

Mitigation Measures for Highway-caused Impacts to Birds¹

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Abstract

Highways cause significant impacts to birds in four ways: direct mortality, indirect mortality, habitat fragmentation, and disturbance. In this paper I discuss highway-related impacts, and suggest solutions from a highway management perspective. Non-flying birds (either behaviorally or structurally) such as gallinaceous birds and ducklings; waterbirds such as terns; owls; ground-nesters; scavengers; Neotropical over-water migrants; frugivorous birds; and birds attracted to salt are often killed from highway-related causes. Suggested solutions include highway crossing structures, diversion poles on bridges or medians, modified right-of-way mowing regimes, road kill removal, appropriate median vegetation, and modified deicing agents. Indirect mortalities caused by highway construction or maintenance include habitat loss and decreased quality; predator attraction or bridges to nesting habitat; increased incidence of invasive species; increased associated lethal structures; and maintenance practices that disrupt reproduction. Suggested solutions include highway management strategies that consider avian needs.

Key words: birds, direct mortality, disturbance, fragmentation, highway, indirect mortality, mitigation, vehicle-animal collision, wildlife crossing structure.

Introduction

As the most mobile of terrestrial wildlife, birds are not often considered significantly affected by highways

(Keller et al. 1996). However, highway impacts to birds occur in four major ways, some of which are unique to birds: by fragmentation, disturbance, and direct and indirect mortality. These impacts could have considerable negative effects on populations, especially when considered in combination with other sources of mortality and habitat loss. The mitigation measures reviewed here have the potential to reduce impacts to birds from all four categories.

Many mitigation techniques reviewed in this paper have been developed for other taxa, particularly ungulates and large carnivores, but are applicable to birds as well. Further information on the projects from which these suggested solutions are drawn can be found at the USDA Forest Service's 'Wildlife Crossings Toolkit' at <http://www.wildlifecrossings.info>. This database is the most complete compilation available of case histories of highway impact mitigation for all taxa. It includes a glossary for biologists unfamiliar with highway infrastructure terminology³.

Several publications have reviewed highway impacts to birds, with most focusing on direct mortality and few offering suggestions for mitigation. A thorough review of impacts of linear developments, including highways, to birds and other wildlife is found in Jalkotzy et al. (1997); suggested mitigation measures focus on large mammals. Forman and Hersperger (1996) review mitigation measures for most taxa, but include relatively little information on measures effective for birds. A review of the impact of forest roads on wildlife, including some information on birds, is in Gucinski et al. (2000).

The current transportation paradigm dictates that highways will continue to be built and expanded to meet increasing transportation needs, and impacts to birds and other wildlife will continue as a result. No mitigation by itself or in combination with others can totally remove the impacts to wildlife. Several methods suggested here might reduce impacts to birds, however, and are based on successes with other taxa. Expensive structural mitigation techniques such as wildlife over-crossings are unlikely to be initiated to mitigate avian impacts alone, but additional benefits to birds might raise the benefit/cost ratio. The first step to reducing the impacts of highways on birds through improved highway design and retroactive mitigations is to understand how highways affect birds. In this paper I review

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³The purpose of the website is to provide a database of known mitigation techniques for terrestrial wildlife for use by professional biologists and highway engineers. The Wildlife Crossings Toolkit was developed by a partnership of the USDA Forest Service's San Dimas Technology and Development Center, Utah State University's College of Natural Resources, Montana State University-Bozeman's Western Transportation Institute, and the Federal Highway Administration.

the current state of knowledge regarding these impacts and effective mitigations.

Fragmentation

Highways can fragment bird populations and habitats in three ways: loss of large carnivores, habitat dissection, and the isolation of less mobile species (*table 1*).

Loss of Large Carnivores

When highways fragment large carnivore populations, birds can suffer increased depredation from smaller carnivores such as bobcats, skunks and weasels (Crooks and Soulé 1999). Many structural designs for encouraging large carnivores to cross highways have been developed, and are being increasingly if not universally considered in appropriate highway projects. Large underpasses or extended bridges are used successfully for such species as Florida panthers (*Puma concolor coryi*), black bears (*Ursus americanus*), and wolves (*Canis spp.*) (Foster and Humphrey 1995; Roof and Wooding 1996; Clevenger and Waltho 2000). In most cases, barrier fencing is needed to encourage these highly mobile species to use the prepared crossing.

Habitat Dissection

Highways are designed to minimize costs. These routes are often the shortest distance between two points, in areas without human development to avoid the cost of land acquisition and to avoid noise effects to homes, and with minimal elevation changes. This may result in rare habitats such as wetlands being disproportionately affected by highway development (FHWA 2000). Habitat dissection may result in patches of habitat too small to complete a territory. Woodland species are more affected by habitat dissection than grassland species, which appear to be more willing to cross highways as part of their territories (Keller et al. 1996).

