Space-Use Patterns of Spotted Turtles Occupying Two Wetland Types in West Virginia

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Abstract - Understanding space-use dynamics of wildlife populations is important for informing habitat management and restoration initiatives. In West Virginia, *Clemmys guttata* (Spotted Turtle) is restricted to the eastern panhandle region and is considered a species of greatest conservation need. The West Virginia Division of Natural Resources is interested in managing and restoring Spotted Turtle habitat, but information on space use is limited. To address this information gap, we used radiotelemetry to track space-use patterns of 9 Spotted Turtles at 2 sites that represent different wetland types in the state from spring 2018 to fall 2020. One site was a wetland complex containing ~13.19 ha of potential habitat, and the other site was a single isolated wetland containing ~2.09 ha of potential habitat. Spotted Turtle home-range size and use of potential habitat varied between the sites, with larger home-range sizes and a larger proportion of habitat used at the wetland complex site. Our results represent the first home-range size estimates reported for Spotted Turtle populations in West Virginia and suggest that space-use dynamics may be variable and dependent on site-level wetland characteristics.

Introduction

Understanding space-use dynamics of wildlife populations is important for informing habitat management and restoration initiatives (Burgess et al. 2020, George and Zack 2001, Hale et al. 2020). To meet their biological needs, wildlife species often use multiple spatially discrete habitats throughout their annual activity cycle. For example, many amphibian species spend most of the year in terrestrial environments but require aquatic environments for reproduction and larval development, in some cases migrating long distances to breeding sites (Dodd 2013, Wilson 2001). Space-use dynamics can also vary across space and time in response to differences and changes in habitat characteristics (e.g., availability, quality, connectivity) and competition pressure (e.g., Nickel et al. 2020, Roe et al. 2009, Ullmann et al. 2018). For species and populations with complex or dynamic habitat requirements, it can be difficult to spatially define habitat for management purposes.

In recent decades, it has become apparent that semi-aquatic turtles are declining worldwide (Gibbons et al. 2000, Lovich et al. 2018). In the US, broadscale conservation plans are being developed and implemented for many of the declining species, such as *Glyptemys insculpta* (Le Conte) (Wood Turtle; Jones et al. 2018), *Glyptemys muhlenbergii* (Schoepff) (Bog Turtle; Erb 2019), *Terrapene carolina* (L.) (Eastern Box Turtle; Roberts and Erb 2023), and *Clemmys guttata* (Schneider) (Spotted Turtle; Willey et al. 2022). Habitat management and restoration are often

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important features of these programs. In general, semi-aquatic turtles use lentic or lotic aquatic environments throughout the year but also use terrestrial environments for nesting, thermoregulation, and in some cases foraging (Ernst and Lovich 2009). Many semi-aquatic turtle species regularly move among discrete wetlands and can make long-distance movements over land (Bodie and Semlitsch 2000, Patrick and Gibbs 2010, Rowe and Moll 1991).

The Spotted Turtle is a semi-aquatic freshwater turtle species with observed and suspected population declines across its distribution in the eastern and upper midwestern US and southeastern Canada (Brodman et al. 2002, Browne and Hecnar 2007, Howell et al. 2019, Lewis et al. 2004). This species is a shallow-wetland specialist that has likely been negatively impacted by broadscale historical draining of wetlands for agriculture and development (Joyal et al. 2001, Lewis et al. 2004). Documented space-use patterns vary widely within and among Spotted Turtle populations, varying from restricted use of a single wetland and adjacent uplands to movement among multiple discrete wetlands (e.g., Beaudry et al. 2009, Ernst 1970, Lassiter et al. 2023, Litzgus and Brooks 2000). For example, a study in Maine documented Spotted Turtles using 1–9 discrete wetlands that were separated by up to 1.15 km (Beaudry et al. 2009). The large individual variation in space use is reflected by large variation in estimated home-range sizes: from <1 ha to >34 ha (Graham 1995, Litzgus and Mousseau 2004, Milam and Melvin 2001). Spotted Turtles have also been documented altering their space-use patterns in response to environmental changes, particularly hydrological changes (Buchanan et al. 2017, O'Dell et al. 2021, Rowe et al. 2013). Collectively, the previous studies indicate that knowledge of how individual populations use the environment is necessary to accurately delineate habitat for conservation purposes.

