Notes of the *Southeastern Naturalist,* Issue 16/3, 2017

Survival of Salamanders in a Severe Flood Event in Louisiana

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Abstract - In August 2016, a park of roughly 200 ha of bottomland hardwood forest in East Baton Rouge Parish, LA, was inundated by up to 5.28 m of water for 5 days in one of southeast Louisiana's most severe floods in recorded history. Here, I document post-flood observations of a terrestrial salamander species at the park, *Ambystoma opacum* (Marbled Salamander). To my knowledge, this is the first documentation of survival of terrestrial salamanders after a freshwater flood event. As such floods are predicted to increase in frequency in the future, it is encouraging that salamanders may be able to tolerate such changes to some extent.

Louisiana has 22 native salamander species (Mitchell and Gibbons 2010). Seven (32%) of those species are protected by the Louisiana Department of Wildlife and Fisheries (LDWF) as Critically Imperiled (LDWF 2017). In addition, LDWF (2017) notes that many of these species are declining in Louisiana due to habitat modification or destruction, as well as pollution of water from agricultural runoff. Bottomland hardwood forests are characterized by alternating wet and dry seasons with regular flooding. In the Mississippi River Alluvial Plain region of southeastern Louisiana, bottomland hardwood forest is the predominant ecosystem type (Holcomb et al. 2015) and is the primary habitat for many of the state's salamander species (Mitchell and Gibbons 2010). The persistence of salamander populations in this region is therefore dependent upon bottomland habitat availability and its climate and flooding regime.

Seasonal flooding from river overflow is a defining feature of bottomlands (Kellison and Young 1997). However, in August 2016, the region experienced one of the most severe flood events in its recorded history. On 12 August 2016, the National Weather Service recorded 28.55 cm of rain at the Baton Rouge Metropolitan Airport station in Louisiana, compared to a normal average daily rainfall for August of 0.48 cm (NOAA 2016). This was 4 times greater than the previous record rainfall for 12 August and the second-largest 1-day rain on record (NOAA 2016). Due to this extreme rain event, area rivers rapidly rose and caused catastrophic flooding in East Baton Rouge and adjacent parishes. At the Denham Springs gauge, the Amite River crested at 14.08 m on 14 August 2016, breaking the previous record of 12.65 m (USGS 2016a); the Comite River at the Joor Road gauge crested at 10.43 m on the same date, breaking the previous record of 9.45 m (USGS 2016b). At the confluence of the Amite and Comite rivers in East Baton Rouge Parish is Frenchtown Road Conservation Area, a park of roughly 200 ha of bottomland hardwood forest habitat, maintained by the Recreation and Park Commission (BREC) of East Baton Rouge Parish (Fig. 1). The average elevation of Frenchtown is 7–8 m, and most of the park was flooded, with the exception of the highest elevations (Amanda Takacs, BREC, Baton Rouge, LA, pers. comm.).

Members of the North American Field Herping Association (NAFHA) had previously observed 3 species of terrestrial salamanders at Frenchtown: *Ambystoma opacum* (Gravenhorst) (Marbled Salamander), *Ambystoma talpoideum* (Holbrook) (Mole Salamander), and *Plethodon mississippi* Highton (Mississippi Slimy Salamander) (NAFHA 2012). The ability of local salamanders to survive such an extreme flood event was unknown. High discharge and debris during flood events have been associated with mortality of stream-

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Manuscript Editor: Kristen Cecala

dwelling amphibians (Cover et al. 2010), and similar dangers would presumably exist for terrestrial salamanders caught in overflowing rivers. In addition, hurricane storm surge has been shown to decrease abundance and community diversity of anuran species in coastal Louisiana ecosystems (Schriever et al. 2009), though those declines may have been caused at least in part by increases in salinity (but see Gunzburger et al. 2010).

On 22 October 2016, I conducted the first of 2 preliminary, partial surveys of Frenchtown to determine whether or not any salamanders had survived the flood. Due to time limitations, I did not do a full survey of the entire park. The delay of 2 months between the flood and the first survey was due to temporary closure of the park from flood damage, as well as life-history timing of the local salamanders. In particular, the high air temperatures of late summer and early fall in southeastern Louisiana greatly reduces the chance of finding salamanders on the surface. On 22 October 2016, I found 2 adult female Marbled Salamanders guarding eggs under the same log (30°28'44.4", -90°59'2.4"; elevation 8.8 m; Fig. 1). During the flood, this site was under up to 5.28 m of water for ~5 days (Fig. 2). While it is possible these salamanders traveled from a nearby site that was less extensively flooded, all areas within a reasonable dispersal distance had some level of flooding; even 0.5 m of water is enough to fully submerge the salamanders. In a second survey on 6 November 2016, I found an additional 2 Marbled Salamanders at the same site. Based on color pattern, these were clearly different individuals from those found in the first survey. I did not find any Mole Salamanders or Mississippi Slimy Salamanders; however, because other species of ambystomatid and plethodontid salamanders were found, the failure to find Mole Salamanders and Mississippi Slimy Salamanders is probably due to lower abundance of

