Chapter 14

Wildlife Accommodation

Wildlife Accommodation

This chapter describes the potential effects of roads on wildlife, descriptions of wildlife accommodation that can be incorporated along new and existing roadways, and wildlife crossing structure guidelines. A great deal of information is available on effects of roads on wildlife, but practical solutions to successfully mitigate adverse effects are much scarcer. In most cases, crossings have been installed on a project-by-project basis, and have been designed for specific habitats, topography, and species. These data are beginning to emerge, and the *References* section at the end of this chapter provide links and studies to assist in appropriate accommodation design for wildlife and fish passage.

Many roads and other forms of linear transportation infrastructure were originally designed to transport vehicles with little understanding about the diverse terrestrial and aquatic landscapes that were traversed. Roads were often located along rivers, through wetlands, or in valleys to avoid steep grades and minimize construction costs. In recent years, a combination of shrinking wildlife habitat, reduced ability for wildlife to move between habitats, and increased wildlife-motor vehicle conflicts has generated a need for transportation agencies to address potential impacts to fisheries and wildlife habitat.

Studies have shown that mortality from vehicles is a threat to wildlife populations when population numbers are already low or when critical habitats occur near roadways. MassHighway recognizes the importance of reducing impacts to wildlife and improving habitat connectivity. However, the emphasis on public safety is paramount and cannot be overstated. As a transportation agency, the function of MassHighway is first and foremost to provide safe and efficient transportation infrastructure for motorists, bicyclists, and pedestrians.

When conflicts arise, safety must come first. For example, in northern New England, one in every 75 motor vehicle collisions with moose (Alces alces) results in a human fatality, as does one in every 2,500 collisions with white-tailed deer (Odocoileus virginianus).

While the moose population in Massachusetts is still small (currently, MassWildlife estimates there are 500 to 700 moose in the state), white-tailed deer are overabundant in some parts of the state. Public safety must take precedence over protection of both deer and moose. In some circumstances, the appropriate measure may be to exclude instead of accommodate wildlife. Sometimes the mortality effects of continued access to the roadway are greater than the fragmentation effects of excluding wildlife. However, in areas of statewide or regional importance for landscape-scale connectivity, exclusion should be coupled with alternative accommodations (passage structures) to avoid fragmentation and facilitate wildlife movement.

The science of road ecology, broadly defined as the study of *"the interaction of organisms and their environment linked to roads and vehicles"* (Forman *et al.* 2003), is still developing. Only in the past few decades has the relevance of the road in a landscape context, and its effects on the adjacent corridor, become a focus of study. Understanding road ecology requires participation and input from biologists, hydrologists, transportation planners, and engineers.

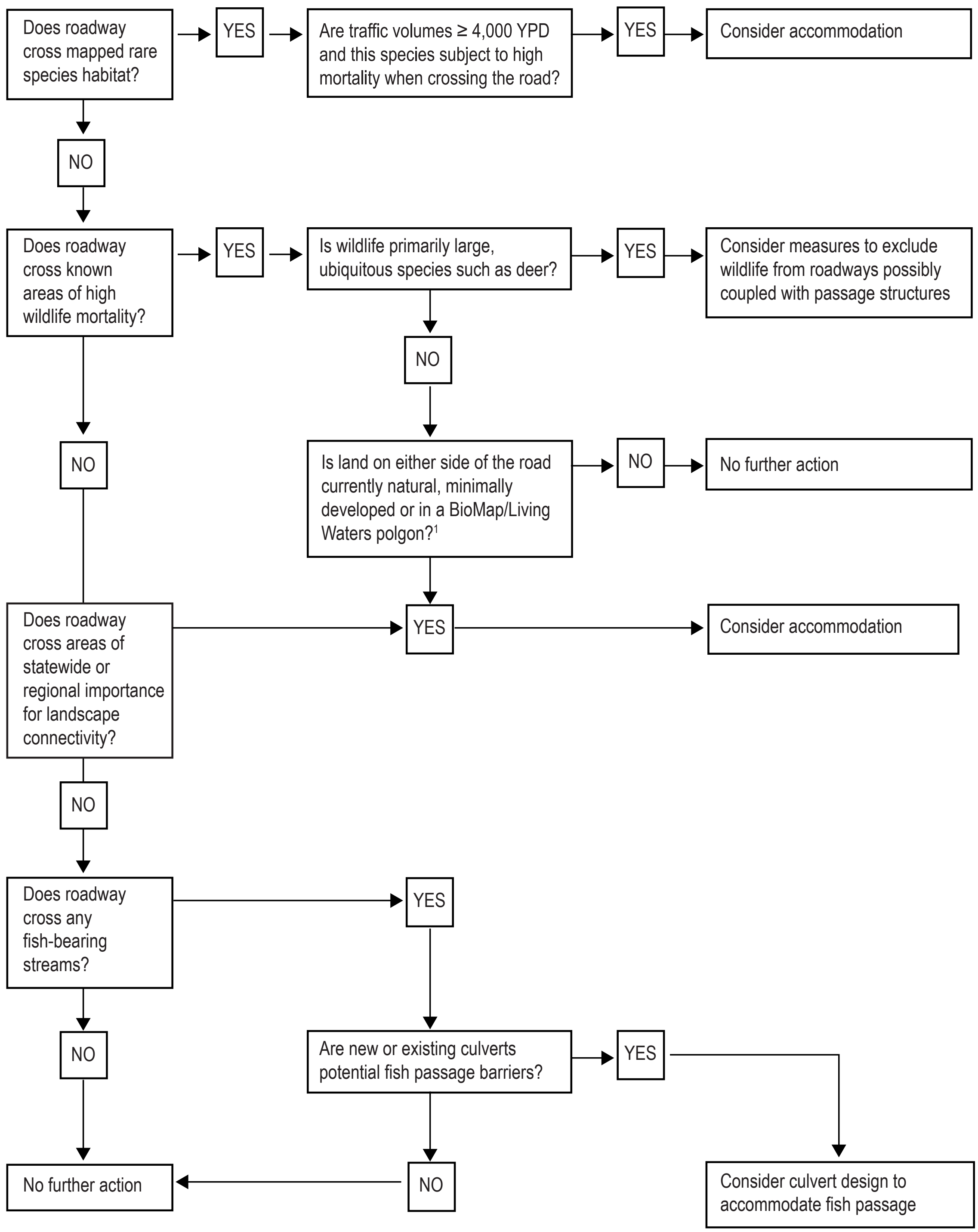
In a landscape context, roadway networks connect communities but often separate natural habitat components as they cross mountains, valleys, streams, forests, and farmland. Rainfall infiltration and drainage patterns may be altered when it encounters a roadway, and runoff from roads may result in reduced water quality in receiving waters. Habitats near roads may change through the introduction of non-native species along a linear right-of-way. Microhabitats adjacent to roads are often vastly different from nearby macrohabitats in terms of temperature, vegetation structure and composition, and substrates.