In West Virginia, Spotted Turtles are restricted to the eastern panhandle region and are a species of greatest conservation need, with only 7 known-occupied wetlands in the state (Mota 2022). The West Virginia Division of Natural Resources (WVDNR) is interested in managing and restoring Spotted Turtle habitat at these wetlands, but information on the spatial distributions of the populations is limited. We sought to improve our understanding of space use at 2 of these wetlands by monitoring individual space-use patterns using radiotelemetry. We estimated home-range sizes and proportion of available habitat used at each site to assist the WVDNR with identifying focal areas for habitat management and contribute to our understanding of how habitat availability influences Spotted Turtle populations.

Field-site Description

The study was conducted at 2 wetland field sites in West Virginia: 1 in Hampshire County (site 1), and 1 in Jefferson County (site 2). The specific locations of the wetlands are being withheld in compliance with state of West Virginia sensitive-species data practices. Site 1 is a 20-ha wetland complex consisting of a matrix of seasonally flooded shallow grassy marshes dominated by *Carex stricta* Lamarck (Tussock Sedge) and *Scirpus* spp. (bulrush), and forest ponds dominated by *Symplocarpus foetidus* (L.) Salisb. ex W.P.C. Barton (Skunk Cabbage) and *Salix nigra* Marshall

(Black Willow), as well as dry upland grassland and deciduous forest dominated by *Quercus* spp. (oaks) and *Acer* spp. (maples). The wetland complex is bisected by a small, moderate-flow stream (Oxenrider et al. 2018). Hydrology at this site remained consistent throughout the study period, with the drying up of some smaller wetlands, such as vernal pools and ditches, during late July and August. Site 2 is a 9-ha wetland consisting of shrubby thicket dominated by the invasive plant *Rosa multiflora* Thunberg (Multiflora Rose) and small, forested wetlands consisting of Black Willow and *Acer rubrum* L. (Red Maple) bordering a small impoundment. Below the small dam, the habitat is dominated by *Typha* spp. (cattails) and shallow, grassy marsh. A narrow, paved maintenance road exists alongside the edge of the impoundment, bisecting the impoundment from the lower marsh (Oxenrider et al. 2019). The wetland is primarily isolated and surrounded by agricultural fields and deep, human-created impoundments. Hydrology at this site remained consistent throughout the study period, with very limited loss of standing water.

Site 1 contains a naturally occurring population that was first documented in 1992 (Humphries 2002). Spotted Turtles have been present at site 2 since at least 1985, when 6 individuals were translocated to the site (Knight 1985). No monitoring occurred to determine the success of this translocation, so it is unknown if Spotted Turtles present at site 2 are the offspring of animals translocated to the site in 1985 or from a naturally occurring population existing at the site prior to the translocation.

Methods

From Spring 2018 to Fall 2020, we used radiotelemetry to track space use of 9 Spotted Turtles across 2 wetland field sites (6 turtles at site 1 and 3 turtles at site 2; Table 1). We captured Spotted Turtles during population surveys conducted as part of a regional species assessment (Willey et al. 2022) and opportunistically by hand. We fitted captured turtles with a 3.8-g glue-on radio transmitter (model R1680, Advanced Telemetry Systems, Isanti, MN) and relocated them weekly in 2018 and 2019, and biweekly in 2020, using a 3-element Yagi antenna and receiver (Advanced Telemetry Systems, Isanti, MN). We glued radio transmitters to the left rear side of each turtle's carapace using a waterproof 5-minute epoxy with a 1-hour curing time (J-B Weld, Marietta, GA). The total weight of the transmitter and epoxy was always less than 10% of the individual turtle's body mass. During each relocation event, we collected date, time, the turtle's behavior, and location using a handheld global positioning system (GPS) unit (Garmin GPSMAP 64x GPS, Olathe, KS).

To delineate potential wetland habitat available to Spotted Turtles, we extracted palustrine emergent wetland boundaries at each site from the US Fish and Wildlife Service National Wetlands Inventory data set (USFWS 2023). We then adjusted the layer boundaries using high-resolution aerial photography (USGS 2018) and in-field observations during the wettest period at each site. We also delineated all open-water sources (i.e., artificial impoundments) embedded within potential wetland habitat and removed these areas from the estimated available habitat. We performed all mapping and area calculations using ArcGIS 10 (ESRI, Redlands, CA).

