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Original research article

An integrative approach to regional mapping of suitable habitat for the Blanding's turtle (*Emydoidea blandingii*) on islands in Georgian Bay, Lake Huron

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ABSTRACT

Mapping suitable habitat for a species at risk is one of the first steps in a conservation plan. Creating habitat suitability maps can be very challenging when the area of interest is large and located in remote areas where field excursions can be difficult to implement. Such is the case for the Blanding's turtle, a threatened species in Ontario, that live on the Georgian Bay archipelago. With increasing anthropogenic pressures, maps indicating suitable habitat can aid management decisions and prioritize areas for protection. We apply an interdisciplinary approach using traditional field data and generalized linear models to produce high resolution, regional maps which identify suitable habitat for Blanding's turtles throughout the archipelago. We assessed the accuracy of our models using an independent survey dataset of 16 island sites distributed throughout the archipelago, and evaluated models using a reference island as a threshold for determining suitability of survey sites. Islands with higher proportions of wetlands and vernal pools were generally considered to be suitable for Blanding's turtles compared to those with lower proportions. Our findings highlight the importance of both permanent and temporary wet habitats for Blanding's turtles. Based on our final model, approximately 64% of evaluated islands support habitat for Blanding's turtles. Our study is the first to produce detailed habitat suitability maps for Blanding's turtles on the Georgian Bay archipelago. We recommend an integrative approach be applied to create habitat suitability maps for other species at risk in Georgian Bay.

1. Introduction

Identifying potential or suitable habitat for species at risk can provide useful information when developing conservation strategies. Habitat suitability models based on environmental variables and habitat classes can be created to predict distribution of important habitats or species occurrence (Ottaviani et al., 2004). Resulting models can guide management plans, identify gaps in distribution, reveal areas with previously undetected populations, and predict distribution changes in response to climate change or land-use alterations (Manel et al., 2001). Development of effective habitat suitability models relies on availability of accurate and up-to-date information on the target species but such information is often limited. In the case of the Blanding's turtle (*Emydoidea blandingii*), conservations plans are empirically derived (The Blanding's Turtle Recovery Team, 2002) and, in Canada, are available for areas where extensive research has previously been conducted

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(e.g. Nova Scotia and Quebec). For Ontario, development of a recovery strategy has been identified as a priority but knowledge gaps exist and additional research is required (Government of Canada, 2015).

Across the species' range, the Blanding's turtle is known to use aquatic habitats such as vernal pools, bogs, marshes, and fens (Rowe and Moll, 1991; Hartwig and Kiviat, 2007; Edge et al., 2010; Markle and Chow-Fraser, 2014), and terrestrial habitats throughout the active season (Ernst and Lovich, 2009). During spring, Blanding's turtles emerge from overwintering habitats such as permanent pools (Ross and Anderson, 1990; Graham and Butler, 1993; Joyal et al., 2001), streams (Ross and Anderson, 1990; Newton and Herman, 2009), marshes (Kofron and Schreiber, 1985; Rowe and Moll, 1991; Edge et al., 2009; Seburn, 2010), and a variety of upland wetlands (Joyal et al., 2001; Edge et al., 2009; Newton and Herman, 2009; Seburn, 2010). During the reminder of the active season, Blanding's turtles have been found to display site fidelity to residence wetlands (Congdon et al., 2011) but utilize a mosaic of aquatic and terrestrial habitats to move among wetlands and access nesting sites (e.g. Standing et al., 1999; Hartwig and Kiviat, 2007; Beaudry et al., 2009 and Markle and Chow-Fraser, 2014). In addition to diverse habitat use, male and female Blanding's turtles may make long distance terrestrial movements (Ross and Anderson, 1990; Rowe and Moll, 1991), suggested to be an important vector for increased gene flow (McGuire et al., 2013); studies have reported males travelling 900 m in early summer (Markle and Chow-Fraser, 2014) and females migrating over 6 km to nest (Edge et al., 2010). Extensive upland movements in combination with varied habitat use requires conservation plans which understand Blanding's turtle response to landscape composition. With the development of habitat suitability models, we can provide a landscape-level perspective on habitat requirements.