Worldwide, much data has been generated on the effects of roads on fisheries and wildlife species, and more data continues to emerge. What to do about the effects of roads on wildlife is not as clear, and research continues to be critically important in understanding what solutions work from a landscape and species perspective.

When prioritizing wildlife accommodation strategies, it is necessary to distinguish between common and rare wildlife. One of the most highly publicized examples of retrofitting a highway to accommodate wildlife is in Florida, where underpasses and bridge widenings were constructed along Interstate 75 between Naples and Miami. The crossings were built to facilitate both water movement into Everglades National Park and to reduce road kill of the federally listed Florida panther *(Puma concolor* *coryi)* along a 40-mile segment of highway. Construction of the underpasses reduced panther road kill, and evidence of several other species using the underpasses has also been documented.

In Massachusetts, most state-listed reptiles and amphibians are more likely to need accommodation than other species, primarily because of a dependence on at least two distinct habitat types (*i.e*. uplands and wetlands) that are frequently separated by roads. Studies have shown that roads have substantial adverse effects on some species, such as the state-listed Blanding's turtle *(Emydoidea blandingii).* Female Blanding's turtles may travel up to a mile in search of a suitable nest site, and are likely to cross at least one road to do so. A flow chart illustrating scenarios suitable for wildlife accommodation is provided as Exhibit 14-1.

Exhibit 14-1
Wildlife Accommodation Requirement Scenarios

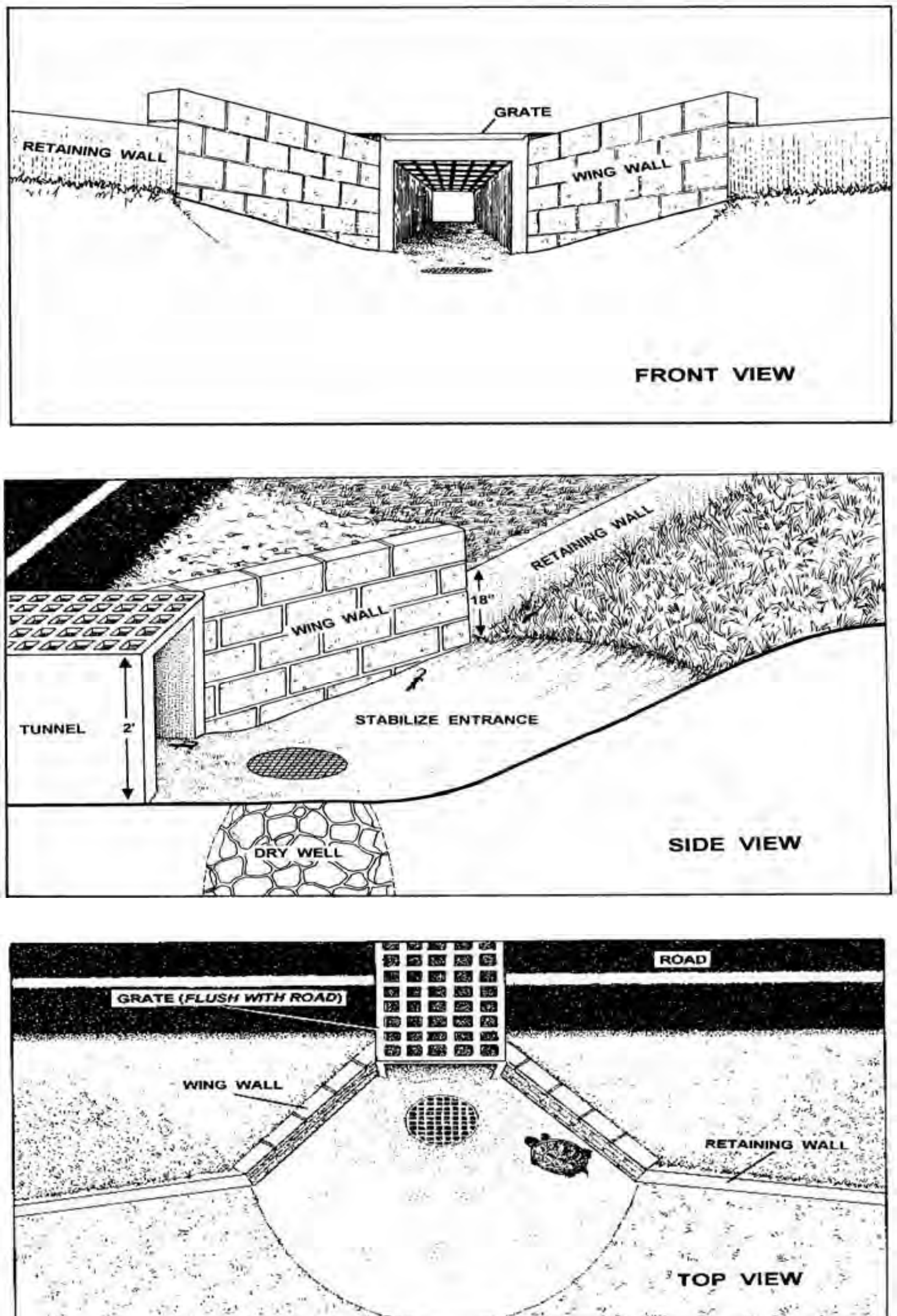


Source: MassHighway[1]

[1] BioMap Living Waters MASSGIS layers.

