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The occurrence of primary burrowing crayfish in terrestrial habitat

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ABSTRACT

A researcher's perception of a target species' landscape strongly influences the design of habitat studies conducted at broad spatial scales. Consequently, researcher-dependent perceptions may misguide conservation efforts. Although the life histories of some crayfish (i.e., primary burrowers) are centered on a fossorial existence independent of surface water, all North American crayfish are viewed in an aquatic context. This paradigm restricts the range of habitats that are typically sampled and managed for crayfish conservation. This study used presence/absence of the primary burrower *Distocambarus crockeri* at 137 locations within the Long Cane Ranger District of the Sumter National Forest, South Carolina, USA, to model the habitat association of the species across a GIS-based landscape. Logistic regression indicated that *D. crockeri* presence was most strongly associated with a terrestrial habitat defined by a set of morphologically similar soils located along ridge tops. Furthermore, the species was negatively associated with aquatic habitats such as streams and floodplains. The results indicate that *D. crockeri* is a terrestrial habitat specialist and should be modeled and managed at the landscape as a terrestrial organism. When viewed as a subset of the total United States cambarid fauna, primary burrowers are disproportionately imperiled. Primary burrowers comprise only 15% of the total crayfish fauna, while they account for 32% of those crayfish ranked critically imperiled. Habitat loss and an aquatic bias that restricted sampling to aquatic and semi-aquatic habitats might explain the group's disproportionate imperilment.

1. Introduction

From an organism-centered view (Wiens, 1985), the landscape of an aquatic organism is radically different from that of a terrestrial organism, even when they occur within the same spatial extent. At its simplest, the 'landscape' concept is intended to capture biologically informative spatial heterogeneity (King, 1997). Although a landscape is often thought to identify large areas, its spatial extent and composition are specific to target species and can range from a single leaf to a continent region (Wiens, 1985; King, 1997). Additionally, as applied to broad-scale, spatially explicit habitat studies, the composition of the landscape depends on the spatial data used and is, therefore, subject to researcher biases (Henebry and Merchant, 2002; Van Horne, 2002). For most species, these biases are minimized by baseline data (e.g., natural history data). However, for understudied species, these biases have the potential to negatively influence the design and conclusions of habitat studies, which can ultimately misguide conservation and management efforts.

With more than 300 species, the southeastern United States is home to the greatest diversity of crayfish in the world (Schuster, 1997). Within the southeast, crayfish occupy a variety of trophic levels, can have strong non-trophic effects

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on community structure, and are found in every major freshwater habitat and some subterranean habitats (Gherardi, 2002; Nystrom, 2002; Creed and Reed, 2004; Helms and Creed, 2005). Within taxonomic groups studied in the United States, crayfish have a higher percentage of vulnerable species than amphibians, freshwater fish, reptiles, birds, and mammals (Primack, 1998; Wilcove and Master, 2005). However, despite their diversity and overall imperilment, surprisingly little is known about most crayfish species (Schuster, 1997).

Hobbs (1942, 1981) identified three categories of burrowing crayfish: primary, secondary, and tertiary burrowers. Primary burrowers spend almost their entire life in and around burrows. Secondary burrowers also spend much of their lives in and around burrows, but inhabit open water during wet seasons. Tertiary burrowers live in open water and construct simple burrows below the mean water level. Because primary burrowing crayfish spend most of their lives in burrows, they are not limited to surface water; consequently, some are rarely found in aquatic habitats (Hobbs, 1942, 1981). Unlike the distribution of some terrestrial crayfish in Australia, the distribution of primary burrowers in the United States was believed to be limited by a connection to a water table that allowed access to free water throughout the year (Hobbs, 1942, 1981; Horwitz and Richardson, 1986; Gherardi, 2002). According to Hobbs (1981) "the only consistent generalized feature of [primary burrowers] is the presence of at least one spiraling-to-subvertical tunnel that extends downward below the water table." In areas where the water table fluctuated greatly, primary burrowers were reported to follow the receding water tables (Hobbs, 1942, 1981; Powers and Bliss, 1983). Lyle (1937) reported burrow depths up to 4 m for the primary burrower, *Procambarus hagenianus hagenianus*; however these depths were unusual, and the burrows of *P. advena*, which reached a depth of 1.5 m, were considered deep by Hobbs (1981). Therefore, it was assumed that primary burrowers were limited to aquatic or semi-aquatic habitats, such as wetlands and spring feed seepage areas where the water table was shallow and accessible.

