OVERVIEW OF TRANSPORTATION RELATED WILDLIFE PROBLEMS

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Abstract

Highways and railways are sources of road mortality that threaten wildlife populations. They also have the potential to undermine ecological processes through the fragmentation of wildlife populations, restriction of wildlife movements, and the disruption of gene flow and metapopulation dynamics. A variety of techniques have been used to mitigate the impacts of transportation systems on wildlife movements. Factors influencing the effectiveness of these structures include: placement, size, openness, light, moisture, hydrology, temperature, noise, human disturbance, substrates, and the nature of the approaches and fencing systems. Important issues and challenges include: 1) fostering greater appreciation of the problems caused by highways and railways, 2) conducting landscape analyses to identify "connectivity zones", 3) enlisting transportation engineers to help solve technical problems, 4) monitoring of mitigation techniques, and 5) information sharing. In particular it is important not just to monitor wildlife use of crossing structures but also to develop and implement monitoring techniques that are sufficient for evaluating mitigation success.

Impacts of Highways and Railways on Wildlife

As long linear features on the landscape, railways, roads and highways have impacts on wildlife and wildlife habitat that are disproportionate to the area of land that they occupy. These elements of transportation infrastructure impact wildlife in a variety of ways.

1. Direct loss of habitat.
2. Degradation of habitat quality. Storm water discharges, air emissions and exotic plants can degrade habitats ranging up to several hundred feet from railways and highways.
3. Habitat fragmentation. Railways and highways dissect contiguous habitat patches resulting in smaller patch sizes and higher edge to interior ratios.
4. Road avoidance. Some wildlife species avoid areas adjacent to highways due to noise and human activity associated with roads.
5. Increased human exploitation. Roads and highways increase human access for hunting and poaching. This may reduce wildlife populations in areas adjacent to roads and highways and contributes to road avoidance.
6. Road mortality leading to loss of populations.
7. Reduced access to vital habitats. Railways and highways reduce access to vital habitats for a variety of wildlife species. Examples include:
    - Summer and winter ranges for ungulates
    - Access to mineral licks
    - Amphibian wetland breeding sites
    - Upland nesting habitat for turtles
    - Snake hibernacula
8. Population fragmentation. Railways and highways create barriers to movement that subdivide animal populations. Smaller populations are more vulnerable to genetic changes due to genetic drift and inbreeding depression, and extinction due to chance events.
9. Disruption of processes that maintain regional populations. Based on metapopulation theory, regional populations may persist in the face of local extinctions because the movement of individual animals among populations: a) supplement declining populations, b) maintain gene exchange, and c) re-colonize habitats after local population extinctions. By disrupting animal movements among populations, railways and highways undermine these processes that are vital for the long-term viability of regional wildlife populations.

For additional summaries of highway and railway effects on wildlife, including effects of habitat fragmentation, see Andrews (1990), Bennett (1991), and De Santo and Smith (1993).

Techniques for Mitigating Transportation Impacts on Wildlife Movement

Over the years a variety of techniques have been used to reduce animal-vehicle collisions and mitigate railway and highway impacts on wildlife.

Modified Drainage Culverts. Culverts originally constructed to convey water have been modified to provide passage for wildlife. In the Netherlands shelves have been attached to the sides of culverts to provide dry passageways for wildlife. Floating docks within drainage ways adjust to changing water levels and are used to maximize clearance for wildlife passage.

Wildlife/Drainage Culverts. Culverts designed to convey water only intermittently can be used for passage by wildlife when the culverts are dry. Drainage culverts have been designed to serve a dual role for water and wildlife passage. In some cases benches have been constructed within culverts so that passing wildlife can avoid flowing water within the culvert. Another, potentially more effective design involves channeling water through a trench within the culvert allowing a wider passageway for wildlife.

Upland Culverts. Not all species of wildlife readily use stream or river corridors for travel routes. Upland culverts facilitate overland movement between wetlands and uplands, uplands and uplands, and from wetlands to other wetlands. Movements to and from wetlands are particularly important for amphibians and turtles. Box culverts are generally preferable over pipes. Larger culverts will generally accommodate more species than smaller ones. Open-top culverts provide more light and moisture, and will be more effective for facilitating amphibian movements than standard culverts.

