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salamanders *Ambystoma maculatum* under roads

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Effectiveness of drift fences and tunnels for moving spotted salamanders *Ambystoma maculatum* under roads

Scott D. Jackson and Thomas F. Tynning

Introduction

In 1987, a project was initiated by the Fauna and Flora Preservation Society Inc. (Boston office) to install a pair of tunnels to facilitate movement of spotted salamanders *Ambystoma maculatum* across Henry Street in Amherst, Massachusetts (USA). Drift fences and tunnels had been used to aid toads migrating across roads in Europe; however, a project of this kind had never been attempted for mole salamanders. The Henry Street project offered an opportunity to evaluate whether techniques used in Europe would work for salamanders in New England.

Spotted salamanders breed in temporary ponds early in the spring. Several aspects of their biology present unique challenges for drift fence design. Spotted salamanders are fossorial; therefore, the bottom 6-10 cm of the drift fence must be buried in the ground. In Massachusetts, breeding migrations occur in late March, while the ground is still frozen. As a result, drift fences must be installed in fall or early winter, before the ground freezes. Spotted salamanders can climb, and steps need to be taken to prevent them climbing over the fences. Drift fences have been used to census spotted salamanders, but pitfall traps are usually placed no more than 3-5 m apart along a fence. Until now, it was not known whether salamanders would move longer distances along a drift fence.

Two tunnels supplied by ACO Polymer Products Inc., Ohio, were installed for the 1988 spring migration. This first year we chose to focus our attention on three initial concerns: flooding; effectiveness of drift fences; and effectiveness of tunnels.

Methods

Flooding

Due to the topography of the Henry Street site and extensive rain run-off expected over frozen ground, flooding was a substantial concern. Three steps were taken to minimize flooding of the tunnels (Figure 1). First, an asphalt pad was designed for each of the four tunnel entrances, which, as well as stabilizing the slope, provided a 15-cm berm to shunt water away from the tunnels (Figure 2). Second, at the base of each pad we installed a dry well (soak-away), extending 0.5-1 m below the surface, to collect any water reaching the tunnel entrance. Third, drift fences were constructed from plastic mesh to allow water to flow through, rather than along, the fences. Six-millimetre-mesh was used on the upland side of the road; three millimetre-mesh (to stop young-of-the-year salamanders) was used on the pond side.

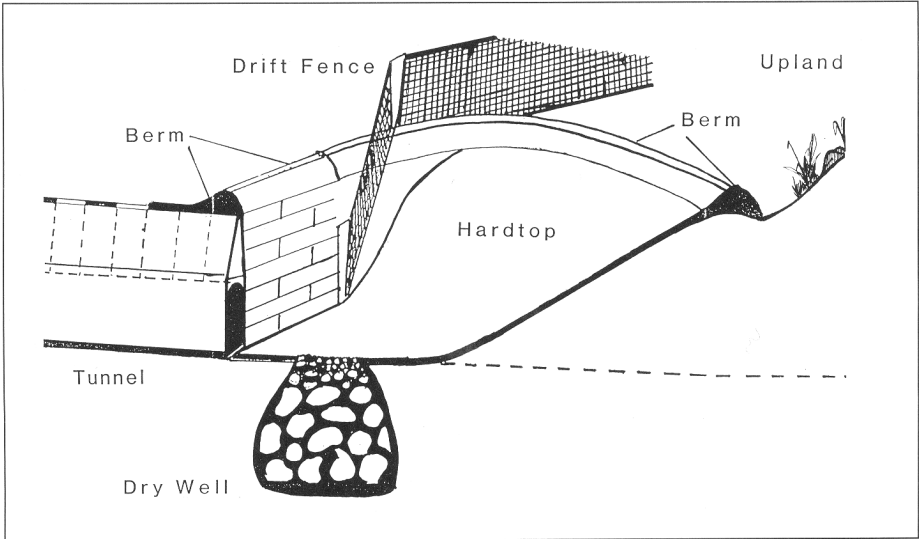


Figure 1. Cross-section of a tunnel entrance.



Figure 2. Tunnel entrance at Henry Street.

Effectiveness of drift fences

We designed drift fences on the upland side of the road, to angle out from each tunnel. Landowner considerations did not allow for this design on the pond side and a straight fence was used instead. Due to time constraints we decided to concentrate only on the upland fence this year.

