# THE EFFECTS OF HIGHWAYS ON ELK (*Cervus elaphus)* HABITAT IN THE WESTERN UNITED STATES AND PROPOSED MITIGATION APPROCHES

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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 manufactures and retailers. Elk are enjoyed by the public for hunting, for food value, for viewing and other aesthetic purposes.

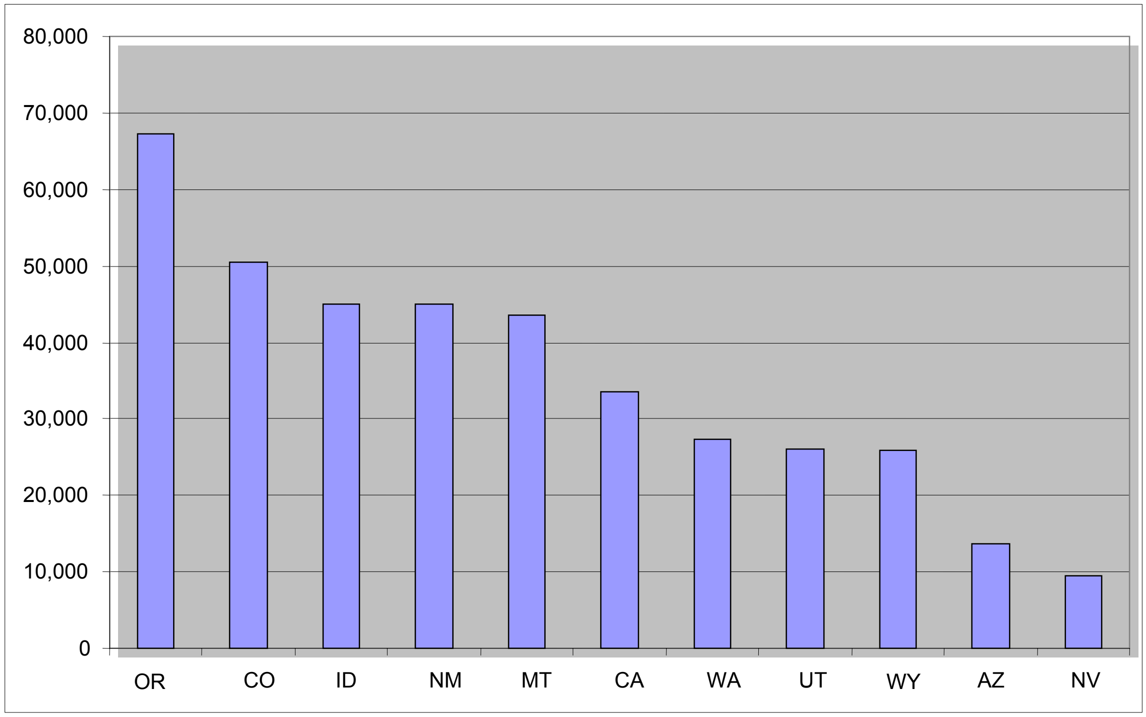
**HOW ELK ARE AFFECTED BY HIGHWAYS:** Before transportation and other agencies can apply appropriate highway mitigation measure, they first must understand how highways affect elk. From these impacts, appropriate and effective mitigation measures can be applied, often benefiting many wildlife species. Figure 2 (located at the end of the paper) 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.

1. **Direct Habitat Loss:** Results from paving and fencing highway right-of-ways. This elk habitat is permanently lost as long as the highway is active. The direct lost of habitat in the highway right-of-way is easily assessed, but rarely mitigated. The significance of habitat loss will be 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 called the habitat loss from direct loss of the pavement and right-of-way as Zone 1.

   A 2005 GIS (Geographic Information System) 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 assumed a 150 foot right-of-way distance, which is common for 2-lane highways. Undoubtedly, many 4-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 of 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




2. **Habitat Fragmentation:** Is one of the most serious impacts of highways 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 noise and activity have on species use of habitat near highways. Habitat fragmentation effects 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, 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 measure 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).

3. **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 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 decreases as the proximity to roads and highways increases. Rowland et al. (2000) found that there was a measurable decline in elk use up to 1.8 kilometers (5,500 feet)) 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 .17 to .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 4-lane road, slightly less for a 2-lane road. See Table 1.