Oversize Stream Culverts. Where culverts are used to cross streams and small rivers, oversize culverts, large enough to allow for wildlife passage may be used. Box culverts generally provide more room for travel than large pipes. Open bottom arches and box culverts that maintain natural streambeds are preferred. Efforts to provide natural substrate, including large flat rocks as cover for small animals, will likely enhance their use by some species. Construction of benches on one or both sides of the stream to allow dry passage during normal high water periods will also enhance these structures. The optimum size for these structures is not known, but generally, the larger the better.

Expanded Bridges. Where railways and highways cross rivers and streams, expanded bridges that provide upland travel corridors adjacent to the waterway can provide passageways for many species of riverine wildlife, as well as other species that may utilize stream corridors for travel. Higher and wider bridges tend to be more successful than low bridges and culverts. Expanded bridges are more expensive than expanded bridges, but also are generally more effective.

Viaducts. Viaducts are elevated bridges used to span entire valleys. They typically provided relatively unrestricted wildlife movement across highway and railway alignments. For wildlife passage, viaducts are generally preferred over bridges and culverts.

Wildlife Underpasses. Wildlife underpasses are larger than upland culverts and can provide relatively unconfined passage for some wildlife species. Underpasses may be either large culverts or bridges. If appropriately sized these structures provide plenty of light and air movement, but may be too dry for some species of amphibians. Wildlife underpasses with open medians can provide a certain amount of intermediate habitat for small mammals, reptiles and amphibians. Open median designs are less confining and are generally preferred over continuous underpasses. However, open median designs are noisier than continuous bridges and may be less suitable for species that are sensitive to human disturbance.

Wildlife Overpasses. Wildlife overpasses have been constructed in a number of European countries but have been rarely used in North America. The most effective overpasses range in width from 50 m on each end narrowing to 8-35 m in the center to structures 200 m wide. Soil on these overpasses, ranging in depth from 0.5 to 2 m, allows for the growth of herbaceous vegetation, shrubs and small trees. Some contain small ponds fed by rain water. Wildlife overpasses appear to accommodate more species of wildlife than do underpasses. Primary advantages over underpasses are that they are less confining, quieter, maintain ambient conditions of rainfall, temperature and light, and can serve both as passage ways for wildlife and intermediate habitat for small animals such as reptiles, amphibians and small mammals.

Fencing. Fencing for large and medium-sized mammals are required for underpass and overpass systems to be effective. Standard fencing may not be effective for some species (black bears, coyotes), but manipulations of wildlife trails and vegetation can also be used to guide animals to passage ways and learning may enhance their effectiveness for these species over time. Fencing for large mammals may also include one-way gates or other structures to prevent animals that get onto roadways from being trapped between fences on both sides of the road. Fencing for small mammals, reptiles and amphibians must be specifically designed to prevent animals climbing over and through, or tunneling under the fencing. Short retaining walls can provide relatively maintenance-free barriers for reptiles, amphibians and small mammals.

Evaluations of wildlife crossing structures indicate the need for careful design and placement, and that effectiveness is dependent on a variety of variables, including: **size and openness** (Reed et al. 1975, Reed 1981, Hunt et al. 1987, Dexel 1989, Foster and Humphrey 1995, Yanes et al. 1995, Rodriguez et al. 1996, Rosell et al. 1997), **placement** (Singer and Doherty 1985, Podloucky 1989, Beier 1995, Paquet and Callaghan 1996, Roof and Wooding 1996, Rosell et al. 1997), **noise levels** (Singer and Doherty 1985, Pedevillano and Wright 1987, Beier 1995, , Foster and Humphrey 1995, Santolini et al. 1997), **human disturbance** (Clevenger 1998) **substrate** (Mansergh and Scotts 1989, Yanes et al. 1995, Linden 1997, Rosell et al. 1997), **vegetative cover** (Hunt et al. 1987, Pedevillano and Wright 1987, Beier 1995, Rodriguez et al. 1996, Rosell et al. 1997, Santolini et al. 1997), **moisture** (Brehm 1989, Jackson 1996), **hydrology** (Jackson and Tyning 1989, Janssen et al. 1997, Rosell et al. 1997, Santolini et al. 1997), **temperature** (Langton 1989) and **light** (Krikowski 1989, Beier 1993, Jackson 1996).

Many mitigation projects are primarily designed to facilitate movements of a single species or small groups of similar species. Some attempts to construct wildlife passage systems for a broad range of species are being tried in Europe and Canada (Banff National Park). Viaducts and large overpass systems for wildlife appear to the most effective designs for accommodating the needs of a broad range of wildlife species.

