Underpass Systems For Amphibians

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The spotted salamander (*Ambystoma maculatum*) is a member of the family of mole salamanders (Family Ambystomatidae) found throughout the eastern United States and southeastern Canada. In New England it is a relatively common inhabitant of deciduous and mixed coniferous/deciduous forests. Each year in response to warming temperatures and spring rains, spotted salamanders migrate from terrestrial over-wintering sites to vernal pools--small temporary ponds--in which they breed. After a brief period of courtship and egg deposition, adult salamanders use relatively warm, rainy nights to migrate back into the forests.

The life history of the spotted salamander is representative of many species of amphibians in New England. Essentially terrestrial animals, these amphibians must migrate to wetland breeding sites and, after breeding, move back into upland non-breeding habitats. Small, temporary ponds provide preferred breeding habitat for many species. In the warm, fishless waters of these ponds, amphibian larvae grow quickly, emerging as freshly metamorphosed juveniles during the summer or early fall. These young-of-the-year then disperse from the pools into the surrounding uplands.

In areas where roads or highways separate breeding ponds from upland, non-breeding habitat, road mortality can be a serious threat to amphibian populations. Road mortality does not just affect the occasional animal that wanders onto the highway, in many instances entire breeding populations are forced to cross roads. Breeding adults are subjected to road mortality twice (incoming and out-going), and young-of-the-year must also cross roads when they disperse from the ponds. Unlike many amphibians, adult spotted salamanders have a naturally high annual rate of survival. The loss of breeding adults as roadkills most likely represents an additive source of mortality. If the toll on juveniles and adults is high enough, road mortality would be expected to result in population declines and local extinctions (for examples see van Gelder 1973 and Fahrig et al. 1995).

Incidences of high amphibian mortality associated with roadways have attracted the attention of the general public and has resulted in a number of amphibian tunnel projects, most of them in Europe (Langton, 1989). In 1987, North America's first salamander tunnels were constructed at a site in Amherst, Massachusetts. The Henry Street site in Amherst was already well known for its volunteer "bucket brigades" and annual road closings to help protect spotted salamanders during breeding migrations. The use of tunnels at this site was considered an experiment; an opportunity to investigate the viability of using tunnels to mitigate the impact of roads on amphibian populations.

Materials for two tunnels were donated by ACO polymer products Ltd., a German company that had a long history of support for amphibian tunnel projects in Europe. The two tunnels were installed approximately 200 feet apart and a system of 12-inch high drift fences were constructed to direct migrating salamanders into the tunnels. Design features were included at the fences and tunnel entrances to divert runoff water and prevent the tunnels from flooding. The tunnels themselves were equipped with slotted tops to allow rain to enter, providing the damp conditions preferred by migrating amphibians.

The tunnels were monitored during the spring migration in 1988 to determine 1) whether the salamanders would follow the 30 m lengths of fencing to reach the tunnels and 2) whether they would use the tunnels to cross the road (Jackson and Tyning 1989). Results of this study indicated that the length of the drift fences was not a deterrent to salamander movement. Salamanders that encountered the fences farthest from the tunnel were just as successful in reaching the tunnels as individuals that encountered the fences closer to the entrances. This study also indicated that the tunnels were successful at moving salamanders across the road. At a minimum, 75.9 percent of animals that reached the tunnel entrances successfully passed through them. Of the remaining 24.1 percent, it is not known whether these animals abandoned their migration, bypassed the fence system or passed through the tunnels on a subsequent night.

Despite the overall success of the Henry Street Tunnel Project, we did observe that many salamanders appeared hesitant to enter the tunnels. Over the next several years, volunteers have monitored this site in an effort to investigate one possible cause for this tunnel hesitation. Although we have not yet collected sufficient data to demonstrate it conclusively, it is clear to all of us that have worked with these tunnels that light, or the absence of it, is one factor responsible for tunnel hesitation. Once artificial light is provided the time it takes salamanders to enter and pass through the tunnels is dramatically reduced. Based on these observations it appears that future tunnels should be designed to maximize the amount of ambient light inside the tunnels. This could be accomplished by using larger tunnels or providing grates, rather than slotted tops, for the tunnels.

While wildlife underpasses that have been constructed for large mammals might be expected to provide sufficient light for amphibian use, several aspects of their design limit their usefulness for amphibians. Over-sized culverts and underpasses for wildlife are typically placed at stream crossings. The inclusion of appropriate substrates (flat rocks) might make them appropriate for stream-associated amphibians. However, the movements and migrations of many amphibians are not associated with streams. Many amphibians, as well as nesting turtles, need to move between upland and wetland sites. An additional concern is that amphibians typically require wet conditions for their migrations. Therefore, underpass systems designed for amphibian use must include some mechanism for allowing rain to moisten the substrate within the underpasses.

Experiments in Europe and at the Henry Street site in Massachusetts have demonstrated that tunnels can be effective for moving amphibians across two-lane roads. It is unclear whether this technique will be as successful with large highways. When migratory conditions change on a given night (i.e. colder temperatures), amphibians will either turn back or seek shelter nearby. Animals caught in the middle of a long tunnel could be killed by freezing temperatures before they find appropriate shelter. Minimizing the width of the highway at designated crossing points would be one way to deal with this problem (i.e. eliminating the median strip). Another approach might be to enhance the median to create islands of stop-over habitat that could serve as half-way points for migrating amphibians. More research is needed to determine whether amphibians will travel through a long culvert or underpass necessary to traverse a major highway, or whether shorter tunnels with an intermediate habitat island in the median strip would be more effective.

Where roads and highways separate habitats that are essential for amphibian populations, it may be necessary to mitigate highway impacts in order to maintain those populations. More important than maintaining populations adjacent to roadways is the need to maintain animal movements that connect and maintain populations over the time. Adult amphibians often demonstrate strong fidelity for breeding sites (i.e. small pools) resulting in relatively discrete populations. These are generally not closed populations, however, and genes and individuals are commonly exchanged among them (Gill 1978, Breden 1987, Berven and Grudzien 1990, Sjögren 1991).

Small breeding pools often support small populations of amphibians. The viability of these small populations is probably dependent on gene exchange and the supplementation of populations via dispersal from other populations. Even if these small habitats represent population sinks, they may provide an avenue for gene exchange between more distant populations. Given their reliance on small, temporary ponds, many amphibian populations may be vulnerable to local extinction events during periods of unusually dry weather. Over time, these populations are probably maintained via a process of supplementation or recolonization. The exchange of individuals among populations and its role in gene exchange, supplementation of populations and the recolonization of populations following extinction events is probably vital for maintaining regional, or metapopulations of amphibians. The same is probably true for reptiles and small mammals.

The proliferation of roads and highways is resulting in a remarkable fragmentation of habitats, populations and metapopulations in heavily developed areas of the United State and elsewhere. Smaller patches of habitat support fewer and smaller populations, thereby increasing the risk of local extinctions. As barriers to gene exchange and dispersal, roadways may be contributing to the gradual eroding of amphibian, reptile and small mammal populations. Eventually, techniques will have to be developed that will facilitate the movement of both large and small animals across highways. Otherwise, the loss of amphibians, reptiles and small mammals from habitat fragments will disrupt food chain dynamics and dramatically reduce the abundance and diversity of wildlife in those areas.

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