Planning the location of a highway to avoid environmental as well as construction costs may be the simplest but least considered solution. If the lands crossed are public lands, then an environmental analysis might develop an alternative that keeps habitat patches intact over one that bisects them. The public's role as stakeholders in this process is very important because many public land managers are still awakening to the avoidable impacts of highway design.

Crossing structures can be a tool to reduce impacts. Structures that are high, wide and open tend to retain the most functional ecosystems (Ruediger 2002). Causeways, viaducts, and expanded bridges provide the most opportunities for birds to cross under a highway because of their openness and the surrounding vegetation is usually continuous under the structure. In Europe, woodland bird species use wildlife over-crossings with planted vegetation significantly more to cross highways than direct overflights, and in some cases have incorporated the over-crossing into territories (Keller et al. 1996).

Isolation

Highways can isolate small populations or individuals because of habitat dissection. Isolation is a variant of habitat dissection, but it also includes those situations where a portion of a daily or annual habitat is difficult or dangerous to access because of the presence of a highway. The tendency of Mountain (*Oreortyx picta*) and California (*Lophortyx californica*) quail to avoid large openings (Gutierrez 1980) may make seasonal habitat virtually unavailable if multiple-lane, high volume highways bisect seasonal or daily movements, and their low flight and tight flocking behavior may increase the risk of mortality when crossing highways.

Correctly locating crossing structures is critical to their effectiveness. Although many wildlife travel along ridges and drainages, some animals, such as Mountain Quail, might have consistent but less obvious crossings. Knowing the location of frequent crossings can help situate the most effective structure.

Table 1— *Fragmentation impacts to birds from highways.*

Impact	Problem	Suggested solution
Loss of large carnivores	Increased small carnivores prey disproportionately on birds.	Highway crossing structures for large carnivores.
Habitat dissection	Habitat parcels are too small to contain complete territories.	Avoid dissection by highway placement. Use causeways or viaducts to maintain small scale habitat continuity.
Isolation	Highways are barriers to less mobile or reclusive birds.	Overall connectivity strategy. Use open-span bridges, viaducts or wildlife over-crossings.

Disturbance

Disturbance from highways may be most pronounced during the breeding season, but can also affect other life history periods (*table 2*).

Noise

Territorial song is only effective if it is heard by other birds, and noise from traffic can be so loud that bird song may be distorted, resulting in difficulties in attracting and keeping females (Reijnen and Foppen 1994). While the mechanism causing decreased numbers of woodland breeding birds next to highways (Reijnen and Foppen 1994) is not clearly understood, noise can disturb birds and render otherwise suitable habitat next to highways less effective (Reijnen et al. 1995, Stone 2000). Increased predation may also occur due to the inability of birds to hear predators (Scherzinger 1973).

Most noise from highways is produced by engines and tires as they contact the surface, with noise varying by tire and surface qualities (FHWA 2000). Noise can be mitigated by providing a barrier to the source of noise, or reducing the source itself. Because most of the noise derives from the road surface, a change in elevation of the road surface may reduce noise, and cuts and fills can be used to advantage. Noise barriers are commonly used in city situations and can be seen as large cement block walls along city highways. While this effectively reduces noise in lower vegetation layers, it also eliminates permeability for most essentially non-flying species, and is expensive. A variant of the common city sound wall can be created by less dense material such as wood, vegetation, or fabric.

The Federal Highway Administration (FHWA) has commissioned much research on environmental noise reduction. Smooth surfaces have been developed to reduce noise while retaining safe traction control; in addition, some tires are much less noisy than others. Land management agencies could reduce noise through

public lands by considering road surface design when constructing or upgrading highways.

Lights

One method of migrant navigation is by reference to stars (Emlen 1975). Light pollution from all sources reduces the visibility of stars, and may entrap migrating birds in dangerous environments especially during inclement weather, causing collision, apparent confusion, and mortality (Ogden 1996). Highway lighting standards are based on the Illuminating Engineering Society of North America's (IES) standards, and newer designs are available that meet the IES standards but have reduced light pollution effects. Lower wattage flat lens fixtures on highways and city streets direct light down and reduce glare, thus reducing light pollution. They are currently being used in a major retrofitting project in Calgary, Alberta to reduce light pollution and to save money and energy (City of Calgary 2002). Increasing the reflectivity of signs and road striping (retro-reflectivity) is a method of increasing the visibility of roads to drivers while reducing the need for electrical lighting (Hasson 2000).