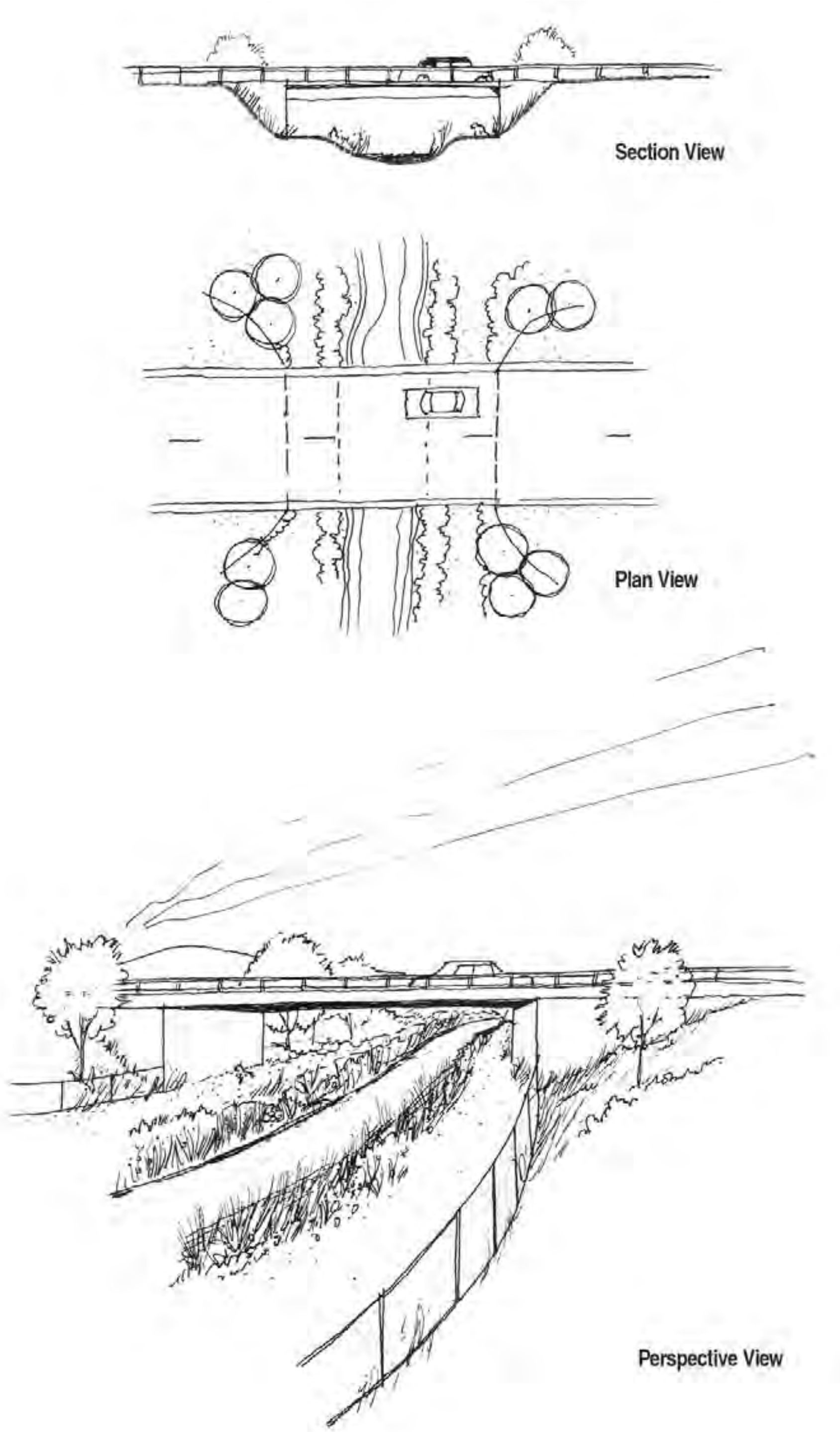
Exhibits 14-2, and 14-3 provide schematics for types of wildlife crossings that can be feasibly used when upgrading roadways.

Exhibit 14-2
Wildlife Crossings – Amphibian Tunnel



Source: Tamara Sayre; used with permission from S. Jackson, UMass Amherst."

Exhibit 14-3
Wildlife Crossings – Extended Bridge



Source: MassHighway

With 313 people per square kilometer, Massachusetts is the third most densely populated state in the country (behind New Jersey and Rhode Island). Public and private roads are knitted across habitats from the Berkshires to the coastal plain, and connect the 351 municipalities across the Commonwealth. Given the high density of existing roads, and the state's Smartgrowth policy, the focus of wildlife accommodation will be retrofitting existing roads.

Measures to minimize or mitigate the potential impacts include enhancing or creating habitat near roads through means such as wetland replication, installing vegetated berms, and incorporating native plantings along rights-of-way. Responsive mowing regimes along roadway rights-of-way and "living fences" can also be considered. Wildlife crossings are another strategy and can be incorporated into reconstructed roadways.

14.1 Types of Effects

Some roads may create adjacent habitat valuable to some forms of wildlife, and mechanisms to facilitate wildlife movement are already in place, primarily in the form of bridges. However, both existing and new roads may affect wildlife and habitat in a number of ways. Several studies have shown that some species avoid roadways and adjacent areas because of increased noise, pollution, visual disturbance, and predators using roadways as corridors.

Traffic speed and density also contribute to wildlife avoidance and barrier effects. Species that require at least two habitat types to complete their life cycle (such as breeding amphibians and reptiles) may continue to attempt to cross roads, resulting in higher mortality from vehicles.

