	<u>APPROX. # VEH. ELK KILLS</u>
Arizona.....	396
California.....	NA*
Colorado.....	560
Idaho.....	70
Montana.....	131
Nevada.....	NA*
New Mexico.....	195
Oregon.....	377
Utah.....	95
Washington.....	77
Wyoming.....	100
Estimated Total:	2,001

Highway Influences on the Spread of Exotic Plants

This paper is not an extensive review of the impacts of noxious weeds spreading into elk and other wildlife habitats. Roads and highways are a primary vector for introduction of non-native plants into parts of the West (Gelbard and Belnap 2003). The spread of noxious weeds has resulted in the degradation of many elk ranges, and roads and highways are a primary cause for noxious weed expansion.

Effects of Improved Highways on Secondary Human Developments

For years there has been an ongoing argument over the issue of whether improved highways accelerate secondary construction, such as housing and strip developments. The total effect of accelerated development created by improved highways is unknown, but in Colorado approximately 35,000 acres of elk habitat is being lost annually, most to real estate development. Colorado is only one of many states where elk habitat is declining rapidly. Most real estate development occurs at lower elevations, which are often within elk winter range.

Elk and Highway Safety

Obviously, elk are large animals, and collisions with vehicles are a serious matter. Elk average 600-850 pounds for adults (Arizona Game and Fish 2004), five to eight times larger than most deer species. This indicates that the average vehicle collision with an elk has the potential to be much more serious than with deer. Two of the most prominent wildlife crossing efforts in North America were built primarily to reduce collisions with elk. These include the Trans-Canada Highway wildlife crossings in Banff National Park, Alberta (Canada), and the SR260 elk crossings near Payson, Arizona (USA).

In Arizona, collision rates for elk were 1.22 collisions per mile yearly (Booth vs. State of Arizona 2003) for a 20-mile section of highway. The state of Arizona was found negligent for not keeping elk off the highway, a hazard that was well known in the area. Similar challenges to other state departments of transportation are likely in the future as information about methods to reduce elk/vehicle collisions becomes more widespread.



Figure 4. Elk are large animals that present significant road hazards. Survey information suggests more than 2,000 are killed annually in the West. (Photo by Lance/April Craighead)

It is common knowledge that collisions with wildlife are associated with the abundance of wildlife and the traffic volume (Gunson and Clevenger 2003, Fahrig et al. 1995, Boulanger 1999, Philox et al. 1999, Romin and Bissonette 1996). In all western states, elk appear to be increasing, traffic volume is increasing, and many respondents mentioned collisions with elk were increasing. In spite of increasing collisions with elk, it was difficult to find any quantifiable information specific to this species in regard to the seriousness of accidents, human loss of life, human injury rates, or costs per collision.

Mitigation Measures - Fitting to Appropriate Impacts

If wildlife mitigation measures are to be effective, they must address the issues created by the highway. Not doing so means that the problems become ever larger. While addressing impacts with mitigation focused on specific ecological issues caused by the road seems logical, many highway projects have not approached terrestrial mitigation in this manner. Often, terrestrial wildlife mitigation is seen as "optional" and is not addressed at all. This is in contrast to wetlands mitigation that focuses in minute detail on replacing the type or function of wetlands that were impacted.

If a highway is causing elk mortality, elk habitat fragmentation, or traffic safety issues, then mitigation measures that address these specific issues should be implemented, such as wildlife crossings and fencing. Certainly, wildlife crossings and fencing should be a standard mitigation measure for highways traversing deer or elk winter ranges or migration routes.

If there is a significant loss of habitat, then habitat acquisition and enhancements should be applied. This includes the loss of the habitat right-of-way acres, plus the loss of habitat due to displacement. Conversely, wildlife crossings and fencing do nothing to address habitat loss.

