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Responses of riparian reptile communities to damming and urbanization

Stephanie D. Hunt [a], Jacquelyn C. Guzy [a,*], Steven J. Price [b], Brian J. Halstead [c], Evan A. Eskew [a,1], Michael E. Dorcas [a]

[a] Department of Biology, Davidson College, Davidson, NC 28035, USA
[b] Department of Forestry, University of Kentucky, Lexington, KY 40546, USA
[c] Western Ecological Research Center, U.S. Geological Survey, Dixon, CA 95620, USA

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ABSTRACT

Various anthropogenic pressures, including habitat loss, threaten reptile populations worldwide. Riparian zones are critical habitat for many reptile species, but these habitats are also frequently modified by anthropogenic activities. Our study investigated the effects of two riparian habitat modifications – damming and urbanization – on overall and species-specific reptile occupancy patterns. We used time-constrained search techniques to compile encounter histories for 28 reptile species at 21 different sites along the Broad and Pacolet Rivers of South Carolina. Using a hierarchical Bayesian analysis, we modeled reptile occupancy responses to a site's distance upstream from dam, distance downstream from dam, and percent urban land use. The mean occupancy response by the reptile community indicated that reptile occupancy and species richness were maximized when sites were farther upstream from dams. Species-specific occupancy estimates showed a similar trend of lower occupancy immediately upstream from dams. Although the mean occupancy response of the reptile community was positively related to distance downstream from dams, the occupancy response to distance downstream varied among species. Percent urban land use had little effect on the occupancy response of the reptile community or individual species. Our results indicate that the conditions of impoundments and subsequent degradation of the riparian zones upstream from dams may not provide suitable habitat for a number of reptile species.

1. Introduction

Riparian zones, defined as transitional, semi-terrestrial areas regularly influenced by freshwater (Naiman et al., 2005), generally contain high levels of biodiversity (Naiman et al., 1993; Pollock et al., 1998). Riparian zones serve as dispersal corridors for many animal and plant species (Burbrink et al., 1998; Jansson et al., 2005) and are valuable reservoirs of biodiversity because they can support a distinct set of species relative to those found in non-riparian habitats (Sabo et al., 2005). Despite the importance of riparian zones for biodiversity, much of the riparian habitat in the United States has been affected by anthropogenic activities, such as damming, forest removal, grazing, water withdrawal, and urban development (Wissmar and Beschta, 1998).

Flow regulation through damming can be especially detrimental to riparian habitat. In the United States alone, over 75,000 large dams disrupt the flow of rivers (Poff and Hart, 2002). Damming changes the water quality of a river system by reducing the sediment load downstream (Allan and Castillo, 2008), increasing sediment load upstream (Baxter, 1977), and by lowering dissolved oxygen levels in impoundments (Clark et al., 2009). Damming has been linked to population declines of aquatic organisms including plants (Blanch et al., 2000), macroinvertebrates (Voelz and Ward, 1991), mussels (Vaughn and Taylor, 1999), and fish (Haxton and Findlay, 2008; Kinsolving and Bain, 1993; Liermann et al., 2012). Recent studies suggest that semi-aquatic species within riparian zone communities can also be negatively impacted by damming (Bateman et al., 2008; Eskew et al., 2012; Reese and Welsh, 1998a,b). Semi-aquatic species are sensitive to damming because flow regulation can fragment habitat by isolating the main river channel from adjacent riparian floodplains (Poff and Hart, 2002). Flow regulation through damming can also reduce periodic flooding, which can lead to population declines among organisms whose life histories are adapted to the river's natural flow regime (Bayley, 1995; Lytle and Poff, 2004; Townsend, 2001). Regulated rivers can provide suitable habitat for non-native organisms that would not thrive under naturally variable flow conditions, and these species may displace native species (Bunn and Arthington, 2002; Fuller et al., 2011; Lytle and Poff, 2004). Finally, high spate events caused by water releases from dams may displace individuals immediately downstream from dams (Lind et al., 1996).

* Corresponding author. Tel.: +1 704 894 2768; fax: +1 704 894 2512.
E-mail addresses: sthunt@davidson.edu (S.D. Hunt), jaguzy@davidson.edu (J.C. Guzy), steven.price@uky.edu (S.J. Price), bhalstead@usgs.gov (B.J. Halstead), eaeskew@ucdavis.edu (E.A. Eskew), midorcas@davidson.edu (M.E. Dorcas).
[1] Present address: Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA.

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Urbanization can also have significant negative effects on riparian zones. Habitat loss as a result of urbanization threatens species across many taxonomic groups and is thought to be the leading cause of species endangerment in the United States (Czech et al., 2000). Adjacent to riparian zones, urbanization creates high levels of nitrification, limits denitrification, and lowers the water table (Groffman et al., 2003). Ecologists often advocate for the maintenance of forested buffer zones around river systems to minimize the detrimental effects of urbanization on the riparian zone and associated biota (Moore and Palmer, 2005). Conversely, some species can take advantage of anthropogenic changes and thrive in urbanized, riparian environments (Barrett and Guyer, 2008; Pattishall and Cundall, 2009).

