RIPARIAN HABITAT OF STREAMS USED FOR BREEDING BY THE STREAMSIDE SALAMANDER (*AMBYSTOMA BARBOURI*) IN MIDDLE TENNESSEE

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Abstract.— The Streamside Salamander (*Ambystoma barbouri*) is a stream-breeding ambystomatid that occurs in southeastern Indiana, southern Ohio, and central Kentucky, with disjunct populations forming the southern portion of the range in the Central Basin (CB) of Tennessee. Because of limited geographic distribution and association with low order, ephemeral streams that generally flow through hardwood forests, this species is under consideration by the US Fish and Wildlife Service for protection under the Endangered Species Act. The CB of Tennessee is a mosaic of habitat types with relatively small patches of forest interspersed amidst agricultural and residential lands, and many of the low-order streams have little, if any, riparian habitat that is forested. We characterized riparian habitat of 14 low-order streams in the CB that were used for breeding during the 2007–2008 and 2008–2009 seasons as forest, agriculture, or residential land. We calculated the percent coverage of these three habitat types in an area that extended 250 m and 500 m from the length of each section of stream in which we counted eggs. Riparian habitat was dominated by agricultural land (pastures and row crops), although at least a small amount of forest cover was found near most streams; thus, terrestrial stages of the Streamside Salamander likely inhabited agricultural land in the CB. Residential land was less prevalent in the vicinity of breeding sites than either agricultural land or forested land. Middle Tennessee, including the CB, is experiencing significant human population growth, a trend predicted to continue for at least the next two decades. The conversion of much of the agricultural and forested lands in the region into subdivisions potentially will negatively affect local populations of this species of conservation concern.

Key words. — abundance**,** Central Basin, conservation, distribution, egg counts, population density, reproduction, terrestrial habitat.

The Streamside Salamander, *Ambystoma barbouri* Kraus and Petranka (1989), is a stream-breeding member of the Family Ambystomatidae (the Mole Salamanders) with a contiguous distribution extending from southeastern Indiana and southwestern Ohio into central Kentucky. Isolated populations occur in western and south-central Kentucky, southwestern West Virginia, and the Central Basin physiographic region (CB) of middle Tennessee (Scott et al. 1997; Petranka 1998; Niemiller et al. 2006; Niemiller et al. 2011; Anderson et al. 2014; Lockwood et al. 2016). The species is of conservation concern in most states it inhabits (NatureServe 2015. Available from http://explorer.natureserve.org [Accessed 22 February 2017]), and the IUCN lists the species as near threatened (Hammerson 2004). The Streamside Salamander is deemed in need of management by the Tennessee Wildlife Resources Agency (TWRA; Withers 2009), a state conservation listing used, in part, for species with either poorly understood distributions or unknown habitat needs, both types of information deemed vital for proper conservation and management (Withers 2009).

Streamside Salamanders breed in low-order streams from late fall through winter (Petranka 1984a). Many adults migrate to the streams during fall before the breeding season, and presumably live in burrows in the streambank while preparing for courtship (Petranka 1984a). Relatively little is known about terrestrial activities outside of the breeding season, but Petranka (1998) has found adults up to 400 m from streams, and he suggests that juveniles probably travel similar distances away from their natal stream. Regardless, the terrestrial stages are fossorial and inhabit burrows in the floor of hardwood forests (Petranka 1998).

Petranka (1998) indicates that terrestrial stages of the species require forested habitat adjacent to breeding streams. Although relatively little is known about population trends of the Streamside Salamander in middle Tennessee, Niemiller et al. (2009) suggest that populations are declining because of deforestation and residential development of the terrestrial landscape adjacent to streams used for breeding. Furthermore, because the Central Basin is a mosaic of habitat types, including small forest tracts interspersed among agricultural fields (pastures and cropland), cedar glades, and residential areas (urban and suburban areas) (Goodhue et al. 2000, Augustin et al. 2005), many of the low order streams flowing within the CB are not bordered by forested land. The objectives of our study are to characterize riparian habitat of streams used for breeding by the Streamside Salamander in the southern edge of its range and to compare number of females breeding, based on number of both egg masses/m and eggs/m of stream surveyed, among breeding sites with different types of riparian habitats.

