Influences of Temporary Emigration and Demographic Structure on Wood Turtle Visual Encounter Survey Results using the Midwest Protocol

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INTRODUCTION

- Standardized Wood Turtle (*Glyptemys insculpta*) survey protocols have been developed and implemented for both Eastern USA and Midwest USA populations
- For both protocols, repeated surveys are completed using a single pass through defined areas, allowing for estimation of survey-specific detection probability (p) and site-specific abundance (Jones et al. 2015, Brown et al. 2017)
- The protocols do not allow for separation of p into the components of availability (p_a) and detectability (p_d) given availability
- If there are systematic influences on p_a or p_d that are not accounted for in the survey design or data analysis, abundance estimates could be highly biased

OBJECTIVES

- Determine whether p_a during each survey is more supported as constant, random, or Markovian (i.e., differs between turtles that were and were not available in the previous survey)
- Determine if p_a or p_d are strongly influenced by age or sex
- Quantify p_a and p_d using the Midwest survey protocol, and p_a using high temporal resolution individual-level monitoring data

METHODS

- We modified the Midwest protocol to include a double-pass design, allowing us to separately estimate p_a and p_d
- We surveyed sites by walking 4 transects on each side of the river and searching for wood turtles, with transects spaced at 15-m intervals beginning with the river-land interface (Brown et al. 2017)
- We conducted 6 double-pass surveys at 8 Wood Turtle monitoring sites in northeastern Minnesota between 3 May and 5 June 2017
- We used GPS loggers and temperature loggers (iButtons) to monitor space use patterns for Wood Turtles that occupied the monitoring sites within the seasonal and daily survey time frame in 2016 (Cochrane et al. 2019)

ANALYSES AND MODEL ASSUMPTIONS

CAPTURE-RECAPTURE

- We created open robust design models with the Huggins estimator using the R package Rmark (model 'RDHuggins') (Laake 2013)
- We assumed that p_d was constant among surveys
- We assumed that no mortality occurred during the 1 month sampling period
- We restricted our analysis to the first 4 primary periods due to a substantial reduction in captures the last two surveys, indicating surveys were conducted outside of the optimal survey window
- We assessed support for p_a structure (no migration, random, or Markovian)
- We assessed support for p_a and p_d being constant or varying across demographic classes (age or sex classes)
  - Age Class: Juveniles (SCL < 160 mm), adults
  - Sex Class: Juveniles, adult females, adult males

SITE OCCUPANCY OF MONITORED TURTLES

- For 18 monitored turtles, we estimated location using GPS loggers, and habitat type (terrestrial or aquatic) using iButtons, at 10 minute intervals (Cochrane et al. 2019)
- We restricted the data set to GPS locations during the survey period (early May – Early June) and survey time frame (8:00 – 19:00)
- To estimate p_a, we calculated the proportion of time spent within the monitoring site, including land + water and land-only
  - Water locations estimated using iButton data

RESULTS: CAPTURE-RECAPTURE

- We detected 86 unique individuals (46 females, 25 males, 15 juveniles)

AVAILABILITY FOR DETECTION (p_a)

- The random temporary emigration model received the most support, but there was also support for differences in p_a by age class and sex class (**Table 1**)
  - Overall p_a = 0.22
  - Age-specific p_a = 0.20 (adults), 0.28 (juveniles)
  - Sex-specific p_a = 0.23 (females), 0.16 (males), 0.27 (juveniles)

TABLE 1. Model Selection for availability (p_a) structure. For all models, survivorship was fixed to 1 and detectability (p_d) was constant.

Model	Par	AIC_C	Δ AIC_C	Weight
Random (.)	3	376.6	0.00	0.58
Random (Age Class)	4	378.3	1.66	0.25
Random (Sex Class)	5	379.7	3.01	0.12
Markovian (.)	7	382.4	5.71	0.03
Markovian (Age Class)	14	392.2	15.5	0.00
Markovian (Sex Class)	19	402.4	25.8	0.00
(.)	2	406.4	29.8	0.00

DETECTABILITY GIVEN AVAILABILITY (p_d)

- The null model received the most support, but there was also support for differences in p_d by age class and sex class (**Table 2**)
  - Overall p_d = 0.72
  - Age-specific p_d = 0.74 (adults), 0.65 (juveniles)
  - Sex-specific p_d = 0.79 (females), 0.58 (males), 0.64 (juveniles)
- Probability of recapture within primary periods (c) = 0.17

TABLE 2. Model Selection for detectability structure. For all models, survivorship was fixed to 1 and availability (p_a) was random. p_d refers to probability of detecting an individual given it is available for detection. c refers to probability of re-detecting an individual during the second pass within each survey.

