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Road mortality of turtles and bullfrogs during a major flood

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Abstract. Flood induced road-mortality of wildlife is a poorly studied and understood phenomenon. In 2008, the worst flood since 1973 hit the Arkansas Delta. I previously surveyed road-killed amphibians and reptiles along interstate 40 from West Memphis to Little Rock in 2002 (189.9 km). In 2008, I re-surveyed this road and added surveys of I-44 (28.2 km) and I-30 (218 km) in Arkansas. Turtle mortality on I-30 was 15.5 times greater in 2008 (n = 124) than in 2002 (n = 8). It was 413% higher on I-40 than on I-30. I-440 only had 1 dead turtle. Species composition of road-kills in 2002 was different from in 2008. It appears that the extreme flood of 2008 forced many turtles onto the road for uninvestigated reasons. This movement resulted in unusually high road mortality. This information will be important for conservationists and planners as they deal with the extension of our highway system to serve the public's transportation demands.

Keywords. Turtles, Chelonia, road mortality, flood mortality.

Introduction

Wildlife road mortality is an area of increasing interest within the conservation community (Lode, 2000, Ray, Preston and McCallum, 2006, Shepard et al., 2008a). The numbers of wildlife casualties on roads and railways have consistently grown as traffic, vehicle speeds, and their infrastructure networks have increased (Seiler, Helldin and Seiler, 2004). In fact, about 15-20% of the United States is ecologically impacted by roads (Forman and Alexander, 1998). Amphibians and reptiles are especially vulnerable to road mortality (Forman and Alexander, 1998; Coleman, Ford and Herriman, 2008; Glista, DeVault and DeWoody, 2008). Most studies with herpetofauna involve fairly small stretches of roads that are studied intensively (see Ashley and Robinson, 1996 Ray, Preston and McCallum, 2006, and Glista, DeVault and DeWoody, 2008). Road mortality of amphibians and reptiles may be associated with adjacent roadside vegetation and seasonal patterns of mortality may follow life history phenology (Ashley and Robison, 1996, Shepard et al., 2008b). Furthermore, more vagile species of amphibians and reptiles are probably more susceptible to road mortality because they must often cross roads during their travels (Carr and Fahrig, 2001).

Reports of flood induced mortality of organisms include mussels (Hastie et al., 2001), birds (Sidle et al., 1992), large mammals (Alt, 1984, Nicholson and Hill, 1984, Foster, 1995). However, our understanding of how floods and roads interact to affect wildlife mortality is paucid. In 2008, Arkansas experienced its worst floods since 1973 (Pouge, 2008a). The flood in the Arkansas Delta started around 19 March 2008 and did not begin to recede until 24 April 2008 (Pouge, 2008b). The floodwaters in the Arkansas Delta forced residents from their homes and left agricultural fields inundated with water. This was particularly evident along the stretch of Interstate 40 between Memphis, Tennessee and Little rock Arkansas (Fig. 1).

After seeing many uncounted dead and injured turtles on the highway between on I-40 between Mississippi River and the highway's junction with I-55, I asked if road mortality due to the flood was similar to the mortality observed in May 2002. I hypothesized that the extensive flooding induced increased road mortality of turtles and predicted that if this was true, mortality in 2008 should significantly exceed the mortality observed in 2002. If flooding did not affect mortality, there should be no statistical difference between years.

Materials and Methods

I counted turtles killed on the highway in 2002 and again in 2008. On 16 May 2002 I drove west on Interstate 40 from its junction with Interstate 55 near West Memphis (35.17249° N, 90.19084° W), Arkansas to its junction with Interstate 440 near Little Rock, Arkansas (Fig. 1; 34.77522° N, 92.24375° W; distance = 189.9 km). This stretch crossed the entire Arkansas Delta region which was flooded in 2008. This transected 14 lowland rivers (Fig. 1). On 12 April 2008, I counted turtles along this same route again. Then, I counted turtles along I-440, from its junction with I-40 to its junction with Interstate 30 (Fig. 1; 34.71120° N, 92.26559° W; distance = 28.2 km). The flooding also affected this area, but much less severely. Also, this section of road had con-