Other types of effects may not be as noticeable but can be detrimental to wildlife populations. These can include habitat loss, habitat fragmentation, altered habitat quality, population fragmentation, and disruption of processes that maintain regional populations. The effects of roadways on wildlife are briefly described in the following sections.

14.1.1 Wildlife-Vehicle Collisions

Wildlife-vehicle collisions are a worldwide phenomenon that injure or kill millions of animals annually. Collisions with large mammals such as deer, moose, and black bear *(Ursus americanus)* also result in human injury and even fatality, with high annual property damage costs. In Massachusetts, there were 33 moose-vehicle collisions in 2003, resulting in one human fatality. In 2004, the number of collisions increased to 52.

Wildlife mortality from vehicles affects species to different degrees, from hoofed species such as deer and moose, to winged species such as songbirds and raptors, to smaller species such as amphibians, reptiles, and invertebrates including dragonflies and butterflies. Wildlife mortality from vehicles has a greater effect on animals with large home ranges and those that must migrate to different habitats in order to complete their life cycle than on those with smaller home ranges. For example, amphibians that live in uplands and breed in vernal pools, and turtles that live in wetlands and nest in uplands, frequently must cross roads to reach suitable nesting or breeding habitat.

Some long-lived wildlife species with low reproductive rates such as turtles are particularly vulnerable to population declines due to the loss of adults to road mortality. Also, populations with few individuals are more affected because of the relative importance of each individual in maintaining a healthy population. Temporal and seasonal variations are also evident. More white-tailed deer are struck by cars at dawn and dusk than any other time of day, and moose accidents are most likely to occur in the spring and fall. Large amphibian migrations occur in early spring. Female turtles cross roads to reach nesting areas in June.

Wildlife mortality from vehicles is also influenced by traffic volumes, traffic speed, roadway width, adjacent landscape, and wildlife behavior and physiology. To date, the literature presents conflicting information on traffic volumes, but most researchers agree that increasing traffic volumes pose greater threats to wildlife up to a certain critical point at which wildlife avoid roads altogether. Research suggests that roads with less than 1,000 vehicles per day (vpd) may cause road avoidance in smaller species, but crossing movements will still occur frequently. Roads with greater than 10,000 vpd likely pose an impenetrable barrier to wildlife, deterring most wildlife from crossing and killing many that do attempt to cross.

Research indicates that some wildlife are affected more by traffic speed than volume. For example, one study concluded that rabbits and songbirds experienced higher mortality rates at speeds greater than 40 miles per hour (mph). In Pennsylvania, deer-vehicle collisions decreased when the speed limit was reduced.

The surrounding context and roadway design features also influences mortality. For example, deer-vehicle collisions in Pennsylvania were lower with a higher number of residences and buildings near roads, when there was a greater distance to wooded areas, and when the minimum sight distance was increased.

14.1.2 Habitat Loss

Habitat is lost when an area previously providing food, cover, shelter, or breeding habitat is developed. As with road mortality, different species have different responses to habitat loss. Species that are long-lived, with low reproductive rates, have large home ranges, and low densities such as many large carnivores are at greater risk than other species.

14.1.3 Habitat Fragmentation

Fragmentation is defined as the subdivision of once large and continuous tracts of habitat into smaller patches. It results from agriculture, urbanization, and transportation or other right-of-way modifications. In general, fragmentation of habitat is viewed as detrimental when considering the original native, climax species composition and abundance, natural history, and relative ecological stability of unmanaged plant and animal populations.

Some species are sensitive to patch edges where they may have to complete with habitat generalists or are vulnerable to predators and brood parasites that are common along forest edges. Other species are “area-sensitive” in that they will not use habitat patches (such as forest, grassland or marsh) unless it is above a particular size threshold. Most species use more than one “patch,” or habitat type, in a landscape, and their survival depends on their ability to move successfully between patches in a landscape. Fragmentation can lead to several ecological processes that adversely affect wildlife populations including edge effects, barrier effects, and loss of genetic diversity.

14.1.3.1 Reduction in Patch Size

Fragmentation of large areas of forest, grassland or wetland habitat is likely to reduce the number of species occupying those habitat patches. In part this is because smaller patches are not able to support enough individuals to maintain viable populations for all species likely to be found in large patches. In addition there are many area-sensitive bird species that simply avoid smaller areas of otherwise suitable habitat.

14.1.3.2 Edge Effects

In fragmented habitats, there is a proportional increase of habitat edge. Habitat edge is the transitional zone from one habitat community to another, such as the zone between pasture and forest, and generally signifies habitat that is more susceptible to edge effects such as predation, and parasitism. The species richness of these areas is often higher than that of either bordering habitat because edges contain species from both habitats. However, species that are more successful near edges may negatively affect forest interior species and contribute to indirect effects of fragmentation.

Edge effects include a range of beneficial and detrimental ecological consequences that are associated with habitat diversity, the most common of which are increased predation and parasitism. Predation effects nearer the edge are most likely attributable to larger predators such as crows *(Corvus brachyrhynchos)*, blue jays *(Cyanocitta cristata)*, raccoons *(Procyon lotor)*, and snakes that tend to use and follow forest edges. In addition, brown-headed cowbirds *(Molothrus ater)* are commonly found in edge habitats, particularly in agricultural areas and are nest parasites of many songbirds, laying their eggs in other birds' nests.

Edges may also have detrimental effects by allowing invasive plants species to colonize newly disturbed areas adjacent to roadways, decreasing habitat quality. In addition, indirect effects of transportation improvements such as altered microclimates near edges may further decrease suitability for the original occupants of a forest such as butterflies, damselflies, and other insects.

14.1.3.3 Barrier Effects

Many species require more than one habitat type to successfully carry out breeding, feeding, or other required functions. The barrier effect created by infrastructure is a physical or psychological restriction on movements or migration by some feature within a corridor that wildlife is either unwilling or unable to cross. Studies have indicated that some small mammals are reluctant to cross a gravel cart path. Connectivity to other patches, or habitat types, in the landscape may be reduced by roads, constituting a barrier effect.