Mitigation is a management decision regarding what is appropriate. However, if terrestrial wildlife habitat is continually eroded by highway expansion, particularly for critical situations like elk winter range and habitat fragmentation areas, then serious losses will continue. Highway mitigation for terrestrial species like elk is inconsistently applied and oftentimes applied only if serious highway safety issues are involved. Current highway mitigation policy for terrestrial

species was developed when highway rights of way were winding, narrow, two-lane roads; when safe speeds were often 30-50 miles per hour; and when traffic volumes were low and the impacts on many species poorly understood. These situations have now changed to multi-lane highways, with 65- to 75-mph speed limits, and traffic volumes that do not provide adequate time between traffic pulses for wildlife to safely cross highways. Also, the consequences on wildlife caused by highways are beginning to be better understood and quantified.

Unfortunately, many highway environmental documents fail to address the cumulative impacts of multiple “small” highway improvements or the effects of wider, faster roads with high traffic volume on elk and other species. This is one important reason why broad-scale or landscape-level wildlife habitat linkage analysis is critical to improving highway mitigation for wildlife. State departments of transportation need to know far ahead of highway projects the type and scope of mitigation measures needed, and they cannot do so late in the transportation planning phases. Statewide wildlife linkage analysis has recently been completed in Arizona, New Mexico, Utah, Colorado, and western Montana. It would greatly improve highway coordination for elk and other wildlife in the remaining elk states. In almost all cases, terrestrial highway mitigation would be more effective if “mitigation banks” were established that focused on large, important areas needing protection. The best mitigation practice for a given highway may be many miles from the project area.

Habitat acquisition

A myriad of potential habitat acquisition options are available to highway agencies. These include (1) replacement of all elk habitat on private and public lands, (2) replacement of all elk habitat affected on public lands, and (3) replacement of habitat in the most critical habitat, which for elk is often winter range. The loss of elk habitat to highway development is serious in terms of its effect on the carrying capacity of long-term elk habitat, and it is permanent in its duration. Highway, wildlife, and land management managers should remember that the rationale for acquiring habitat is for replacement of like lands lost directly (highway right of way) and indirectly (displacement loss) as a result of highways. Acquiring habitat does not affect habitat fragmentation, safety, or elk mortality caused by the highway, nor does it mitigate for loss of habitat caused by ancillary human developments encouraged by highway development.

To fully replace lost elk habitat, highway agencies should provide 750.4 acres of acquired mitigation habitat for each mile of highway in the project area for a four-lane highway and 732.2 acres (per mile of highway) for two-lane highway projects (see table 2).

Elk crossings and fencing

Wildlife crossings and fencing are mitigation for elk habitat fragmentation, elk mortality, and highway safety. News media occasionally take issue with the high costs of wildlife crossings as being poor expenditures of public funds. Actually, the opposite is true in high collision deer and elk areas. The cost of structures can often be offset in a few years by reductions in vehicle costs, human injuries, human fatalities, and a reduction in elk or deer mortality. Various types of wildlife crossing structures can be built that elk will use. Elk are large animals, and their size must be considered when planning appropriate crossings. The best highway investments in wildlife crossings are those that result in a high percentage of use.

Several elk crossing designs are effective. These include bridge extensions, wildlife overpasses or ecoducts, open-span underpasses, box culverts, and large elliptical culverts. Each has advantages and disadvantages and appropriate applications. Most effective for elk are large, wide wildlife overpasses, as seen on the Trans-Canada Highway in Banff National Park, Canada (Forman et al. 2003). Although very effective for elk and other ungulates, the downside of wildlife overpasses is their high cost and scarcity of appropriate location sites. For optimal use, wildlife overpasses may have to be approximately 50 meters wide (Pfister et al. 1997). Almost as effective and less expensive are open-span crossings. These are large bridge-like structures that are wide at the top and usually narrower at the bottom. Engineers and biologist in Canada and Arizona often recommend open-span wildlife crossings as both effective and cost efficient. Elliptical culverts (7x4 meters) are effective in some situations and are less expensive than open-span bridges. Bridge extensions and pathways are less frequently studied, but offer effective alternatives. These can be provided at existing bridge replacement projects, as is being done in Oregon (Bonoff 2005). Box culverts have less use in Canadian studies, and are smaller than other structures. Appropriate-sized box culverts for elk should be larger than for deer – such as 4x8 meters, or larger.