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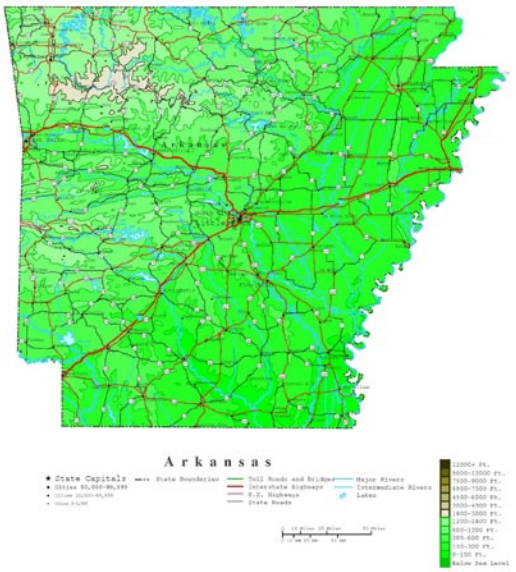

Figure 1. Study area showing I-30, I-40, I-440, major rivers and forests in Arkansas.

crete barriers on both sides suggesting that most wildlife could not cross. Finally, in 2008 I counted turtles along I-30 from its junction with I-440 to 33.48021° N, 94.00416° W near the Texas-Arkansas border in Texarkana, Arkansas (Fig. 1, distance = 218 km). This road crossed 11 major rivers along its extent (Fig. 1) and transects upland areas of the southern edge of the Ouachita Mountains. I compared the number of turtles killed in 2008 on I-40 to the number killed in 2008 on I-30, and to the number killed in 2002 on I-40 using Chi square ($\alpha = 0.05$).

Results

There were 124 (0.65 turtles/km) on I-40 in 2008 versus 8 (0.04 turtles/km) in 2002. In 2008, I-30 had 3 (0.01 turtles/km) and I-440 had 1 (0.03 turtles/km) killed. Road-killed turtles were in all observations (Fig. 2). However, there were differences among the transects ($\chi^2 = 206.9$, df = 2, $P < 0.000001$). I-40 had more road-killed turtles in 2008 than in 2002 ($\chi^2 = 101.04$, df = 1, $P < 0.000001$), and more in 2008 than found on I-30 in 2008 ($\chi^2 = 115.28$, df = 1, $P < 0.000001$). There was no difference in the number of road-killed turtles observed on I-30 in 2008 than seen on I-40 in 2002 ($\chi^2 = 2.27$, df = 1, $P < 0.13$). A different assemblage of turtles was road-killed in 2008 than in 2002 and different species assemblages were observed on the different roads (Table 1). *Terrapene carolina triunguis* Agassiz, 1857 (Three-toed Box Turtles) dominated the counts in 2002, but *Trachemys scripta* (Wied-Neuwied, 1839) (Red-eared Turtles) and *Pseudemys concina* (LeConte, 1830) (River Cooters) were most common in 2008. Additionally, large adult *Lithobates catesbeianus* (Shaw, 1802) (Bullfrogs) were observed along I-40 in 2008 but in no other years. Large *Apalone spinifera* Lesueur, 1827 (Spiny Softshell Turtle) were found road killed along I-40 in 2008, but in no other year. Only one dead turtle was observed on I-440, this was at the end of the on-ramp from I-40.

Discussion

These results demonstrate that the exceptional flood of 2008 that occurred in the Arkansas Delta may have stimulated exceptional road-mortality along I-40 during its two-month inundation. I desired to make additional surveys on I-40, but other obligations for time and money precluded this from taking place. However, observations of flood-induced road-mortality of amphibians and reptiles are few, although some studies demonstrate interactions between this in other wildlife and road-stream intersections (Chanin, 2006), incidentally with floods (Foster and Humphery, 1995), and drought (Roe and Georges, 2006). It is vital that these kinds of data be reported, especially in light of predicted increases in dramatic floods due to extreme weather events associated with climate change (IPCC, 2007).