Isolation of populations due to the barrier effect of roads may lead to reduced genetic diversity. Researchers in Germany found that a bank vole (Clethrionomys glareolus) population separated by a highway experienced significant genetic variation, but not within populations separated by a county road. Barriers may also lead to reduced ability for individuals such as young of the year to colonize new areas, and can also cause difficulties for reproducing adults to locate one another.

The permeability of a road (*i.e.,* the degree to which it presents a barrier to wildlife) is influenced by the adjacent roadside habitat and the occurrence of safe locations for wildlife to cross. For example, a roadway with a wide cleared roadside will be relatively more impermeable to a forest-dwelling species than a road with suitable forested habitat adjacent to the road. However, the cleared roadside may benefit other species by providing a visibility zone to drivers and wildlife attempting to cross roads.

Barrier effects may also result in species being unable to complete a portion of their life cycle. For example, mole salamanders (Ambystomidae) spend the majority of their lives in forested uplands and wetlands and breed only in seasonal pools known as vernal pools. If an impermeable road separates the two habitats, the ability to successfully reproduce and maintain a population may be reduced or eliminated.

14.1.3.4 Population Fragmentation

Smaller isolated populations of plant and animal species are more susceptible to genetic deterioration as a result of inbreeding, depression and genetic drift, possibly resulting in extinction.

14.1.4 Altered Habitat Quality

Most effects of roads on habitat quality are negative, though in some cases they can prove beneficial to wildlife. Reduced habitat quality has been documented for birds adjacent to high-volume roads, primarily from noise associated with passing vehicles which may interfere with the ability of breeding males to successfully establish territories and attract females. However, other research found no difference in the number of breeding birds adjacent to highways from numbers at a greater distance, presumably because the roadside and median provided acceptable breeding habitat.

As introduced above, not all habitat modifications are negative. Beneficial habitat adjacent to roads can be created for amphibians in roadside ditches, perching sites for raptors, and as corridors for various wildlife. Beneficial habitat increases in value when roadsides and medians are planted with native species and are mowed less frequently. Of course, the habitat benefits of unmowed roadsides must be carefully balanced with safety effects of such conditions. The creation of attractive habitat along a roadside can also have negative consequences for wildlife.

Amphibians may attempt to breed in roadside ditches or detention ponds where conditions are not suitable for successful reproduction. Wildlife attracted to roadside habitats or food sources (carrion) may be subject to higher mortality.

In addition to terrestrial habitats, aquatic ecosystems may be indirectly affected by transportation improvements due increased water runoff. Increased runoff may increase erosion, causing decreased water quality through sedimentation and higher pollutant loading. Highway runoff may also affect vegetation composition and aquatic species, especially in areas of heavy traffic. For example salt laden runoff from roads and highways can facilitate the invasion of Phragmites into wetlands. Drainage system design can help to mitigate these impacts.

14.2 Types of Wildlife Accommodation

Research has suggested six policy initiatives that should be considered as goals and guidelines to address wildlife issues. To the extent possible, MassHighway will consider these initiatives in roadway design and maintenance. Clearly, some of these principles are outside the scope of MassHighway's activities and influence, but are presented to provide a contextual overview. Most roadway design and maintenance will be on existing roads, which minimizes applicability of some of these initiatives.

- Conduct landscape-based analyses to identify important "connectivity zones" and set priorities for mitigation

- Evaluate road-stream crossings for their barrier effects and prioritize structures for replacement
- Perforate road corridors for frequent wildlife and water crossings to reduce the road-barrier effect and habitat fragmentation.
- Depress roads and use soil berms and vegetation to reduce traffic disturbance and noise effects on wildlife and adjacent residential areas.
- Collect and consolidate traffic, including trucks, and channel it onto primary roads to reduce the dispersion of both noise and barrier effects on lower classification roadways.
- Improve engineering designs or road surfaces, tires, motors, and vehicles (aerodynamics) to reduce the ecological effects of noise.
- Use cleaner fuel and "life-cycle" vehicular materials (by designing vehicle parts to be recycled) to reduce greenhouse gases as well as pollutants of soil, water, and air.
- Consider exclusion fencing to keep wildlife off high-volume roadways.

Several techniques have been used in the United States to mitigate the impacts of transportation facilities on wildlife and habitat, though most measures have been shown to have limited success. The value of monitoring accommodation strategies is critical to understanding what works, and future studies may indicate different success rates.

Mitigation techniques that attempt to alter human behavior include:

- Signage
- Animal detection technology
- Public education and awareness
- Roadway lighting
- Reduced speed limits

Mitigation techniques that attempt to alter wildlife behavior include:

- Habitat alteration
- Fencing

- Modified Jersey barriers
- Wildlife crossing structures
- Hazing
- Whistles
- Mirrors and reflectors

Devices such as high frequency whistles attached to vehicles, increased highway lighting, reflectors (e.g., Swareflex®) placed along highway shoulders, and hazing are being used by some states in an attempt to scare wildlife away from oncoming traffic. However, results of studies on the effectiveness of these techniques indicate they are ineffective in reducing deer-vehicle collisions, and are not discussed further in this chapter. Descriptions of the most feasible and effective methods to accommodate wildlife in Massachusetts are described below.

14.2.1 Signage

Installing wildlife crossing signs where traditional wildlife pathways intersect highways can alert drivers to potential encounters with wildlife. Although the ability of these signs to reduce vehicle collisions with animals has not been proven, they at least heighten the awareness of drivers to wildlife mortality problems. Variability in signage increases the possibility of motorist observance.

For example, Maine placed signs along roads during high deer and moose activity periods and found that collision frequency was lower than in areas where signs were left in place year-round. In addition to seasonal signage, some states in northern new England have instituted “fatality signs.” These signs are updated on a regular basis to reflect the current number of motorist fatalities from moose and deer collisions.