In Canada, the Great Lakes/St. Lawrence population of Blanding's turtles is listed as both federally and provincially threatened (COSEWIC, 2005; Government of Canada, 2009). Within the Great Lakes, a population of Blanding's turtles exists on the Georgian Bay archipelago, located in the eastern arm of Lake Huron and designated a world biosphere reserve (UNESCO, 2014). Because Georgian Bay is only 2 h north of Toronto, it is easily accessible to many weekend users and contains the busiest recreational waterway in Canada (Walton and Villeneuve, 1999). Although the archipelago consists of mostly pristine habitat (Cvetkovic and Chow-Fraser, 2011), increasing development pressures threaten species and habitats (Walton and Villeneuve, 1999). Limited data exist because the remote location and large number of islands make it difficult to conduct intensive field studies in the archipelago. Comparison of two Blanding's turtle populations on Canadian Shield, one on an island (protected island, Markle and Chow-Fraser, 2014) and the other on mainland (Algonquin Park, Edge et al., 2010), revealed differences in habitat use and home range size. Selection of ephemeral wetlands was more pronounced in the island population, and average home range sizes were smaller compared to the mainland population (female: 20.5 ha vs. 61 ha; male: 15 vs. 57 ha, respectively; Edge et al., 2010 and Christensen and Chow-Fraser, 2012). Such a comparison of populations living in different parts of Ontario highlights difficulties that may arise when managers develop conservation strategies with data derived elsewhere when no relevant information exists for the system of interest (Hubert and Rahel, 1989). In addition to differences in turtle home range size and habitat use, Georgian Bay is also recognized as the northern range limit for Blanding's turtles (Ontario Government, 2014), and this may have implications for ectotherms that must adapt to cooler temperatures. Therefore, it is important that we develop a habitat suitability model using parameters appropriate to the Georgian Bay landscape, based on data collected only from the Georgian Bay archipelago.

To date, three models have been published for the Blanding's turtle, those of Poynter (2011), Barker and King (2012) and Millar and Blouin-Demers (2012). Millar and Blouin-Demers (2012) used two modelling approaches (boosted regression trees and maximum entropy modelling) to predict habitat suitability for southern Ontario. In their resulting models, Millar and Blouin-Demers (2012) determined that habitat suitability increased with increasing air temperature and wetland area, and decreased with increasing cropland area. Given that cropland is limited only to the southern portion of Georgian Bay, the southern Ontario model may be unable to discriminate between suitable and unsuitable habitat in most of eastern Georgian Bay. Results obtained at a broad provincial scale are particularly useful for evaluating species distribution patterns, but are usually difficult to incorporate into specific conservation or recovery strategies that agencies aim to develop for specific parcels of land Barker and King (2012) developed a parcel-specific model for the Gatineau Park, Quebec. They identified the suitability of individual wetlands for Blanding's turtles; however, transferability of their model to Georgian Bay is limited by inclusion of habitat features that they identified as being important to Gatineau Park, but which do not correspond with features in the Shield landscape of Georgian Bay (Edge et al., 2010; Markle and Chow-Fraser, 2014). A similar approach was used to identify potential Blanding's turtle habitat in Ohio (Poynter, 2011), although vegetation categories used were too coarse to be applied to the Georgian Bay context. Overall, it appears that the published models of habitat suitability are not directly applicable or transferable to the Georgian Bay archipelago.

The primary objective of our study is to develop a habitat suitability model for the Blanding's turtle specifically for the Georgian Bay archipelago, so that suitable habitat can be identified and marked for protection in conservation plans before habitat is degraded or developed. We assume that radio tracking data for a population of Blanding's turtles on a protected island can be used to indicate suitable habitat. Therefore, we use landscape composition of the reference island to map habitat suitability of other islands within the archipelago. Secondly, we investigate changes in model accuracy when habitat data are extracted with different buffers (i.e. circular or grid). Specifically, we hypothesize that the approach which more specifically quantifies habitat used by radio-tracked turtles (circular buffer centred on locational point) will be more accurate in determining important landscape components compared to a more general approach (grid overlaid on the study area). The resulting model can produce maps at the regional scale for use in conservation and management strategies. We use an interdisciplinary approach that combines field data, remote sensing, and statistical modelling to produce spatially explicit