METHODS AND MATERIALS

Streams surveyed—. To locate streams used for breeding by the Streamside Salamander, we searched for eggs, larvae, juveniles, and adults approximately 50 m upstream and downstream of road crossings of select low-order streams in southern Rutherford, northern Bedford, northeastern Marshall, eastern Maury, and southeastern Williamson counties from December 2007 through April 2008, and from December 2008 through April 2009 (Fig. 1). If we located eggs, we would continue to search the stream until we no longer encountered eggs for a distance of approximately 50 m. We selected streams based on site access and on

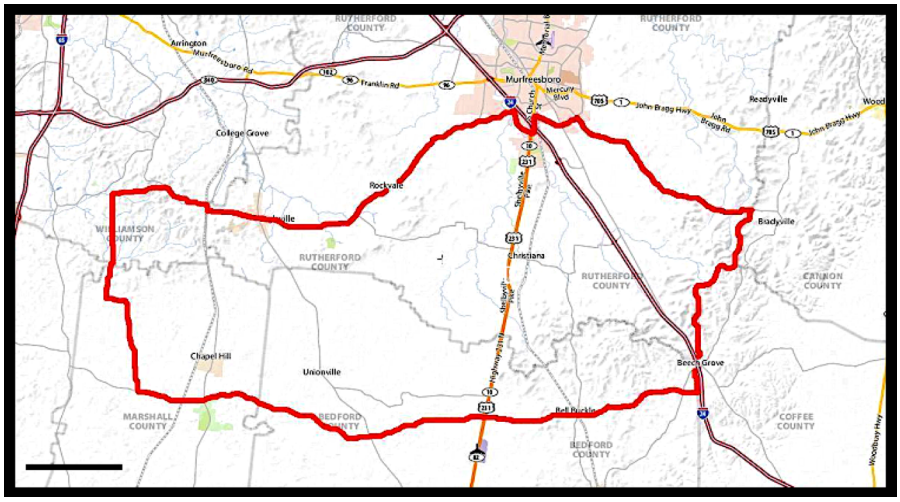

Fig. 1. The area bordered by the red polygon indicates the section of the Central Basin physiographic region in which we searched low-order streams for eggs, larvae, and adult Streamside Salamanders (*Ambystoma barbouri*) during either the 2007–2008 or the 2008–2009 breeding seasons.

similarity and proximity to known breeding sites reported by Niemiller et al. (2006). All streams that we searched were clear and ephemeral, and either became reduced to isolated pools or flowed underground during summer and fall.

Relative abundance of eggs and masses—. We counted eggs at six low-order streams during either the 2007–2008 or the 2008–2009 season. We lifted rocks in both pool and riffle habitats to locate eggs, larvae, and breeding adults, and rocks and other cover objects adjacent to streams to locate juveniles and adults. We carefully returned rocks and other objects to their original positions to limit habitat destruction. In these sections of streams, we lifted rocks suitable for egg deposition and checked the undersurface of the rock for the presence of eggs. We considered all eggs and embryos on the undersurface of a rock to form a single mass unless they were at distinctly different stages of development. When we found eggs and embryos at different stages of development on the undersurface of a rock, we regarded each group of similar staged embryos to represent a distinct mass. In addition to counting the number of masses, we counted the number of eggs within each mass. We counted eggs on site if the mass was relatively small; however, we photographed large masses, and those with either eggs or embryos tightly packed, with a digital camera. To accurately count eggs on digital photographs, we used the application Windows Paint (Microsoft Corporation, Redmond, Washington, USA) and placed a dot on each egg as it was counted.

Riparian habitat—. We used aerial photographs available on Google Earth to determine the length of the section of stream surveyed, and we overlaid a grid onto aerial photographs of each site to estimate the proportion of the type of riparian habitat (forested, agricultural cropland, agricultural pasture, or residential) along the length of the section of the stream in which we found eggs or larvae. Because Streamside Salamanders have been reported to travel up to 400 m from a breeding stream (Petranka 1998), we characterized riparian habitat at distances up to 250 m and 500 m on each side of the surveyed sections. We revisited each site to verify our habitat characterization based on the aerial photographs.

Statistical analysis—. We used Microsoft Excel 2016 (Microsoft Corporation, Redmond, Washington, USA) to perform four single linear regression analyses to elucidate the relationships between egg density (eggs/m of stream length) and the following potential predictor variables: % forest cover within 250 m of stream, % forest cover within 500 m of stream, % field cover within 250 m of stream, and % field cover within 500 m of stream. For these analyses, we used only egg count data from 2009 for the Lynch Hill stream to ensure data independence, as our 2008 counts were conducted after many of the egg masses had hatched. Egg masses from other sites were only counted during one field season each. We also omitted egg count data from the unnamed tributary of the Middle Fork Stones River north of Christiana Hoovers Gap Road, as the salamanders did not appear to be breeding throughout most of the stream area searched, thus potentially skewing the egg density measurement.