14.2.2 Public Education and Awareness

Public education can take the form of educational videos distributed at driver education classes and distribution of maps at rest areas, visitor centers, and welcome centers along major roadways, and local Registries of Motor Vehicles, that detail types of common crashes, likely causes, and ways to avoid being in a wildlife-related crash.

14.2.3 Reduced Speed Limits

Maine evaluated data through 1998 for moose and deer crashes, and found that most crashes occur on roads with speed limits of 50 to 55 mph, indicating that many crashes are caused by drivers whose decision distance is greater than the distance that can be seen under headlight illumination.

14.2.4 Habitat Alteration

Habitat alteration presents two potentially conflicting objectives: to attract or repel wildlife from roadsides and medians while at the same time allowing motorists adequate visibility to avoid hitting wildlife that venture too close to the roadway. Alteration can consist of removing vegetation along roadways, planting species adjacent to roadways that are undesirable to wildlife, or planting native species to provide habitat for some wildlife and reduce the spread of non-native vegetation along a transportation corridor.

Roadsides and medians are usually mowed for safety reasons. Untrimmed vegetation reduces visibility adjacent to roads (potentially increasing risks to wildlife, pedestrians, and bicyclists) and also reduces sight distance to oncoming vehicles and roadway geometry.

Changes to mowing regimes can be considered where benefits to wildlife such as rare birds or insects or rare plants growing in the verges may be realized. For example, in central Wisconsin, the state-endangered Karner blue butterfly *(Lycaeides melissa samuelsis)* is dependent on wild lupine *(Lupinis perennis),* a plant that is commonly found adjacent to roads.

The Department of Defense instituted a protocol where lupine populations adjacent to roads at Fort McCoy are staked out each year, and mowing crews lift their blades to avoid cutting them during routine maintenance. Other possibilities to consider for mowing regimes include timing and frequency. Mowing roadsides outside of breeding bird population dates (generally early May through late June) can benefit breeding birds that use roadside verges and medians. Lessening the frequency of mowing not only costs less but increases plant species diversity.

Washington State, among others, employs a three-tiered approach to roadside vegetation management. There are three zones adjacent to a road, and vegetation is cut at different rates and to different heights.

The purpose of this is to allocate maintenance resources most effectively, but it is also useful for ecological management as well.

Additionally the limited use of herbicides in areas of critical habitat can reduce impacts to adjacent wildlife populations. In areas where such treatments are required, chemicals with low toxicity to animal populations of concern should be used. Design techniques, such as careful plant species and construction materials selection can also be used to reduce the need for these treatments.

14.2.5 Modified Jersey Barriers

First designed in New Jersey, Jersey barriers are concrete dividers that are typically used on divided highways as a means of keeping two-way traffic separate or to prevent access to a restricted area (e.g. during highway construction). Where installed in the median, they may increase some wildlife mortality by trapping small and medium-sized mammals. Jersey barriers have been modified (and are in use on Route 6A on Cape Cod, and along sections of Route 24 and Route 3) so that "scuppers" allow passage of small species through the barrier, as well as promoting more efficient drainage. Jersey barriers can also be installed at the outer edges of a highway to keep wildlife off roadways.

14.2.6 Fencing

Fencing is a common practice used to keep wildlife off highways. For high-volume roadways such as interstates, fencing should be considered as an exclusionary measure for wildlife such as deer and moose. Exclusion fencing may also benefit small mammal populations by providing forage and cover habitat near highways. Fencing is typically 7 to 10-foot high chain link or rectangular mesh but can be smaller for reptiles and amphibians. If smaller species are the target, fencing is usually buried and angled to prevent animals from climbing over.

For wildlife crossings (described below) to be successful, studies indicate that areas adjacent to the road must be fenced to direct animals to crossing structures, and to prevent them from crossing over the roadway. For deer, fencing should be at least 7 feet high (preferably 8 feet high) upright chain link "outrigger" fencing (sloped) to prevent deer from approaching close enough to jump over the fence.

For amphibians and reptiles, fencing can be constructed of silt fence or concrete retaining wall. Installing silt fence is significantly less expensive than constructing a retaining wall, but requires considerably more maintenance to be successful. Fencing must be maintained to be successful. Gaps resulting from poor construction, erosion, or crawl holes dug by animals reduce efficacy, as wildlife will exploit fence gaps.

14.2.7 Wildlife Crossing Structures

Crossing structures are designed to safely move wildlife either over or under a roadway, maintaining natural population movements and reducing road kill. Several factors, such as location, hydrology, light, openness ratio (cross-sectional area of a culvert divided by its length), and cover are important in designing successful wildlife crossing structures. Overall, crossing structures should maintain landscape connectivity rather than redirect wildlife movements. Therefore, they should be placed in known wildlife migration/travel routes.

Geographic Information Systems (GIS) analysis is a landscape-based tool that can be used to determine the most valuable habitat for wildlife and wildlife movement by characterizing landscape features such as vegetation, riparian corridors, development, and topography. Determining species distribution and corridors of movement and understanding target species biology is critical in designing effective wildlife crossing structures. A community/ecosystem approach rather than species-specific approach has been found to be most effective in maintaining habitat connectivity and ecological functions.

Most researchers agree that location is the most critical aspect of design, particularly for species of low mobility (small mammals, reptiles and amphibians). Wildlife crossing structure success also depends on noise levels, substrate, vegetative cover, moisture, temperature, and light, as well as roadway width, openness, traffic volumes and human disturbance.

Openness is negatively correlated with use by small mammals, indicating that large openings without cover from predators were avoided by small and medium-sized mammals (except coyotes *(Canis latrans*) and shrews), possibly because of higher predation associated with larger culverts. However, lagomorphs (rabbits and hares) and carnivores are inhibited by low openness. Distance to cover, such as shrubs or trees, was also negatively correlated to small and medium-sized mammal use. This correlation indicates that these species (particularly voles, weasels *(Mustela* spp.), and coyotes rely on the increased cover when moving about.