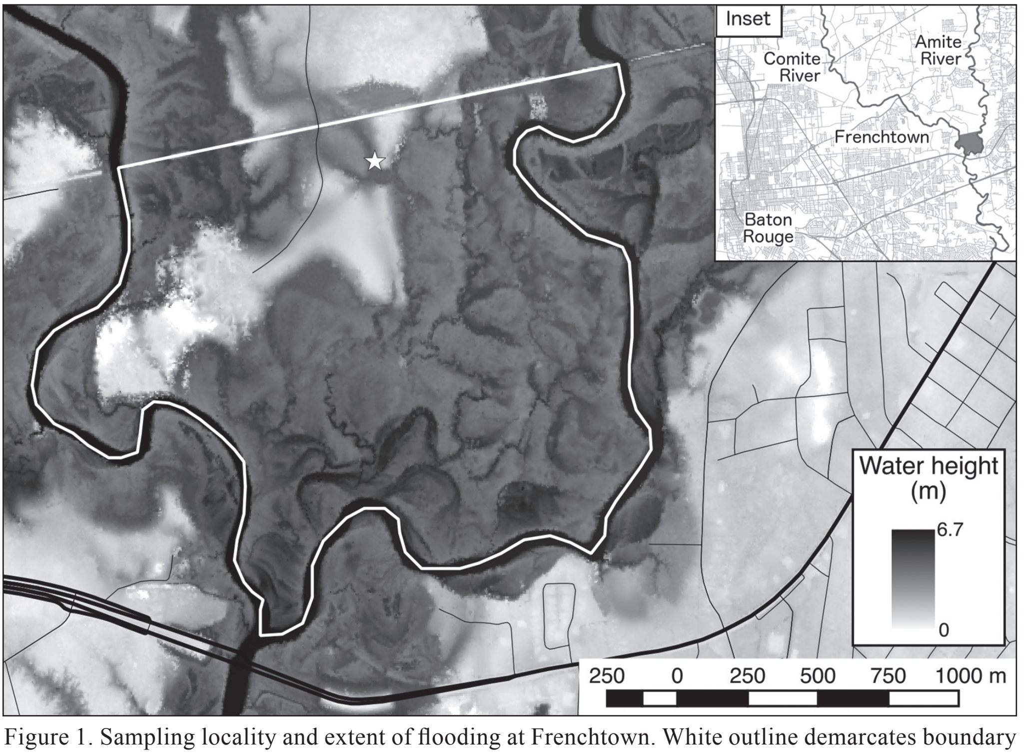

Figure 1. Sampling locality and extent of flooding at Frenchtown. White outline demarcates boundary of Frenchtown Road Conservation Area. Star indicates locality for *A. opacum* (Marbled Salamander) observations. Black lines represent roads. Inset: location of rivers and Frenchtown relative to the greater Baton Rouge area.

those species in general, rather than an effect of the flood on those species to the exclusion of the others. Furthermore, although the system was not closed to migration, dispersal distances reported for these species in the literature are very small (e.g., average of 0.4 km for Marbled Salamanders; Gamble et al. 2007), and the park is bounded by 2 rivers and development. Therefore, I believe immigration into Frenchtown during the 2 months preceding the surveys is highly unlikely.

These surveys do not provide any insight into the mechanisms of survival. However, onset of flooding at Frenchtown was sudden and worsened rapidly; in the first 24 h, the waters of the Amite River at Frenchtown rose by 4.75 m (Fig. 2). Given the limited vagility of salamanders and extent of flooding at Frenchtown, it is unlikely they would have been able to escape to higher ground. Studies have shown that lungless salamanders (family Plethodontidae) can tolerate full submersion in water without access to buccopharyngeal aerial respiration for at least 2 weeks with no apparent negative effects (Gatz and Piiper 1979, Gatz et al. 1974, Whipple 1906a). However, lunged terrestrial salamanders such as the Marbled Salamander appear to be less able to survive long periods underwater,