Bullfrog road mortality was a secondary observation during this study. I did not observe this species on any other trip, suggesting that the floods increased their susceptibility to road-mortality. These four frogs were very large adults. Considering the extent of the flood waters, it is certainly believable that many more small frogs moved onto the highway but that their mortality went undetected.

I lumped observations of River Cooters and Red-eared Turtles because these were often indistinguishable while driving unless the turtle was lying on its carapace, but it was not always possible to stop and identify turtles

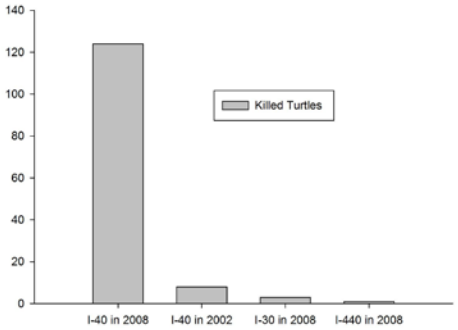

Figure 2. Turtle mortality along I-40 in 2002, and on I-40, I-30 and I-440 in 2008.

Table 1. Species of turtles and bullfrogs killed along Arkansas Highways in 2002 and 2008.

I-40, 16 May 2002	I-40, 12 April 2008	I-440, 12 April 2008	I-30, 12 April 2008
6 *Terrapene carolina* 1 *Chelydra serpentina* 1 *Trachemys scripta*	116 *Trachemys* and *Pseudemys* sp. 4 *Apalone spinifer* 3 *Chelydra serpentina* 1 *Terrapene carolina* 4 *Lithobates catesbeianus*	1 *Trachemys scripta*	3 *Trachemys scripta*
Total: 8 turtles	Total: 124 turtles, 4 bullfrogs	Total: 1 turtle	Total: 3 turtles

while driving on the interstate. However, I have high confidence of the identity of other species because I stopped for almost all other turtles to obtain a positively identity.

My observations of turtle mortality are clearly underestimates of what was actually killed along these stretches of highway, but this is typical of these kinds of studies (NRCS, 2007). I know that some turtles were missed due to traffic conditions, and am certain that many small turtles were missed. I recall on several occasions seeing a small turtle-like object that I was unable to identify due to traffic. These observations were not included in my tallies. Therefore, flood-induced road-mortality was probably at least somewhat higher than reported here. Additionally, the traffic during 2002 and on I-30 in 2008 was not as severe, allowing me to stop for most turtles. Therefore, I am confident that the observations made in 2002 and on I-30 in 2008 had higher levels of detectability than did the observations on I-40 in 2008. This suggests that differences in road-mortality on I-40 between 2002 and 2008 represented low estimates of differential mortality.

Although I-440 was only a small stretch of road, it constitutes an important observation. I-440 loops south around Little Rock, Arkansas and crosses the Arkansas River. Despite the flooding here, no road mortality was observed except on the on-ramp. I-440 has barriers on both sides along this road-segment and clearly prevented turtles from transecting the road. Although such barriers may have negative influences as dispersal barriers, it appears they may have important positive roles in turtle conservation.

Assuming that the mortality I observed was representative of the total mortality taking place in a week, in excess of 1000 turtles (124 turtles × 10 wks) may have perished along I-40 during the extensive 2008 flood. However, it is more likely that observed road mortality was representative of a shorter time period because most of the turtles appeared to be unscavenged and various wildlife (e.g. *Dasypus novemcinctus* L. [Nine-banded Armadillos], *Procyon lotor* L., [Raccoons], and *Didelphis virginiana* Kerr, 1792 [Virginia Opossums]) in this region forage on, and remove from roadways, road-killed small animals such as turtles very shortly (< 2-3 days) after vehicle collision (pers. observ.). Regardless, the dramatic differences observed in this study between flood-affected highways and non-affected roadways are dramatic. Considering the many threats facing amphibians (McCallum, 1999; 2007; 2010; McCallum and Trauth, 2003) and turtles (McCallum, McCallum and Trauth, 2009) it is important to understand how natural phenomena interact with human actions to impact wildlife resources (Bury, 2006, McCallum and McCallum, 2006). This information should be used by planners and conservationists when addressing road-wildlife conflicts in the future.

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