For species with low mobility (amphibians and reptiles), crossings should not be more than 500 feet apart. Crossings can be placed closer to each other if cost and context permit. If crossings are considered for wildlife with large home ranges [bobcat *(Lynx rufus)*, deer, moose, fisher *(Martes pennanti)*], they should be placed no more than 1 mile apart. Again, crossings may be constructed closer to each other if possible. For long projects, spacing should be prioritized according to habitat suitability and future potential development. A variety of crossing structures is recommended to provide passage for several species.

14.2.7.1 Culvert Replacement and Stream Restoration

Replacement of undersized culverts with bridges or "stream simulation" culverts can restore river and stream continuity and facilitate passage by fish and other aquatic organisms. Stream restoration may occur as part of a culvert replacement (to address scour or aggradation that may have occurred due to the undersized structure) or in other areas such as eroding or previously riprapped banks or stream sections that were artificially straightened to accommodate a road or highway.

14.2.7.2 Wildlife Underpasses

Wildlife underpasses can be large or small, depending on the target wildlife species. They can take the form of amphibian tunnels, ecopipes, wildlife culverts, and oversized stream culverts. Amphibian tunnels are widely used in Europe to facilitate annual amphibian migrations under roads, but to date have not been used extensively in the United States. One of the first amphibian tunnels was constructed beneath Henry Street in Amherst, Massachusetts to minimize road kill of spotted salamanders as they migrated to and from breeding sites (see Figure 14-2). Another larger tunnel, greater than 10-feet wide was constructed under Route 57 in Agawam.

Although best-suited to new construction, wildlife underpasses can be considered in roadway reconstruction where circumstances warrant. They can also be used to replace existing in–stream structures in culvert replacement situations. Providing such crossing opportunities, particularly in areas adjacent to late successional forest, may facilitate forest ecological functions involving small mammals (e.g. the dispersal of seeds and fungal spores).

Migrating amphibians are hesitant to enter tunnels with a microclimate that is significantly different from their surroundings, including differences in light, air flow, and humidity levels. Concrete tunnels are preferred over steel or plastic. Culverts should be at least 2 feet by 2 feet, and should be grated to allow ambient light, air and moisture to enter and pass freely through the tunnel.

Ecopipes are small, dry tunnels (1-foot to 1.3-foot diameter) used to facilitate movements of small and medium-sized mammals. They have been installed in the United Kingdom and the Netherlands, and appear to be successfully used by badger *(Meles meles)* and otter *(Lutra lutra)*. Wildlife culverts are similar to ecopipes but are installed over waterways. They are up to 4 feet wide and have raised dry ledges, or shelves, on one or both sides of the waterway that allow wildlife to cross under the road and adjacent to the river or stream. The shelves also ensure that the appropriate stream channel configuration is maintained, which prevents possible morphological streambank degradation.

Oversized stream culverts or extended bridges are options in replacement culvert or bridge situations along waterways where target species include both upland wildlife and aquatic species (see Figure 3). Extended bridges maintain terrestrial habitat connectivity by providing an unsubmerged area adjacent to the waterway. Abutments extend beyond water's edge to provide a natural bank under the bridge – animals can cross under the bridge instead of over the road.

Construction of a concrete shelf above the floodplain will encourage use by terrestrial species; care should be taken to not alter stream hydrology. Bankfull width must be maintained for the stream to continue to convey the appropriate water volume and bedload material (i.e. material transported by a stream).

Dry drainage culverts have been used in Canada, the United States, Europe, and Australia. They are useful to small and medium-sized mammals, ungulates, and possibly reptiles, and can be constructed in uplands particularly in areas of high quality wildlife habitat, or areas with nearby wetlands. Results of wildlife crossing monitoring highlighted the importance of dry drainage culverts for small mammal movement.

14.2.7.3 Wildlife Overpasses

These buried highway sections that function by providing a wildlife "bridge" over a highway have been constructed in Canada and Europe, and one is proposed to be constructed along I-70 in Colorado. They are generally only feasible in areas of new construction and where substantial areas of high-quality wildlife habitat occur on both sides of the roadway. They are usually constructed at high points in the landscape over roadway to connect habitat, and can be planted with grasses, shrubs, and small trees.

14.2.7.4 Viaducts

Viaducts are elevated roadway spans over entire valleys, floodplains, wetlands, or gorges and provide unrestricted wildlife movements. They are excellent for a multi-species design approach, but are the most expensive option for all wildlife crossing structures. They are only appropriate in new design scenarios and on large projects.

14.3 Wildlife Accommodation Guidelines

Many states recognize that roads can result in a series of adverse effects to wildlife, and are beginning to formalize initiatives and policies to address these impacts. In the Northeast, Maine has developed a task force to address large mammal-vehicle collisions, as well as a fish passage policy. Vermont is in the process of developing a wildlife crossing initiative. Currently, most states address wildlife accommodation on a project-by-project basis. In general, if the road crosses an area of statewide or regional importance for landscape connectivity wildlife accommodation should be considered.

As described earlier in this chapter, efforts to accommodate wildlife will be primarily on reconstructing existing roads and bridges. Wildlife accommodation should be focused on rare species that require conservation (*e.g*. state-listed reptile and amphibian species) instead of more ubiquitous wildlife such as deer (see Figure 14-1).

Wildlife accommodation should be prioritized so that areas of high-value habitat are connected, and areas that do not provide habitat on both sides of a roadway should not be included. Accommodations for wildlife should be considered where high crash statistics indicate a problem exists for wildlife. Anecdotal or statistical evidence of high crash locations may be available from local DPWs, the state Division of Fisheries and Wildlife, and other natural resource agencies. Aquatic animals should also be provided passage across roadway corridors. The designer should provide bridges or culverts that maintain stream continuity and allow fish passage, including migratory passages for diadromas fish.

14.3.1 Design Guidelines

This section lists potential accommodations for wildlife that could be used for typical MassHighway projects. They are intended to assist readers with deciding what types of accommodation should be considered for a project. This menu should be used in conjunction with the flow chart provided in Exhibit 14-1.