Table 1. Acres of Lost Elk Habitat for Direct and Displacement Effects per Mile of Highway. * For 2-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<br>(each side of hwy) | .25 | 432.0 acres/mile/hwy |
| Zone 3 | 0.65 mile<br>(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 displacement effects to elk of 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 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 they could 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.

4. **Elk Highway Mortality:** Highway mortality of elk has been studied very little. The extent 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 mentions that the actual number of elk killed on highways may be 2-3 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)**

| STATE | APPROX. # VEH. ELK KILLS |
|---|---|
| **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** |

5. **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.

6. **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 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 and the SR260 elk crossings near Payson, Arizona.

In Arizona, collision rates for elk were 1.22 collisions per mile yearly (Booth vs State of Arizona 2003). This was for a twenty 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 department's of transportation are likely in the future as information about methods to reduce elk/vehicle collisions becomes more wide spread.

**Figure 4. Elk are large animals that present significant road hazards. Survey information suggests more than 2,000are killed annually in the west. Lance/April Craighead photo.**

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 on specific to this species in regard to 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 wetland's mitigation that focuses in minute detail in replacing specifically the type of wetland's that where impacted.

Applied to elk situations, if a highway is causing elk mortality, elk habitat fragmentation or traffic safety issues, factors addressing these specific issues should be applied 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 has 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 on what is appropriate. However, if terrestrial wildlife habitat is continually eroded away by highway expansion, particularly for critical situations like elk winter range and areas of habitat fragmentation, then serious losses will continue. Highway mitigation for terrestrial species like elk is inconsistently applied and then often only if there are serious highways safety issues involved. Present highway mitigation policy for terrestrial species was developed when highway right-of-ways were winding, narrow two-lane roads, safe speeds were often 30-50 miles per hour, traffic volumes were low and the impacts on many species poorly understood. These situations have change to multi-lane highways, 65-75 mile an hour 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 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 what the type and scope of mitigation measures needed and they can not 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. 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 affect on long-term elk habitat carrying capacity and 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 4-lane highway and 732.2 acres (per mile of highway) for 2-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 optimum 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 studied, but effective alternatives. These can be provided at existing bridge replacement projects as is being done in Oregon (Bonoff 2005). Box culverts had less use in Canadian studies, but were smaller than other structures. Appropriate sized box culverts for elk should be larger than for deer – such as 4x8 meters, or larger.

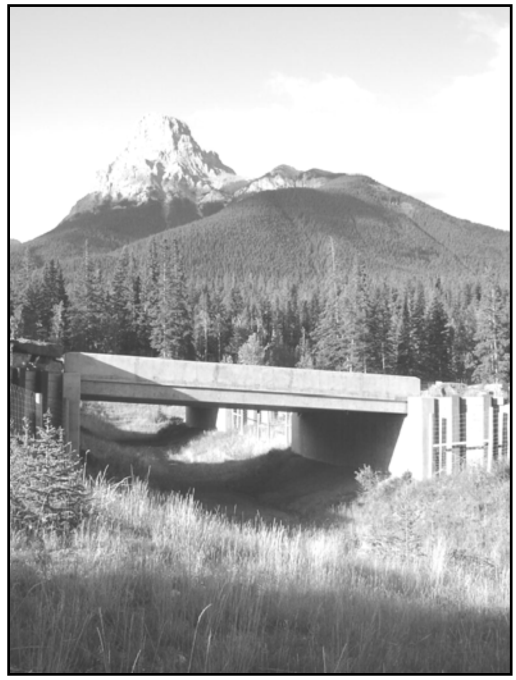


**Figure 5. Single span wildlife crossings, like this structure near Canmore, Canada are effective for elk. Photo by Tony Clevenger.**

In general, under-crossing structures for elk should be 12 feet, or higher, to allow use by all sexes and ages 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 should be provided to all animals that get into the right-of-way a way to get out. Often, gates are provided for this purpose, but 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 access highways. Out of control vehicles commonly hit fences and create openings.

**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 developments 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 that over 35,000 acres of elk habitat is lost yearly to subdivisions.

A 2004 GIS assessment of elk habitat and highways by the authors indicated 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 Zones 1 (highway right-of-way), Zone 2 (from the right-of-way to .45 miles on each side) and in Zone 3 (from .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 2 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 1900's. Billions of dollars of public and private funds have gone into reestablishment 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. 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 group 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.