The upland fence consisted of four wings (Figure 3), A and B, which led to the north tunnel, and C and D leading to the south tunnel. Each wing was divided into three sections, each about 10 m long. Migrating salamanders were counted and the wing and section where they first encountered the fence was recorded.

Salamanders were marked either with paper dots, number and colour-coded for wing and section, or identified by charting their distinctive spot patterns. Paper dots (punched from IBM cards) were glued into place with cyanoacrylate (super-glue) (Figure 4). A dot with a small amount of glue could be applied with forceps so as not to detain or disrupt migrating salamanders. Salamanders were counted again as they passed through the tunnels. 'Fence efficiency' was calculated as the percentage of animals encountering the fence that actually passed through the tunnels. By calculating fence efficiency for each section of the drift fence we were able to compare sections closest to the tunnels with those further away.

Effectiveness of tunnels

Salamanders were observed at the tunnel entrance to see how they reacted to the tunnel. The number of animals reaching the tunnel was counted and the number of those that passed through, as opposed to turning away, was also counted. 'Tunnel efficiency' was calculated as the percentage of salamanders reaching the tunnels that actually passed through.

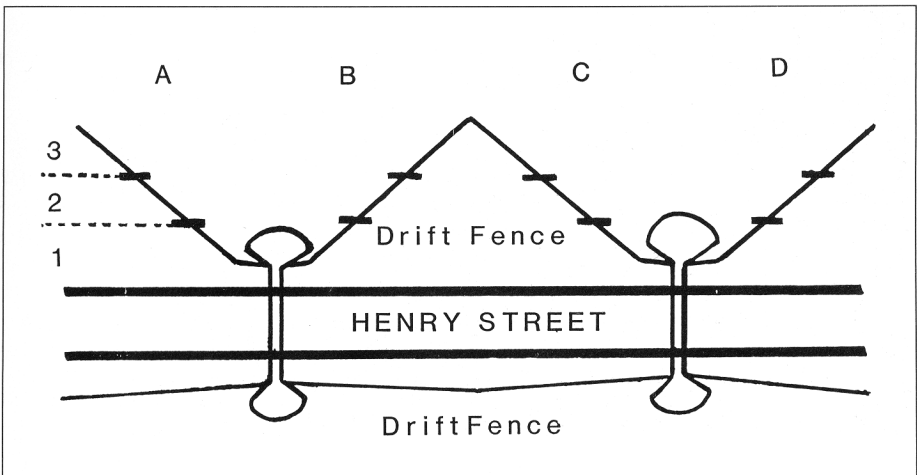


Figure 3. Henry Street drift fence plan.



Figure 4. Salamander marked with numbered paper dot.

Results

Flooding

Springtime conditions vary greatly from year to year. The amount of rain and snow meltwater, along with the depth to which the ground freezes can all affect run-off. So far, flooding has not been a problem, but continued monitoring in the next few years is necessary.

Effectiveness of drift fences

Breeding migrations were monitored on four nights in late March and early April (26/3, 1/4, 3/4, 4/4). A total of 95 salamanders were marked or identified by spot pattern. Of these, 65 (68.4%) successfully passed through the tunnels. There does not appear to be any difference in fence efficiency between marked animals (68.1%, n=69) and those identified by spot pattern (69.2%, n=26). These data were grouped together for further analyses.

Data for fence efficiency are presented in Table 1. Fence efficiency for wings varied from 64% (D, n=25) to 76.9% (A, n=13). Surprisingly, among sections, fence efficiency was lowest for animals that encountered the fence closest to the tunnels (Section 1: 65.6%, n=61).

Effectiveness of tunnels

Eighty-seven salamanders were observed at the tunnel entrance. Of those, 66 (75.9%) passed

Table 1. Drift fence efficiency by wing and section

Wing	Section (distance)			Total %
	1	2 (recapture/marked)	3	
A	7/9	3/3	0/1	76.9
B	16/25	3/3	7/10	68.4
C	7/9	3/6	3/4	68.4
D	10/18	4/5	2/2	64.0
Total %	65.6	76.5	70.6	68.4

through. Salamanders that did not go through generally hesitated before the entrance and then turned back. Even among those animals that passed through, several hesitated at the entrance, sometimes turning away and returning several times before going through. Several possible explanations exist for this 'tunnel hesitation', including differences in temperature, humidity or light, air flow or human disturbance.