Direct Mortality

Direct mortality is the impact most people likely associate with highways. Birds are listed as killed most frequently in most multiple taxa road mortality studies (Forman et al. 2003). One estimate of bird mortalities from all causes lists vehicle deaths as the fourth or fifth most numerous at 60 million or more per year in the United States, after pesticides and high-power transmission lines (U.S. Fish and Wildlife Service 2002), both of which can be associated with highways and cause cumulative impacts. The extent of mortality from highways is underestimated (as it is in most studies of mortality from man-made structures) because scavengers pick up small bird carcasses rapidly, often within minutes (Morris 2002). Bird mortality from vehicle collisions affects some groups more than others (*table 3*).

Table 2— *Disturbance impacts to birds from highways.*

Impact	Problem	Suggested solution
Noise	Noise disrupts song or intimidates shy species.	Noise barriers. Reduce noise sources such as tires and road surfaces.
Lights	Migrants can't see stars to navigate.	Coordinate light-pollution reduction. Ensure lights are necessary before installation. Use lower wattage flat lens fixtures on highways, retroreflective elements on signs and pavement.

Table 3— *Direct mortality from highways.*

Impact	Problem	Suggested solution
Walking birds	Non-flying birds incur greater mortality risk.	Crossing structures with large openness ratios (underpasses) or wildlife over-crossings.
Water birds	Winds over bridges can slam flying birds into vehicles.	Diversion poles on bridge decks.
Owls	Owls hunt at headlight height.	Diversion poles or short fences along highway medians and rights-of-way.
Ground nesters	Mowing rights-of-way kills nesters.	Mow after August 1.
Scavengers	Corvids or raptors are killed while foraging on roadkill. Attracted scavengers reduce productivity adjacent to highways.	Reduce roadkill. Remove roadkill from road.
Migrant landfalls	Exhausted cross-gulf migrants fly into vehicles.	Low temporary fences to encourage higher flight across roads.
Frugivores	Fruiting median plants attracts birds across traffic.	Plant non-fruiting varieties. Remove fruiting varieties.
Winter finches	Deicing salt or sand attracts birds to road surface.	Velocity spreaders. Road temperature sensors to reduce quantities. Concentrate runoff appropriately. Public education program.

Ground-Dwelling Birds

Birds that fly infrequently because of morphology, foraging behavior or age are at greater risk of vehicle collisions because they spend longer time on the roadway, and often have a shallow escape flight trajectory. Species affected include gallinaceous birds, juvenile anatids, and *Melanerpes* woodpeckers foraging on road-killed insects (Stoner 1925). Crossing structures such as open bridges, large V-shaped underpasses, viaducts or causeways with vegetation maintained beneath highways can be used to mitigate impacts to these species. Causeways elevated on pilings or other intermittent supports across wetlands maintain ecological function better than causeways built on dikes because they allow water flow and uninterrupted movement of marshland species of all taxa.

Water Birds

When bridges are approximately perpendicular to wind direction they can cause downdrafts that increase the risk of collisions between birds and traffic or bridge structures. At Sebastian Inlet State Park, Florida, Royal Terns (*Sterna maxima*) and Brown Pelicans (*Pelecanus occidentalis*) suffered mortality particularly during northeasterly winds. In one case, a semi truck killed several Brown Pelicans at once (A. Bard, pers. comm.). The installation of aluminum fence poles spaced at intervals along the edge of the bridge created an apparent barrier that caused birds to fly higher, resulting in significantly fewer mortalities (Bard et al. 2002). On Queen Isabella Causeway on South Padre Island, Texas, avian mortalities during certain wind directions in-

cluded Common Loons (*Gavia immer*), Peregrine Falcons (*Falco peregrinus*), and Brown Pelicans. Signs warning of the danger of pelican collisions on the bridge may not be effective at reducing mortalities (G. and S. Colley, pers. comm.).

Owls

Several species of owls, particularly Barn Owls (*Tyto alba*), Great Horned Owls (*Bubo virginianus*), and Short-eared Owls (*Asio flammeus*), often forage near roads at about the same height as vehicle windshields and are common victims of vehicle collisions. In the Central Valley of California, juvenile Barn Owls suffer heavy mortality from vehicles along Interstate 5 and smaller county roads (Moore and Mangel 1996). No mitigation has been attempted in this case, however, a concept similar to the Sebastian Inlet State Park barrier poles may be effective for owls as well. If so, a low fence or fence material such as plastic construction fence or closely spaced, frangible reflective highway markers may be effective if installed along highway verges and medians.