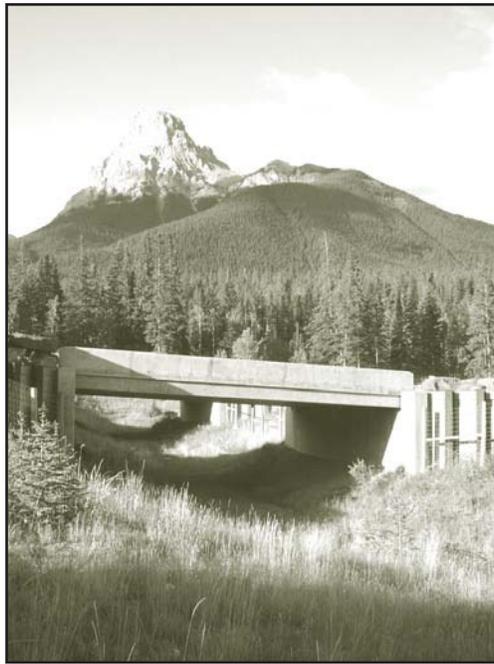


Figure 5. Single-span wildlife crossings, like this structure near Canmore, Canada, are effective for elk.
(Photo by Tony Clevenger)

In general, under-crossing structures for elk should be 12 feet, or higher, to allow use by all sexes and age classes. The size of structures, location, type of structure, vegetative cover, noise levels, bottom material, “openness ratio,” human use patterns, and fencing configuration can influence elk use and structure effectiveness.

Fencing is an integral aspect of elk and other wildlife crossings. Fencing commonly increases elk use by 80 percent, or more. Even though large wildlife structures may appear excessively large by human standards, elk and other ungulates view many wildlife crossings as potentially threatening situations and may go considerable distances to cross over highway road surfaces. Fencing helps funnel animals into the crossing structure and provides a disincentive for avoiding it. Acceptance of structures is a highly individual trait with some animals accepting crossings at first encounter and some animals may avoid them entirely. As time goes by, use usually increases as animals become more accustomed to moving through them, especially young animals that are brought through the structures by their mothers.

Fencing for elk and other ungulates and large carnivores is usually 8-foot page wire. The bottom of the fence may need to be buried to prevent bears and coyotes from digging under the fence and providing access to the highway for them and other animals. Jump-out shoots or Texas gates can provide a means of escape for animals that may get into the right of way. Often, gates are used for this purpose, but they must be opened to allow animals out and closed afterwards.

Side road access is usually by gates, if traffic volume is low, or double cattle guards if traffic volumes are higher. Structures to prevent elk and other wildlife from accessing higher volume roads is problematic, as is snow compaction in cattle guards that may allow animals to walk across and into the roadway.

The cost of fencing is not incidental and may exceed the wildlife crossing costs. Maintenance is also expensive and critical, or animals will find openings and gain access to highways. Out-of-control vehicles, for example, commonly hit fences and create openings that require repair.

Wildlife warning signs

Wildlife warning signs are not appropriate for many highway situations. However, imaginative designs are being tried and studied. Most highway warning signs with a visual representation of an elk or deer have limited or no success in reducing elk mortality or vehicle accidents. Exceptions include large signs used in Canadian National Parks and “interactive” signs that flash warnings only when animals are in the right of way (Huijser 2005).

A GIS Assessment of the Amount of Elk Habitat Affected by Highways in the Western United States

The authors superimposed major highways with recently updated elk habitat mapping provided by the Rocky Mountain Elk Foundation. This information provides a number of interesting and pertinent data on how elk habitat is affected by highways. Highways were also assessed based on public land ownership including USDA Forest Service, USDI Bureau of Land Management, USDI National Park Service, USDI Fish and Wildlife Service, and others. These lands are critical for long-term elk conservation and should be protected, along with key other lands, if elk productivity is to be maintained. Most Federal and State lands are managed for multiple uses, including wildlife conservation. Conversely, many

private lands in elk habitat are under pressure for development, such as housing. Many agencies and conservation groups are trying to purchase critical elk habitat, or buy conservation easements, but still elk habitat is declining rapidly in some areas. It is estimated that in Colorado over 35,000 acres of elk habitat is lost yearly to housing subdivisions.

