Experimental tests of tunnel and barrier options for reducing road mortalities of freshwater turtles

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INTRODUCTION

Road mortality is believed to be one of the primary factors causing turtle populations to decline. Turtles are extremely vulnerable to road mortality because their life history includes low annual recruitment, high adult survival, and delayed sexual maturity (Congdon et al. 1993, 1994). A 2-3% additive mortality caused by vehicle collisions is suspected to be more than most turtle populations can withstand and still maintain positive population growth rates (Gibbs & Shriver 2002).

Passage systems that facilitate the safe movement of turtles under roads are one way of mitigating this problem. Few experimental studies that have evaluated the factors affecting passage use by turtles and other reptiles. Our research has focused on using behavioral trials to identify cost effective structures that allow turtles to safely move between habitats bisected by roadways.

Figure 1: study species

OBJECTIVES

1.) Evaluate variations of tunnel opening size, length, and light levels on movement behavior of painted turtles, Blanding's turtles, and spotted turtles.

2.) Evaluate variations of fence opacity, fencing entrance angle, and septum use on movement behavior of painted turtles , Blanding's turtles, and spotted turtles.

STUDY DESIGN AND METHODS

At outdoor laboratories, we examined the movements of painted turtles in response to varying light levels, tunnel size, tunnel entrance design, and barrier opacity during 2007 and 2009-2011. The response of Blanding's turtles and spotted turtles was examined for a reduced set of these variables in 2011. A factorial experimental design was used to test for effects of (1) tunnel lighting and size, (2) artificial lighting, and (3) guidance structure characteristics, that included tunnel entrance septa, angle of fencing, and opacity of barriers. Behaviors of turtles were quantified both as binomial responses (success/fail), and continuous responses (total time for the turtle to complete the trial, total number of hesitations at the tunnel entrance, as well as rate and distance of travel) (Table 1, Table 2).

TUNNEL TESTING

Table 1: Response and predictor variables.

Response variables	Predictors (categorical)	Predictors (continuous)
Completion (in ≤ 60 minutes)	Age, sex, gravidity	Body size
Rate of travel in culvert	Capture location	Temperature
Total time	Pen behavior, start position	Time - hour, day
Total # of hesitations	weather	

Figure 2: Tunnel types

Figure 3: outdoor tunnel laboratory

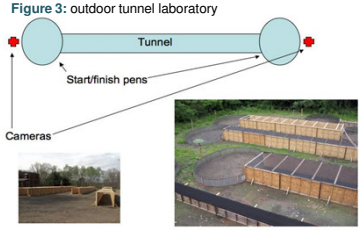


Figure 4: artificially illuminated culvert

TUNNEL RESULTS

1001 painted turtles, 54 Blanding's turtles and 50 spotted turtles have been tested in our culvert labs.

- Lighting level: level of ambient light permitted to enter from overhead was the most significant predictor of trial completion for all 3 turtle species.
- Artificial lighting: completion significantly increased for painted turtles.
- Probability of completion decreased with an increase in culvert length.
- Painted turtles were more hesitant to enter tunnels that were below grade.
- Simulated highway median had no effect on passage of painted turtles.

Table 2: Percentage of painted turtles (red) that successfully passed through experimental tunnels.

Culvert length	tunnel opening size	% available light transmitted		
		100%	75%	0%
40'	2'x2'	100%	100%	56%
	4'x4'	92%	81%	60%
	4'x8'	96%	96%	70%
80'	2'x2'	88%	92%	31%
	4'x4'	88%	81%	54%
	4'x8'	79%	77%	52%

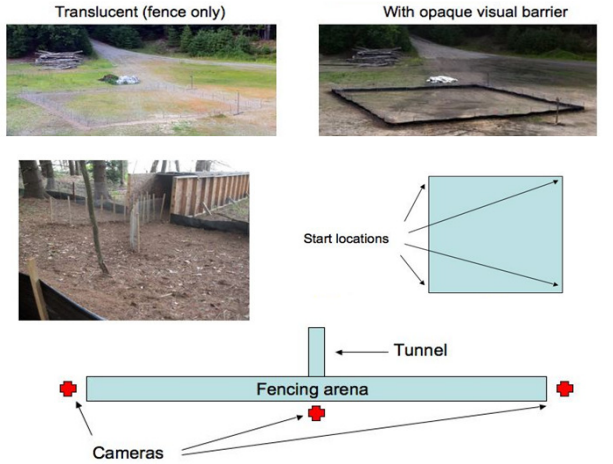
Table 3: % of turtles that successfully passed through experimental tunnels (2' x 2' x 80' culvert).

	0% available light	100% available light
Spotted turtles	0%	68%
Blanding's turtles	8%	89%
Painted turtles	30%	89%

FENCE AND ENTRANCE TESTING

Table 4: Fencing response and predictor variables.

Response variables	Predictors (categorical)	Predictors (continuous)
rate of travel	Age, sex, gravidity	Body size
total distance traveled	Pen behavior, start position, capture location	Temperature
time until give up (1 hr max)	weather	Time - hour, day



FENCING RESULTS

A total of 203 individual painted turtles, 54 Blanding's turtles and 50 spotted turtles have been tested in our fencing laboratories.

- Barrier opacity: for all species tested, an increase in opacity increased the rate of travel.
- Septa and angle of the fencing entrance: did not affect completion rates for painted turtles.

CONCLUSIONS

- % completion of trials increased as light permitted to transmit through the tops of tunnels increased for painted turtles.
- Light level was very important for all 3 turtle species tested.
- Artificial lighting nearly as effective as 100% available light. Artificial lighting may be viable alternative or a means of retrofitting existing culverts with inadequate lighting levels.
- A visual barrier may be used to direct turtles swiftly to passage entrances.