Ground Nesters

Birds nesting in highway rights-of-way are vulnerable to direct mortality due to mowing practices. Most states mow rights-of-way to maintain sight distances and for esthetic reasons. The most vigorous spring growth and onset of mowing in May or June coincides with nesting season. Mowing affects primarily grassland species or waterfowl by directly killing eggs, fledglings or adults attending nests. An estimated 4,500 ducks are killed on

highway rights-of-way each year in the prairie pothole region of North Dakota because about a third of nesting ducks have not hatched by the early July mowing (Cook and Daggett 1995). Illinois Department of Transportation currently delays mowing until August 1 to protect nesting birds (Cook and Daggett 1995). Mowing for esthetic purposes instead of vegetation control may be possible to forego. Highway users in several states supported unmowed verges when the environmental ramifications were explained (Harper-Lore 2000). In addition, naïve fledglings of many species nesting near roadways are vulnerable to collisions with passing vehicles.

Scavengers

Scavengers such as corvids and raptors are at risk of being hit by vehicles as they forage on other road killed carcasses (Mumme 2000). At the same time, because road kills are a reliable source of food, the same avian and mammalian scavengers patrol highways for food, and thus are at higher densities along highways. These scavengers may then turn to adjacent habitat for other foraging opportunities, including nesting birds. In most states, the state Department of Transportation (DOTs) is responsible for removing road kills (Cook and Daggett 1995). Where this is the case, it may be helpful to encourage agencies to expeditiously follow the policy to remove large animal carcasses, or create one where no policy exists.

Migrant Landfalls

Exhausted cross-Gulf migrants can congregate by the thousands at first landfall. Some of these locations are now prime oceanfront real estate with developments that include highways. In 1996, many cross-Gulf migrants were blown off course and landed in the Florida Keys. Florida State Park road kill records indicate a huge number of warblers and vireos that year (Fahrig et al. 2002), suggesting a situation likely to be repeated at many other locations. Some normal landfalls such as the Mississippi and Alabama coastline contain highways immediately adjacent to the nearest vegetation after shoreline, thus concentrating birds near a high mortality risk (B. Sargent, pers. comm.). While land use planning to maintain habitat adjacent to the shoreline is the ultimate solution, some areas known to be mortality hotspots, such as Highway 180 near Fort Morgan, Alabama (B. Sargent, pers. comm.), may need to be monitored after heavy flights (predictable by radar images broadly available over the Internet) and extraordinary measures taken to prevent birds from attempting low flights across highways while still exhausted. In some of these locations, it might be possible to erect temporary fences or other barriers that encourage migrants to fly at some height over passing

traffic, in a manner similar to the Sebastian Inlet State Park approach.

Frugivores

Frugivores such as Cedar Waxwings (*Bombycilla cedrorum*) and thrushes are attracted to fruiting plants grown in highway medians as barriers to vehicles. In many eastern states, thorny eleagnus (*Elaeagnus pungens*) has been planted in medians, causing the attraction and death by collision of hundreds of waxwings, American Robins (*Turdus migratorius*) and Common Grackles (*Quiscalus quiscula*) (Watts and Paxton 2001). Removal of thorny eleagnus is being accomplished in Virginia as a result of the identification of the problem and effective negotiations with the Virginia DOT.

Winter Finches

Deicing highways in snow country costs transportation agencies considerable expense and time. Solutions to this safety concern are continually being sought. Both sand and salt as deicing agents are deadly for gregarious winter finches such as Pine Siskins (*Carduelis pinus*) and crossbills (*Loxia* spp.) when ingested. Salt is highly toxic to birds and causes lethargy or passive escape reactions to vehicles; the combination of salt and sand sometimes causes massive mortality (Environment Canada 2001). Solutions are complex but may include continued research into better deicing agents, velocity spreaders, and temperature sensors in roadways to minimize application rates. In Glacier and Mount Revelstoke National Parks in Canada, visitors are given a brochure explaining the issue and advising motorists to honk their horns at congregated birds to give them time to escape (Morris 2002).

Indirect Mortality

Habitat Loss and Habitat Sinks

Habitat loss to highway development is huge and insidious because highways may facilitate further development. Highways cover about 1 percent of the land base of the United States, or an area about the size of South Carolina (Forman 2000). Land use planning, and transportation options such as mass transit, intermodal transportation (transportation between public and private modes), and intelligent transportation systems are urgently needed. It is probably safe to assume that at least some percentage of that highway growth forever alters valuable bird habitat.

Highway medians and rights-of-way do provide some habitat for species in heavily developed areas, particularly grassland species in the eastern states, but it is still

unknown whether or not these small, linear habitats function as overall population sinks or as sources.