Current and Future Issues and Challenges

Much progress has been made in the past several years in understanding the impacts of transportation infrastructure on wildlife and developing techniques and approaches for mitigated those impacts. None-the-less several challenges remain.

Fostering Greater Appreciation of the Problems Caused by Highways and Railways. One important challenge is getting people to understand the scope and complexity of transportation impacts on wildlife. Too often the issue is viewed as one of an incidental take of animals rather than as a threat to wildlife populations. We must seek to frame the issue not as concern for individual animals but rather that of maintaining the ecological integrity of natural systems intersected by railways and highways. The movement of animals through the landscape is one of many ecological processes that must be maintained in order to insure the integrity of ecosystems over time. The impacts of railways and highways do not simply occur at the time of construction but accumulate over time as populations fail due to transportation impacts and pathways for re-colonization are precluded. Appropriate planning and mitigation at the time of construction can go a long way in preventing long-term degradation of wildlife populations and the ecosystems in which wildlife are important components.

Landscape Analyses to Identify "Connectivity Zones". The most effective techniques for facilitating wildlife movement (overpasses, viaducts, and large underpasses) are also quite expensive. Therefore, it is generally not practical to make entire highways or railways permeable to wildlife movement. A practical strategy for mitigating transportation impacts on wildlife movement may dictate that comprehensive efforts utilizing expensive elements be reserved for areas that are identified and designated as important travel corridors or connections between areas of significant habitats (Jackson and Griffin 1998). These landscape analyses are common in Europe (see Canters 1997) and there are some notable examples from North America (Wagner et al. 1998, Carr et al. 1998). To the extent that these areas can be identified ahead of time, planning for new transportation infrastructure can more effectively focus on minimizing and mitigating impacts to these critical areas.

Enlisting Transportation Engineers to Help Solve Technical Problems. There still is much work to be done in designing wildlife crossing structures that are effective for facilitating animal passage and practical for use in transportation systems. Biologists need to establish the performance standards for such structures based on the characteristics and needs of wildlife. The assistance of transportation engineers is needed to provide technical solutions and approaches so that crossing structures more effectively meet the standards identified by biologists. An example of a problem in need of a technical solution is how best to provide a wet environment within crossing structures to facilitate amphibian use during migration. Given the incredible feats of engineering accomplished over the years by transportation engineers, collaborative partnerships between biologists and engineers should be able to find practical solutions to many technical problems related to animal passage.

Monitoring and Evaluation of Wildlife Crossing Structures. Monitoring studies that evaluate the effectiveness of wildlife crossing structures have provided valuable information that is now available for use in designing future mitigation. As new structures are built it is particularly important that these efforts be monitored and the lessons learned from these mitigation experiments shared with others. There are a variety of techniques that can be used to monitor animal passage structures and evaluate their effectiveness.

Tracks and Track Beds

One of the simplest methods to monitor use of animal passage structures is surveys for animal tracks. In some instances tracks may be obvious in naturally occurring mud or soil within the crossing structure. A more effective technique involves the preparation of track beds. Track beds may involve simply raking and smoothing naturally occurring soil to facilitate track detection and identification. Use of marble dust or fine white sand will generally increase the effectiveness of track beds. Soot or ink panels with paper can be used along narrow passages and are useful for recording the tracks of small animals such as amphibians, lizards, and small mammals.

Track beds ideally should be 1-2 m wide and extend the entire width of the passage. Where underpasses and culverts contain streams or rivers, track beds will only be useful for recording those animals that pass along the banks and will not provide accurate counts (animals traveling in the stream channel will be missed). Fluctuating water levels within the passage structure may provide serious problems for track beds, as rising water levels are likely to wash away tracks.

In order to provide the most useful information about wildlife use of crossing structures, track beds should be established at both ends of the structure. This will allow monitors to determine whether animals that entered the passage actually passed through the crossing structure.

Automatic Cameras

Automated cameras have been used in a few studies of animal passage systems and have provided evidence that these structures are used by a variety of large animals. If properly installed they may be useful for detecting passage by large animals, although they may not be reliable enough to provide accurate counts of animals using a passage. One of the particular difficulties with using camera setups is detecting small animals. Photographs of large animals are usually identifiable even at some distance. Small animals must be photographed up close for proper identification. In some settings it may be possible to channel small animals through a narrow shute to facilitate photo-documentation.