RESULTS

Streams used for breeding—. We found eggs, embryos, or larvae of the Streamside Salamander in eight streams in the Stones River watershed of southern Rutherford County (Fig. 2a) and in four streams in the Duck River watershed of northern Bedford County (Fig. 2b). Furthermore, we found one juvenile in eastern Marshall County.

Egg counts—. We counted eggs only from those streams where we discovered salamanders breeding early during the season, before eggs had started hatching. Consequently, our egg

(a)

(b)

Fig. 2. Aerial photograph of a portion of (a) southern Rutherford County and (b) northern Bedford County, Tennessee. Note the mosaic landscape of agricultural fields, residential developments, and forest stands of different sizes. The white ellipses encompass sections of eight low-order streams where we found Streamside Salamanders (*Ambystoma barbouri*) breeding during either the 2007–2008 or 2008–2009 breeding seasons. The length of the colored path in each circle indicates the relative length of streams searched. White scale bar in lower left of photograph is 5 km.

counts were limited to six streams (five streams in southern Rutherford County and one of the northwest Bedford County). We counted 42,804 eggs in 528 egg masses in these six streams (Table 1). We found more than half (55%) of the egg masses and just under half (45%) of the eggs in two low-order tributaries to the Middle Fork of the Stones River (Table 1; Fig. 2a). However, we found a greater density of egg masses (masses/m) and of eggs (eggs/m) in the nearby first-order tributary to the Middle Fork of the Stones River near Lynch Hill Road (Table 1; Fig. 2a).

Egg die offs—. During the 2007–2008 breeding season, we found 38 egg masses comprising 2,550 eggs in Dry Creek (Table 1), with 17 masses and 1,668 eggs in the 690 m upstream and 21 masses and 882 eggs in the 420 m downstream of Cobb Road. However, nearly all embryos we found upstream of the road were dead (white and motionless); whereas, those we found downstream of the road were living. During the 2008–2009 breeding season, we

Table 1. Egg mass data for the Streamside Salamander (*Ambystoma barbouri*) at seven streams in the Central Basin, near the southern edge of the range of the species in southern Rutherford and northern Bedford counties, Tennessee, from December 2007 to May 2009.

Stream	Number of Egg Masses	Survey Length (m)	Min – Max eggs/mass	Total number of eggs	Eggs/m
UNT Middle Fork Stones River, north of Christiana Hoovers Gap Road	5	1090	25 – 205	446	0.4
UNT Middle Fork Stones River, south of Christiana Hoovers Gap Road	288	1730	1 – 439	19,371	11.0
Long Creek	64	620	2 – 345	6,064	9.8
Dry Creek	38	1110	2 – 376	2,550	2.3
Lynch Hill 2008	44	320	8 – 270	2,516	7.8
Lynch Hill 2009	65	320	6 – 910	10,249	32.0
Dolly Branch	24	230	6 – 276	1,608	7.0
Totals	528	5,420	1 – 910	42,804	7.9

found only a few egg masses and larvae upstream of Cobb Road, and we found only one larva and no eggs downstream from the road.

Riparian habitat—. The riparian habitat varied among streams used as breeding sites by Streamside Salamanders during the 2007–2008 and 2008–2009 seasons (Table 2). Although the riparian habitat of most streams included some forest cover, the extent of this coverage varied from 10% or less to nearly 75% (Table 2). Furthermore, the type of field coverage varied based on watershed. For example, the percent field coverage of the seven streams of the Stones River watershed varied from 25% to 89%, but all of the field coverage was either old field or pasture; none of the riparian habitat was cropland in the Stones River watershed. In contrast, the field coverage of the four streams in the Duck River watershed varied from 31% to 90%, but all of the field was tilled cropland (Table 2).

Statistical analysis—. Within 125 m of streams, we found no significant correlation between egg density and % forest (n = 5, r^2 = 0.281, P = 0.358) or % field cover (n = 5, r^2 = 0.298, P = 0.342). Within 250 m of streams, we found a significant positive correlation between egg density and % forest cover (n = 5, r^2 = 0.811, P = 0.037) and a significant negative correlation between egg density and % field cover (n = 5, r^2 = 0.803, P = 0.040).