Distocambarus crockeri is one of five species of crayfish in the genus. All members of *Distocambarus* are primary burrowers and are geographically limited to a small portion of the Piedmont section of South Carolina and Georgia. The geographic range of *D. crockeri* includes portions of Saluda, Edgefield, McCormick, and Greenwood counties, South Carolina (Hobbs and Carlson, 1983; unpublished data). *D. crockeri* is a vulnerable species (TNC, 2005), listed as a species of special concern by the American Fisheries Society, Endangered Species Committee (Taylor et al., 1996) and identified as a priority species of conservation concern by the South Carolina Department of Natural Resources. Like most North American crayfish, little is known about the natural history of the species, and information pertaining to *D. crockeri* is largely limited to the original publication describing the species (Hobbs and Carlson, 1983).

This paper presents the results of our efforts to create a predictive model of occurrence for *D. crockeri* across a GIS-based landscape. Our initial objective was to develop a predictive model of occurrence, which was intended to provide a template for future efforts to model the occurrence of other primary burrowing crayfish. However, in order to achieve our objective, we were compelled to conduct three successive surveys. For each survey we expanded the range of habitats sampled across the landscape, and eventually began to test basic assumptions about the distribution and life histories of primary burrowing crayfish.

2. Methods

2.1. Study area

Surveys were conducted in the Long Cane Ranger District (LCRD) of the Sumter National Forest, South Carolina, USA (34°01′17″ N, 82°15′59″ W). The LCRD was established in 1936 and currently consists of 48 188 ha managed for timber production, watershed and wildlife protection, mineral leasing, and recreation. The LCRD is situated in the Piedmont physiographic province of the Middle Savannah River watershed. The area is characterized by rolling hills of moderate relief and elevations ranging from 50 to 250 m. The soils vary in texture, drainage, and depth. Streams in the LCRD are low gradient with substrates ranging from silt-clay and sand to cobble-gravel and bedrock.

2.2. Data collection

Data used to model the distribution of *D. crockeri* across the landscape were collected during three successive surveys. The initial survey was conducted from March 2000 to July 2001, and framed the species landscape within an aquatic context. The survey used standard techniques for collecting crayfish (Hobbs, 1981) and focused on a cross-section of suitable crayfish habitats that included stream channels, banks, and floodplains along a range of stream orders. Thirty sites were sampled for a minimum of 1 h by kick seining and dip-netting surface water and excavating crayfish burrows. Sampled sites were within 50 m of a road and were chosen to represent a cross-section of streams within the LCRD. Although *D. crockeri* were collected opportunistically from burrows along roadsides within the study area, the species was not collected at any site selected for the actual survey. We hypothesized that ditches along roadsides acted as intermittent streams. Therefore, we conducted a second survey that expanded the range of habitats sampled across the landscape by including intermittent streams and colluvial valleys. The second survey was conducted from August through November 2001, and included 47 sites within 50 m of a road in randomly selected colluvial valleys, intermittent, and first-order streams. Although *D. crockeri* were found during the second survey, colonies of the crayfish were also observed in terrestrial habitats that included upland areas along ridge tops. These observations cast doubt on the appropriateness of framing the survey in an aquatic context that limited sampling locations to drainage units and prompted us to conduct yet a third survey. The third survey was conducted from January through April 2002, and consisted of 60 sites that were randomly located across the landscape within 50 m of a US Forest Service (USFS) road. Sites for the third survey included terrestrial habitats and were sampled by visually searching for crayfish burrows for a minimum of 15 min per site (garden rakes were used to remove leaf litter when necessary).