Predator Bridges

Land-filled bridges across open waterways can allow predators to access previously predator-free island seabird nesting colonies. Following the construction of a new highway in Norway, foxes, martens and badgers were able to cross to the island of Tuatara on rocky fill below the highway. Remedial measures such as noise-makers and an open-grid drawbridge have been unsuccessful to date (Quell 2001). Avoidance of these situations is the best policy.

Brood Parasitism and Noxious Species

The expansion of Brown-headed Cowbirds (*Molothrus ater*) and several species of noxious plants and animals is facilitated by the cleared line of sight along highways, particularly where these species had been limited by blocks of unsuitable habitat. Line of sight clearing is a safety measure that normally is a minimum of 10 m (30 ft). Where cowbird brood parasitism is a concern, large blocks of minimally cleared rights-of-way may be part of a suite of mechanisms used to control this species.

Lethal Associated Structures

When associated with highways, powerlines, railroads and canals are a few structures cumulatively more hazardous to birds. Vehicle traffic may cause birds to fly higher to avoid cars only to collide with parallel powerlines. Raptors continue to be electrocuted on powerlines, possibly in greater numbers along highways because of the attraction of roadkill scavenging opportunities. Gallinaceous species are attracted to canals in desert areas only to become vehicle mortalities (or drowned). Some of these structures can be buried, relocated or made safer if planners are aware of the cumulative impacts to birds because of their proximity to highways. The guidelines recommended by the Avian Power Line Interactions Committee to minimize electrocutions and collisions should be followed whenever possible (APLIC 1994, 1996).

Maintenance Practices

Peregrine Falcons and Cliff Swallows (*Hirundo pyrrhonota*), among others, may use bridges as nesting habitat. Bridge maintenance, however, typically occurs in warmer seasons, so it can conflict with successful nesting. Washington DOT developed specific and strict protocols to minimize impacts to Peregrine Falcons, formerly a State- and Federally-listed endangered species (Carey 1998). Under the Migratory Bird Treaty

Act active nests containing eggs or young, or colonies with at least one such nest, are protected; intermittent take sometimes occurs regardless. On a bridge in Montana, DOT officials removed Cliff Swallow nests prior to the breeding season and applied a sticky repellent. The repellent was removed after maintenance was completed, limiting the loss of productivity to at most one year (Wabash et al. 2002).

Table 4 is a summary of these indirect sources of mortality to birds from highways, associated structures, and maintenance activities.

Conclusion

There are few data regarding the impacts of highways on birds and fewer on the effectiveness of the relatively few mitigation measures devised to reduce those effects. Nationwide, estimates of direct mortality from bird-car collisions range from 10 to 380 million (see Erickson et al. this volume). These are based on extrapolations from local studies, none of which corrected for the unquestionably large bias from carcass scavengers and searcher efficiency. There are no estimates for the sub chronic effects on populations from habitat loss, fragmentation, disturbance and other indirect effects of highway construction. Thus, there is a need for systematic efforts to assess these impacts locally and nationwide. Without these data, it is difficult to promote effective mitigations to highway planners. There might be little to be done to minimize impacts along the majority of the roughly 4 million miles of roadway in the United States, but protective measures addressed in this paper and other innovative solutions should be attempted along certain highly vulnerable locations, e.g. next to wetlands, over rivers, through riparian areas, and along migration corridors or fallout locations.

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Table 4— *Indirect mortality from highways.*

Impact	Problem	Suggested solution
Habitat loss	Highways facilitate development.	Land use planning; Mass transit or other change in transportation paradigm.
Habitat sink	Suitable habitat near highway increases mortality.	Make habitat unsuitable; Haze birds away; Reduce mortality through above methods.
Predator bridges	Bridges or land causeways allow access to nesting islands.	Design to avoid predator crossings; Drawbridge or open grid deck on bridge; Noise.
Brood parasitism	Cowbirds increase along cleared rights-of-way.	Reduce line-of-sight clearing; Other cowbird control mechanisms to break continuous pathway.
Noxious species	Highways facilitate noxious species travel.	Plants: herbicides, biological controls; Work with local DOTs to emphasize control.
Lethal structures	Birds fly into associated structures; Additional structures increase distance to cross.	Follow APLIC guidelines; Attach visibility markers; Bury telephone/power lines; Require raptor-safe power poles; Consider cumulative impact of railroads, power lines, canals, frontage roads.
Maintenance practices	Maintenance often occurs during nesting season.	Maintenance protocols; Timing restrictions; Acceptance of one year loss of productivity.

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