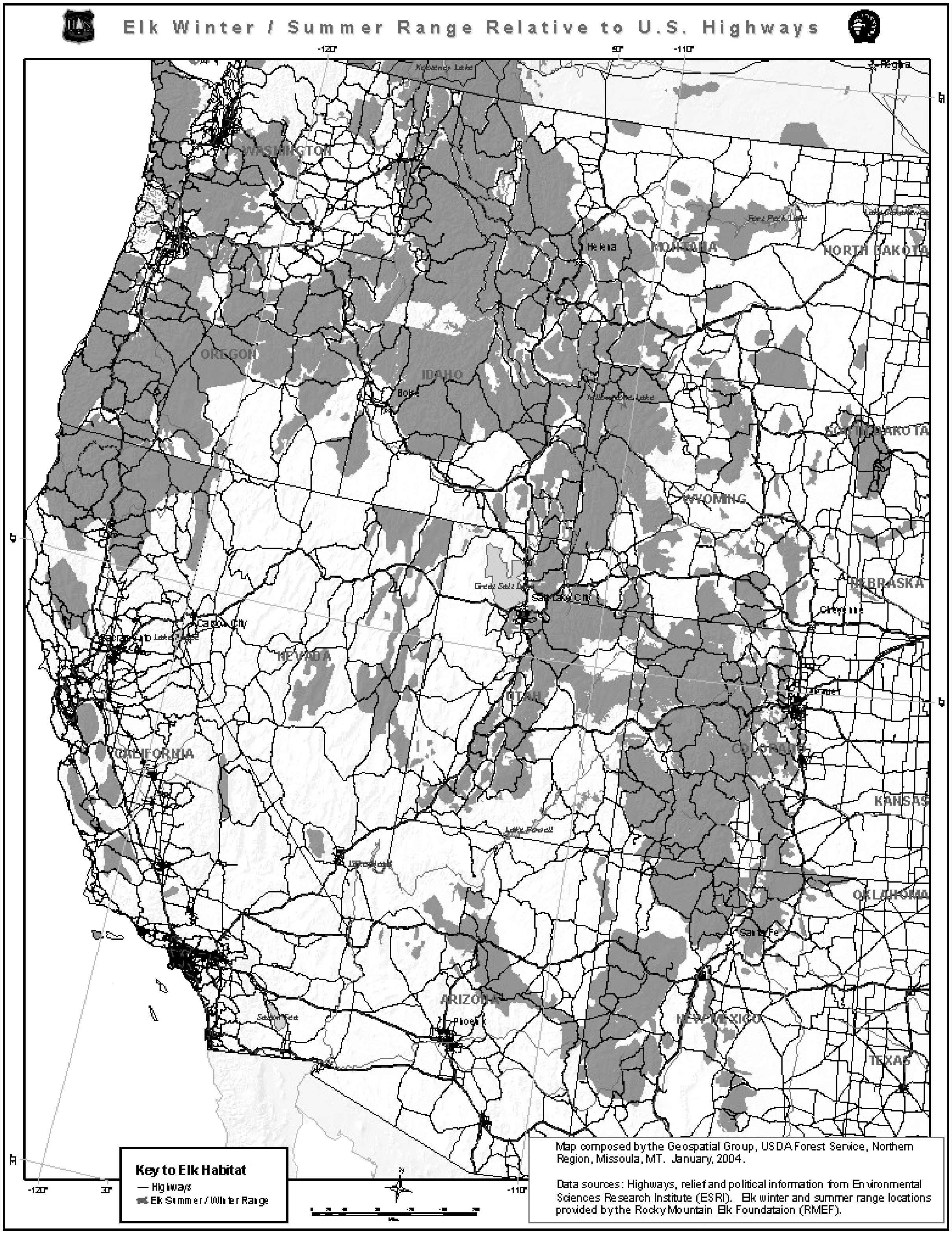
Ideally, highway projects can result in improved wildlife habitat conditions as well as enhanced highway safety and less overall ecological impacts.

Highway policy needs to change, particularly for important public wildlife habitats such as National Forests, National Parks, Bureau of Land Management, Department of

Defense 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 would have human safety benefits as well. The time has come to address all the effects 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 can not afford not to take.

**Figure 2. Overview of Highway System with Elk Habitat in the Western U.S.**



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