A 2004 GIS assessment of elk habitat and highways by the authors indicates that most highways have been built in elk winter range because these lands are lower in elevation and more suitable for highway locations. Highways in winter range affect elk during the most stressful time of year when food is limited and elk are concentrated.

Table 3 provides information on highways in elk habitat for all western states. Included is the total miles of highways in all ownerships of elk habitat, the number of miles of highways in elk habitat on Federal Lands (public lands), and the number of acres of elk habitat affected in Zone 1 (highway right of way), Zone 2 (from the right of way to 0.45 miles on each side), and in Zone 3 (from 0.45 miles to 1.1 miles on each side). The total elk habitat loss for the eleven western states assessed is estimated to be over 15.5 million acres. Several individual states exceed or approach two million acres of elk habitat loss, including Oregon, Colorado, Idaho, New Mexico, and Montana.

Table 3. Miles of Highways in Elk Habitat by State, Miles on Federal Lands, and Estimated Acres of Habitat Loss for All Elk Habitat in Zones 1, 2 and 3

STATE	HWYS ELK HAB ALL (MI)	HWYS IN ELK HAB FED. LANDS (MI)	ACRES ELK HAB ALL
Oregon	3,696	910	2,706,044
Colorado	2,774	836	2,031,151
Idaho	2,475	591	1,812,031
New Mexico	2,471	650	1,809,008
Montana	2,395	624	1,753,760
California	1,839	581	1,346,481
Washington	1,506	391	1,102,601
Utah	1,434	360	1,050,242
Wyoming	1,425	607	1,043,190
Arizona	754	640	552,174
Nevada	517	49	378,472
TOTAL	21,285	6,238	15,585,155

Summary and Conclusions

Elk herds in the western United States are a national treasure that has taken many decades to establish and nurture since the early 1900s. Billions of dollars of public and private funds have gone into re-establishment of elk and other terrestrial wildlife species. While some highway agencies have begun to address elk and other terrestrial wildlife species in new highway projects, more progress is needed. Consistency is a problem. Some projects in elk habitat consider wildlife crossings, often for safety purposes only. Land management and state wildlife agencies need to be more involved in highway projects and wildlife mitigation.

Wildlife mitigation on highway projects could be vastly improved by integrating highway agency mitigation dollars, State and Federal wildlife agency conservation funds, Federal land management wildlife improvement funds, and private conservation efforts, such as land acquisition projects sponsored by the Rocky Mountain Elk Foundation. Integration of these funding sources would provide many benefits to elk and other wildlife, including synergies created from larger projects; larger habitat acquisition and habitat improvement projects with lower costs per unit; and the combined energies, specialties, and talents of conservation groups and agency personnel. Funding for transportation projects is increasing, in contrast to many wildlife and land management agency funding. Partnerships make sense from many perspectives.

Ideally, highway projects can result in improved wildlife habitat conditions as well as enhanced highway safety and less overall ecological impacts.

Highway policy needs to change, particularly for important public wildlife habitats, such as National Forests, National Parks, Bureau of Land Management lands, Department of Defense lands, and State lands, so that wildlife crossings, fencing, and habitat replacement mitigation measures are more consistently applied. Terrestrial highway mitigation policy is archaic and needs to be modernized to reflect social values, protection of significant ecological resources, and better integration with wildlife and lands managed to benefit wildlife habitat. European countries have done so for decades. The knowledge to improve highway coordination with wildlife and the environment, called *road ecology*, is one of the fastest growing natural sciences in North America and throughout the world.

Reducing elk and other wildlife habitat fragmentation and mortality caused by highways and vehicle traffic have human safety benefits as well. The time has come to address all the effects that highways have on elk and other species, and to apply the scientific knowledge we have gained over the last decade. It is a road we cannot afford *not* to take.

Biographical Sketches: Bill Ruediger, wildlife biologist consultant and retired ecology program leader for highways, USDA Forest Service, has over 34 years experience with highway issues related to wildlife ecology and fisheries. Species-specific experience includes large and mid-sized carnivores, salmon, spotted owls, and other threatened and endangered species issues. Ruediger is currently head of Wildlife Consulting Resources, based in Missoula, MT.

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