Infrared beam triggers present a variety of problems for documenting small animals. Infrared beams are difficult to position for reliable results on uneven ground. It also is difficult to use a single beam that will work for animals that jump or bound (frogs, chipmunks, jumping mice). Camera setups positioned low to the ground also are vulnerable to vandalism.

Camera setups with motion detectors may be more effective than infrared beam triggers for documenting mammals, provided that they are well positioned. In large culverts or underpasses, both the camera and triggering mechanism can be mounted high in the structure out of the reach of people. None-the-less, they will need to be armored to prevent damage from stone-throwing vandals. One important disadvantage to using motion detector triggers is that they are only effective for detecting "warm-blooded" animals.

Counters

Counters make use of either infrared beam or motion detector triggers without cameras to count the number of animal passages at a particular point. The advantages of using counters without cameras is that they are less obvious and easier to protect from vandals, less expensive (no camera, film or photo processing required) and more reliable than camera setups, and require less attention (no need to change film). The obvious major disadvantage is that when using counters alone it is impossible to know what species are being documented. Further, the counters also possess the same limitations of triggering devises discussed in the section on automatic cameras. In some cases use of counters with track beds may provide a practical means of monitoring wildlife use of crossing structures.

Video Cameras

The advantage of using video cameras is that it allows observations of behavior that may indicate hesitancy or stress in animals using a crossing structure. Standard video cameras have been used in the day time. In Europe wildlife crossing structures have been monitored by infrared video cameras allowing observations at night (when many animals are more active). The primary disadvantages of this technique are: 1) they are not generally suitable for monitoring small animals (unless the crossing structure is small), 2) the high cost (approximately $10,000 for an infrared unit), and 3) the amount of time needed to review a large volume of videotape.

Radio Tracking

Tracking of radio tagged wildlife can provide some information about the crossing rates for individual animals. However, while records of animals on both sides of a highway or railway indicate that a crossing has occurred, it is usually not possible to know for certain whether the animal utilized a particular crossing structure. In some areas, such as where fencing may effectively limit crossing points, it might be credibly inferred that animals are using crossing structures. Another important limitation of radio-tracking is that it is not possible to get an absolute count of how often crossings occur. Unless tracking is continuous, an animal could cross several times in between times when its location is recorded via radio telemetry.

Radio tracking is most useful for comparing crossing rates or home range configuration between areas along transportation corridors and areas remote from highways and railways, or between highway and railway stretches with crossing structures versus areas lacking structures. Radio tracking is particularly well suited for studies to document 1) whether home ranges for a particular species change when a highway or railway is constructed and 2) the degree to which crossing structures affect that change.

Mark-Recapture Studies

For small animals, especially small mammals, trapping studies can provide similar information as radio-tracking, with many of the same limitations. Recaptures of marked animals have been used to evaluate the degree to which railways and highways inhibit the movement of small mammals. Comparing mark-recapture data for stretches of transportation infrastructure with and without crossing structures may be the only effective method for evaluating the effectiveness of such structures in facilitating movements of small mammals.

Passage Use versus Mitigation Success

Most attempts to evaluate the success or failure of wildlife crossing structures have focused on documenting wildlife use of the structures. Use of tracking beds, cameras, and counters do provide information about animals that use the structures. Unfortunately, monitoring structure use provides little information on species or individuals that fail or refuse to use the structure. Radio-tracking and trapping studies provide less information about structure use, but are more useful for determining the extent to which railways and highways inhibit wildlife movement and the degree to which crossing structures are able to mitigate these effects. In order to fully assess the effectiveness of wildlife crossing structures it may be necessary to use a combination of two or more techniques that will evaluate both structure use and the degree to which railway or highway effects on animal movement are mitigated.

<u>Information Sharing</u>. Recent conferences on this topic (ICOWET I & II, and the International Conference on Habitat Fragmentation, Infrastructure and the Role of Ecological Engineering, 1995 in The Hague) have played an important role in drawing attention to issues of wildlife ecology and transportation. They also have been invaluable as forums for information sharing among the diverse groups of people who are working on wildlife ecology and transportation issues. It is essential that we continue to document and share information about mitigation successes and failures. The information shared at this conference will be a valuable addition to this process.

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