Figure 5. Breeding pond for spotted salamanders and wood frogs.

Discussion

The Henry Street Tunnel Project appears to have been a qualified success so far. Design modifications have worked to prevent flooding and salamanders did use the tunnels. Although our study gave the fences an efficiency of 68.4%, the actual efficiency was probably higher. Salamanders generally migrate only when conditions are right. If the rain stopped on migration nights, salamanders stopped migrating. Five nights separated the first (and largest) sampling night from the second. It is probable that some of our marked animals moved undetected through the tunnels on these nights. Other animals were observed climbing over fences and bypassing the tunnels. Design changes this year should reduce the number of animals bypassing the tunnels.

Generally the drift fences seem well suited-to salamander use. Only one individual crossed from one set of fences to pass through the other tunnel, indicating that the fences did not cause much confusion or random movement. It also appears that spotted salamanders will readily move 30 m along a drift fence, and that distance is not a serious problem.

The tunnels also performed well, though 'tunnel hesitation' is a real concern. Temperature and humidity differences are possible explanations for the hesitation, as is air flow. Light may also be involved. In order to prevent flooding, the tunnel vents were sealed approximately 0.5 m from each entrance. It is possible that darkness at the tunnel entrance created a problem. Another possible explanation is human disturbance. Thanks to an over-abundance of publicity about the project, an estimated 200 spectators showed up on the largest migration night.

One other concern arose from this year's work. Spotted salamanders commonly share breeding habitats with wood frogs *Rana sylvatica*, and such is the case at Henry Street (Figure 5). Numerous wood frogs were observed along the drift fences, but almost none passed through the tunnels. It is possible that while the tunnels and drift fences are helping salamanders, they are also creating a barrier to wood frog migrations. This is certainly something that deserves careful study.

In the short term we have several objectives for research in the next year or two:

1. Evaluate the adjusted drift fence design;
2. Assess the effectiveness of tunnels and drift fences for young-of-the-year salamanders;
3. Investigate explanations for tunnel hesitation.
4. Assess use of tunnels by wood frogs.

In the long term, this research has the opportunity to explore several issues related to tunnel projects in general:

1. The effectiveness of a variety of drift fence designs;
2. The design of permanent drift fences.
3. The usefulness of tunnels for research (i.e. population studies);
4. The appropriate use of tunnels for mitigation.

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Discussion

Zuiderwijk: Was the effectiveness of the fence measured by the percentage of recaptures?

Jackson: It is the percentage of animals that encountered the fence that actually passed through the tunnel. So it is not the effectiveness in terms of the whole population, only the effectiveness of the fences for those animals that encountered them.

Zuiderwijk: Where were the salamanders captured, at the entrances to the tunnels or along the fences?

Jackson: At the entrances to the tunnel, on the entrance path. Those were the animals that we considered marked and those that came through the tunnel were considered recaptured. All salamanders passed through in less than five minutes. The tunnel is only about 7 m long, but there was no hesitation once they got inside; they went right through.

Zuiderwijk: You marked the animals to monitor their migration; did you catch animals for a second time along the fence that were going in a different direction to that when first encountered?

Jackson: Only rarely, most animals encountered the fence and moved directly to the tunnels, and if they did not move towards the tunnels it was usually because they either climbed over or under the fence, or stopped migrating because the rain stopped. There were no signs in our observations that there were any problems with the fences.

Reading: Do you think it is possible that the salamanders that passed through the tunnel and were therefore not being killed on the road and subsequently breeding in the pond will lead to a higher concentration of larvae in the pond, which will then increase intraspecific predation?

Jackson: I do not expect that to be a problem because other studies on *Ambystoma maculatum* in the USA indicate that the number of young-of-the-year that leave the pond tends to be relatively constant regardless of how many adults come to the pond. The determining factor in recruitment is the persistence of the pond, whether it holds water long enough, and food space, because they will consume the available food and consume each other until they reach what seem to be similar densities from one year to the next.

Reading: If the densities are, as you say, constant, might additional adults have no effect on the population?

Jackson: True, except that if the population drops below a certain threshold, in which case the population would decline. We do not know what that threshold is. At this point we have chosen the spotted salamander as a species that can tolerate some experimentation and we hope to apply the same techniques to rarer salamanders and maybe, anurans and turtles in the future.