Model	Par	AIC_C	Δ AIC_C	Weight
p_d (.) c (.)	3	376.6	0.00	0.50
p_d (Age Class) c (.)	4	378.5	1.80	0.20
p_d (Sex Class) c (.)	5	378.7	2.06	0.18
p_d (Age Class) c (Age Class)	5	380.4	3.74	0.08
p_d (Sex Class) c (Sex Class)	7	381.9	5.22	0.04

RESULTS: SITE OCCUPANCY OF MONITORED TURTLES

- 7 of 18 turtles tracked during 2016 occupied the monitoring sites during the survey period (estimates below only include turtles that used a monitoring site)
  - 12,016 location points (mean = 1,717 per individual)
- Mean availability in study area (land + water) = 0.33 ± 0.29 (**Figure 1**)
  - Range = 0.01 – 0.69
- Mean availability in study area (land-only) = 0.28 ± 0.24
  - 85% of estimated locations during the survey period were terrestrial

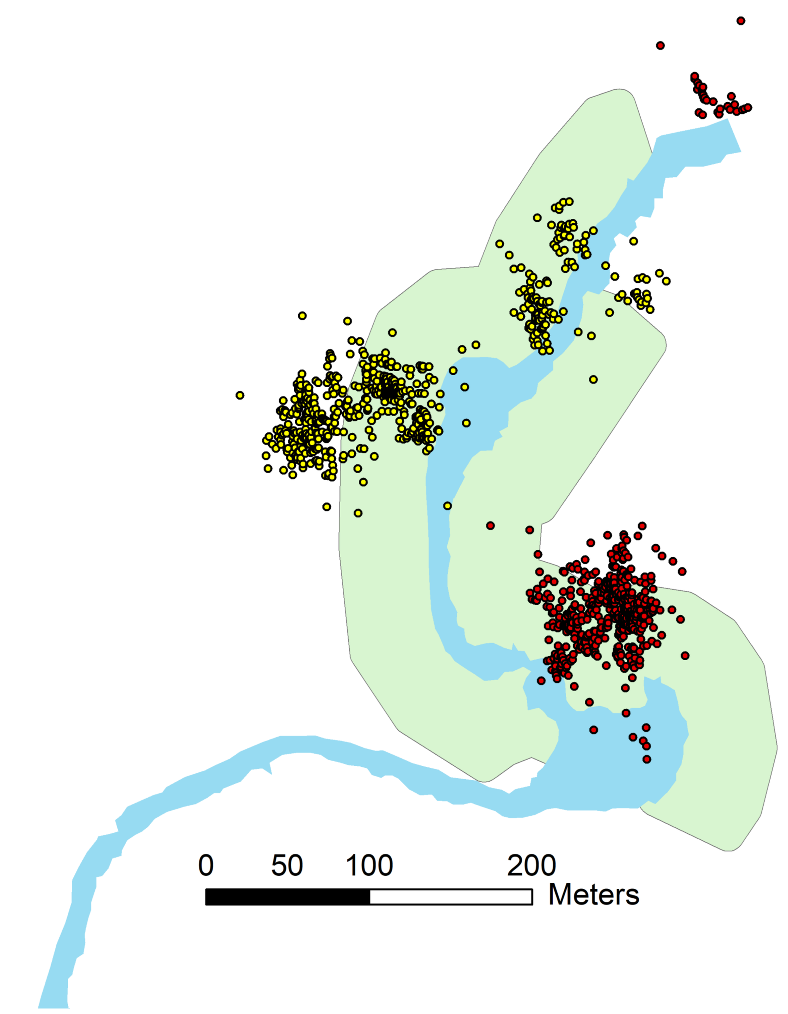

Figure 1. Availability in a monitoring site during the spring survey period for two adult Wood Turtles tracked using GPS loggers.

DISCUSSION

- Both analyses indicated a high probability that an individual turtle will be outside the survey area during a given survey
  - There was support for availability being random
  - Additional work needed to assess influence of survey covariates (e.g., air and water temperature, precipitation)
- The high prevalence of temporary emigration means that estimates of population size from single pass survey protocols refer to the superpopulation size, with the assumption that p_a is either random or accounted for using covariates
- The individual turtle monitoring data analysis indicated a higher mean availability than the capture-recapture analysis, but this estimate did not account for unavailability due to turtles being present but hidden in the survey area
- High temporal resolution monitoring data confirmed that individuals were mainly terrestrial during the survey period
  - A terrestrial-based survey design can be effective for detecting individuals

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