14.3.1.1 Footprint Bridge Program

This program was undertaken in 1991 to replace debilitated bridges along essentially the same alignment, resulting in fewer environmental impacts. For projects that qualify for this program, the following accommodation measures should be considered:

- Stream restoration
- Extended bridges

14.3.1.2 New Bridges

New bridge construction includes projects that would construct a new bridge on a new alignment. The following accommodation measures should be considered:

- Extended bridges
- Viaducts

14.3.1.3 Roadway Widening, Reconstruction, and Maintenance Projects

Roadway widening includes projects that add a least one lane to a roadway. Reconstruction projects include those projects that add shoulders or a bicycle lane, widen an existing road to meet current design standards, and propose sidewalks. Maintenance projects are those that qualify for the Footprint Roads Program that was initiated in 2003 to allow some roads to be reconstructed without widening to current design standards.

If projects do not include stream crossings, the following measures should be considered:

- Signage
- Public education and awareness
- Reduced speed limits

- Habitat alteration
- Modified jersey barriers (on divided highways)
- Fencing
- Dry drainage culverts
- Amphibian tunnels

For those widening and reconstruction projects that include stream crossings, the following measures should be considered in addition to the above measures:

- Culvert replacement
- Stream restoration
- Extended bridges

When practical, drainage and stormwater measures should be brought up to standard as part of reconstruction.

14.3.2 Other Guidelines

In Massachusetts, there are published guidelines and manuals that focus on proper stream crossing installations, particularly culverts. Each is briefly described below.

14.3.2.1 Massachusetts River and Stream Crossing Standards

In 2004, the multidisciplinary River and Stream Continuity Steering Committee developed technical standards to facilitate the implementation of stream crossings. General and optimal standards for new and retrofit culverts are described. The guidelines are excerpted here and referenced at the end of this chapter.

The goals of the Committee were to develop standards that would address fish passage, riparian wildlife, and river and stream continuity. The guidelines should be considered for permanent roads that cross perennial streams (or intermittent streams that provide fish habitat), and where amphibians and/or reptiles are known to cross in high concentration. Guidelines were developed for new and replacement culvert installation as summarized below.

General Guidelines - New Culverts

These standards should be implemented when new crossings are planned over rivers or streams that support one or more species of fish, or in areas with known amphibian or other wildlife crossings.

- Bridge span preferred
- If box culverts are used, structure should be embedded (sunken) at least two feet (minimum of 2 feet or 25 Percent whichever is greater)
- Natural bottom substrate should be provided within culverts that generally matches upstream and downstream substrates
- *Spans channel width (a minimum of 1.2 times the bankfull width)*
- Designed to provide water depths and velocities at a variety of flows that are comparable to those found in upstream and downstream natural stream segments (e.g. low flow channel)
- Openness ratio of >10 inches. Openness ratio is the cross-sectional area of a structure divided by its crossing length (with all dimensions measured in meters). For a box culvert, openness = (height x width)/length

Standards for Culvert Replacement

Whenever possible replacement culverts should meet the design guidelines for general standards (see Standards for New Crossings above) If it is not possible or practical to meet all of the General Standards, replacement crossings should be designed to meet the General Standards for crossing width (1.2 times bankfull width), meet other General Standards to the extent practical, and avoid or mitigate the following problems.

- Inlet drops
- Outlet drops
- Flow contraction that produces significant turbulence
- Tailwater armoring
- Tailwater scour pools
- Physical barriers to fish passage

As indicated by long profiles, scour analyses and other methods, design the structure and include appropriate grade controls to ensure that the replacement will not destabilize the river/stream. To the extent practicable conduct stream restoration as needed to restore river/stream continuity and eliminate barriers to aquatic organism movement

14.3.2.2 U.S. Army Corps of Engineers Programmatic General Permit Conditions

On January 20, 2005, the U.S. Army Corps of Engineers (ACOE) reissued the Programmatic General Permit (PGP) for Massachusetts. The PGP Condition 21 requires:

- Designing new permanent waterway crossings to not obstruct aquatic life movement.
- New permanent crossings must conform to the General standards of the Massachusetts River and Stream Crossing Standards (see Section 14.3.2.1) unless otherwise authorized by ACOE.
- For new stream crossings, open bottom arches, embedded culverts or bridge spans are required to qualify as a Category 1/non-reporting project.

The ACOE permitting process allows projects meeting the PGP's Category 1 definition and the PGP's general permit conditions to process without application or notification to the Corps. These projects are referred to as Category 1 – Non-Reporting Projects. If these designs are impractical, applicants must consult with the ACOE.

14.4 Conclusions

Roads have been traditionally viewed solely as a means of transporting humans and goods. As the understanding of road ecology grows, a multidimensional view of roads emerges, which takes into consideration not only the safety and efficiency of roadway networks to humans, but the ability to maintain ecological processes as well. Careful consideration of these ecological processes during planning for roadway upgrades and reconstruction will require close collaboration between planners, engineers, landscape designers, biologists, and maintenance staff.

Monitoring wildlife accommodations should be a priority. A recent success for rare wildlife in Massachusetts was achieved along relocated Route 44 in Carver. This 8-mile section of new state highway between Carver and Plymouth crossed an area providing high-value habitat to state-listed spotted turtles *(Clemmys guttata)* and eastern box turtles *(Terrapene c. carolina).* A two-year pre-construction study conducted as partial mitigation for rare species habitat impacts showed that an entrance ramp would bisect two habitats used extensively by spotted turtles and, although all permits had been obtained, MassHighway redesigned a portion of the project. An intermittent stream that flowed under the entrance ramp proved to be a major migration route for the turtle population to travel between habitats, and it was redesigned from a 24-inch pipe to a 6-foot by 6-foot box culvert. The culvert was sunk approximately 6 inches below the streambed, and had an openness ratio of 0.8. A post-construction study of the turtle population documented use of the culvert by several turtles, indicating that the population integrity remains intact.

14.5 For Further Information

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