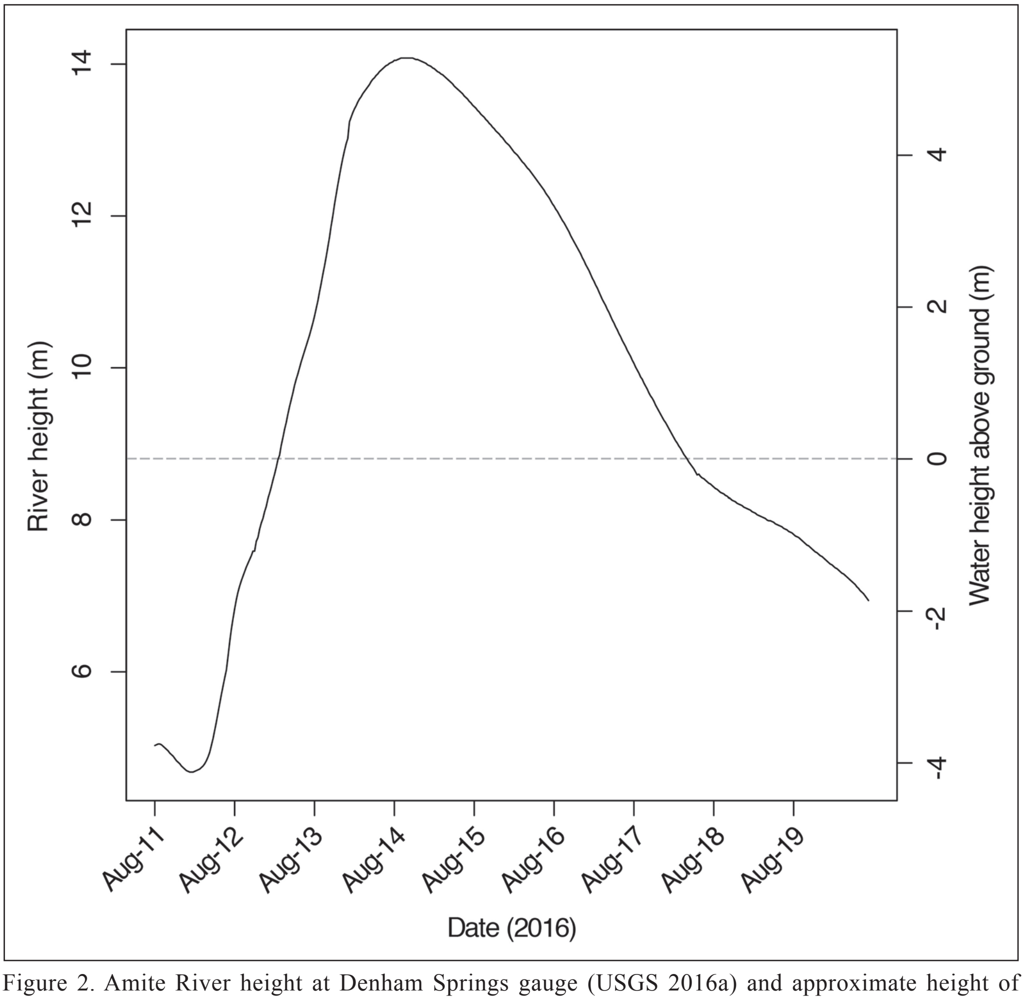

Figure 2. Amite River height at Denham Springs gauge (USGS 2016a) and approximate height of water above ground level at site where salamanders were found on 22 October 2016. Gray dashed line denotes ground level.

though it is not clear if survival varies among species. Whipple (1906b) showed that mortality in Marbled Salamanders occurs "in a short time" if restrained in water without access to air. Wojnowski (2000) also noted that Marbled Salamanders must escape to higher ground or drown during floods. While lunged salamanders can use hydrostatic mechanisms to float near the surface, providing access to air (Ultsch et al. 2004, Whipple 1906b), any such floating salamanders would have been transported away from Frenchtown by the current.

It is therefore most likely that the salamanders at Frenchtown survived the flood in underground burrows. There is some evidence that terrestrial salamanders may use existing burrows, often those made by small mammals (Douglas and Monroe 1981, Welsh and Droege 2001), to prevent desiccation during very warm and/or dry periods. *Ambystoma* in particular are rarely seen during July and August in southeastern Louisiana and typically do not emerge before the fall breeding season. The flood event occurred prior to the breeding season for both *Ambystoma* species (AmphibiaWeb 2016), so most adults may have been sheltering in burrows. Presumably, the salamanders could have survived underground if they were able to plug burrow entrances, as observed for rodents (Vorhies and Taylor 1922) and beetles (Lin and Okuyama 2014). Nevertheless, regardless of mechanism, it is important to document this survival of a lunged salamander species after an extreme flood event, particularly because data predict that such events will increase in frequency due to climate change (van der Wiel et al. 2017). Salamander populations inhabiting bottomland hardwood forest habitat may be able to tolerate changes in flood cycle periodicity or severity, at least to some extent.

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