Although global reptile declines have received less attention than parallel declines among amphibians, reptile species may be in greater danger of global extinction due to threats including habitat loss, pollution, and unsustainable harvest (Gibbons et al., 2000). The southeastern United States is home to approximately 100 species and subspecies of aquatic and semi-aquatic reptiles, 62 of which are of significant conservation concern (Buhlmann and Gibbons, 1997). Riparian zones are critical habitat for many reptiles (Brode and Bury, 1984; Burbrink et al., 1998; Soares and Brito, 2007); however, relatively few studies have focused specifically on the effects of anthropogenic habitat disturbance on riparian zone reptile communities (but see Barrett and Guyer, 2008; Clark et al., 2009; Reese and Welsh, 1998a,b). Some reptile species may be sensitive to urbanization pressures (Hamer and McDonnell, 2010), but others may benefit from riparian urbanization because it decreases canopy cover and creates deeper, warmer waters which riverine turtles and snakes prefer (Barrett and Guyer, 2008). Decreases in habitat quality through flow regulation may also negatively affect certain reptile species (Clark et al., 2009; Reese and Welsh, 1998a,b). However, some turtle species do prefer lentic habitats (Bodie and Semlitsch, 2000), and might therefore favor impoundment habitats upstream from dams.

Because habitat alteration and loss affect a large number of reptile species (Gibbons et al., 2000), our study examined the effects of: (1) flow regulation through damming and (2) urbanization on reptile occupancy and species richness in riparian zones. Specifically, we used a multi-species hierarchical analysis which allowed us to simultaneously generate site-specific species richness estimates and examine habitat-dependent occupancy patterns for the reptile community despite low detectability for individual species (Zipkin et al., 2009).

2. Methods

2.1. Study sites

Active searches for reptiles and amphibians were conducted at 21 study sites in the upper Piedmont of South Carolina. The sites included floodplains, ephemeral ponds, and riverbanks along the Broad and Pacolet Rivers. At the outset of the selection process, we used a geographic information system (ArcGIS 9.1 ESRI, Redlands, CA), with layers from the National Wetland Inventory (NWI, http://www.fws.gov/wetlands/) and the National Land Cover Database (NLCD; available on the USGS seamless server (http://www.seamless.usgs.gov/index.php)) to identify approximately 200 riparian wetlands within our study area. After ground-truthing, we determined that 21 sites were sufficiently accessible for time-constrained active searches (Fig. 1; see Eskew et al., 2012 for more information on study site selection).

2.2. Data collection methods

We sampled for reptiles using time-constrained active search techniques consistent with recommendations for terrestrial reptile species inventories (McDiarmid et al., 2012). For each 30-min survey, two experienced investigators searched a site independently, lifting groundcover and visually scanning the area to detect and identify reptile species. Occasionally, one investigator searched alone for an hour at each site. Surveys were conducted during daylight hours and weather variables (i.e., air temperature, wind, degree of cloudiness, precipitation) were recorded after each survey. We conducted a total of thirteen surveys per site: three surveys were conducted at each site in June and early July of

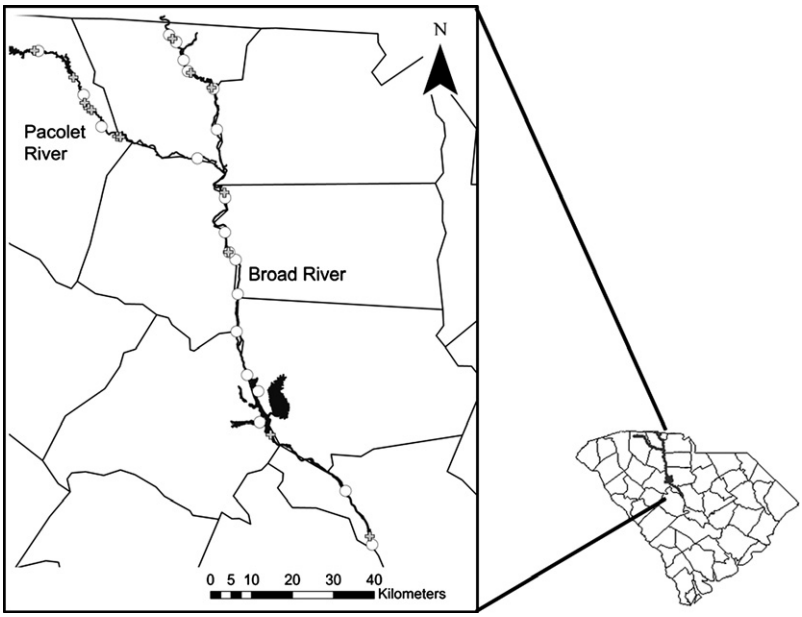

Fig. 1. Active search study sites along the Broad and Pacolet Rivers, South Carolina, USA. Study sites are shown as white circles and locations of dams are shown as gray crosses. Some of the crosses are obscured because of the proximity of the dams and the scale of the study area.