Statistical analyses

With the radio-telemetry data from each wetland site, we estimated home-range sizes for individual Spotted Turtles, as well as combined locations for all monitored turtles, calculated as both 95% and 50% kernel density estimates (KDE) using program R (version 4.3.2; R Foundation, Vienna, Austria) and the 'kernelUD' function in the package 'adehabitatHR' (Calenge 2006). To calculate the smoothing parameter, we used the ad hoc method described by Silverman (1986). We calculated the 95% KDE home range using relocations of all turtles from each site, clipped to the delineated potential wetland habitat boundary to estimate proportion of available habitat used at each site. No turtle relocations were observed outside of the delineated potential wetland-habitat boundary. Due to the small sample sizes, particularly at site 2, we used summary statistics rather than statistical tests to characterize differences in space-use patterns between sexes and sites. We summarized the data by site and individual for the study period and within years.

Table 1. Duration of radio tracking, number of relocations (*n*), and 95% and 50% kernel density estimates (KDE; ha) for 9 *Clemmys guttata* (Spotted Turtle; 6 males [M], 3 females [F]) tracked at 2 wetland sites in West Virginia.

		Overall			2018			2019			2020		
	Duration	*n*	95%	50%	*n*	95%	50%	*n*	95%	50%	*n*	95%	50%
Site 1													
M 1	11 April 2018–01 Oct 2019	78	2.67	0.32	57	1.51	0.24	21	6.62	0.95	-	-	-
M 2	13 April 2018–30 Oct 2019	95	7.31	1.96	53	9.63	2.55	42	6.13	1.69	-	-	-
M 3	23 April 2018–30 Oct 2019	82	1.09	0.24	51	1.32	0.27	31	1.07	0.27	-	-	-
Average		85	3.69	0.84	54	4.15	1.02	31	4.61	0.97	-	-	-
F 1	13 April 2018–04 June 2020	112	5.07	1.04	53	8.15	1.75	42	2.99	0.77	17	2.81	0.72
F 2	05 April 2018–04 June 2020	119	2.08	0.31	62	2.38	0.49	40	2.85	0.48	17	0.10	0.02
F 3	05 April 2018–04 June 2020	117	0.44	0.08	57	0.51	0.13	43	0.43	0.07	17	0.15	0.02
Average		116	2.53	0.48	57	3.68	0.79	42	2.09	0.44	17	1.02	0.25
Site 2													
M 4	02 May 2019–15 Nov 2020	39	0.72	0.12	-	-	-	24	0.46	0.09	15	1.12	0.22
M 5	07 May 2019–26 May 2020	37	1.17	0.21	-	-	-	24	0.86	0.16	13	2.03	0.49
M 6	25 June 2019–27 April 2020	24	0.61	0.14	-	-	-	15	0.28	0.07	9	1.31	0.34
Average		33	0.83	0.16	-	-	-	21	0.53	0.11	12	1.49	0.35

Results

Spotted Turtles were tracked from April 2018 through June 2020 at site 1 and from May 2019 through November 2020 at site 2 (Table 1). At site 1, male Spotted Turtles were tracked until October 2019, but female Spotted Turtles were tracked throughout the duration of the study. The number of relocations varied among individual Spotted Turtles from 78 to 119 relocations at site 1 (mean = 85 [male]; 116 [female]) and from 29 to 34 relocations at site 2 (mean = 33.3).

Estimated space use varied among individuals and among years within individuals (Table 1). Overall Spotted Turtle home-range size appeared to differ between sexes at site 1, with 95% KDE varying from 0.44 to 5.07 ha (mean = 2.53 ha) and 50% KDE varying from 0.08 to 1.04 ha (mean = 0.48 ha) for females, and 95% KDE varying from 1.09 to 7.31 ha (mean = 3.69 ha) and 50% KDE varying from 0.32 to 1.96 ha (mean = 0.84 ha) for males (Fig. 1, Table 1). Only male Spotted Turtles were radio-tracked at site 2, and home-range sizes were smaller than at site 1; KDE varied from 0.61 to1.17 ha (mean = 0.83 ha), and the 50% KDE varied from 0.12 to 0.21 ha (mean = 0.16 ha) at site 2 (Fig. 2, Table 1). In 2019, when males were tracked at both sites, the mean male 95% KDE was 4.61 ha at site 1 and 0.53 ha at site 2. The proportion of available habitat used also appeared to differ between sites. We estimated that site 1 and site 2 contained 13.19 ha and 2.09 ha of potential habitat, respectively. Our radio-tracked turtles used an estimated 8.38 ha (63.5%) of the available habitat at site 1 (Fig. 1) and 1.06 ha (50.7%) of the available habitat at site 2 (Fig. 2).

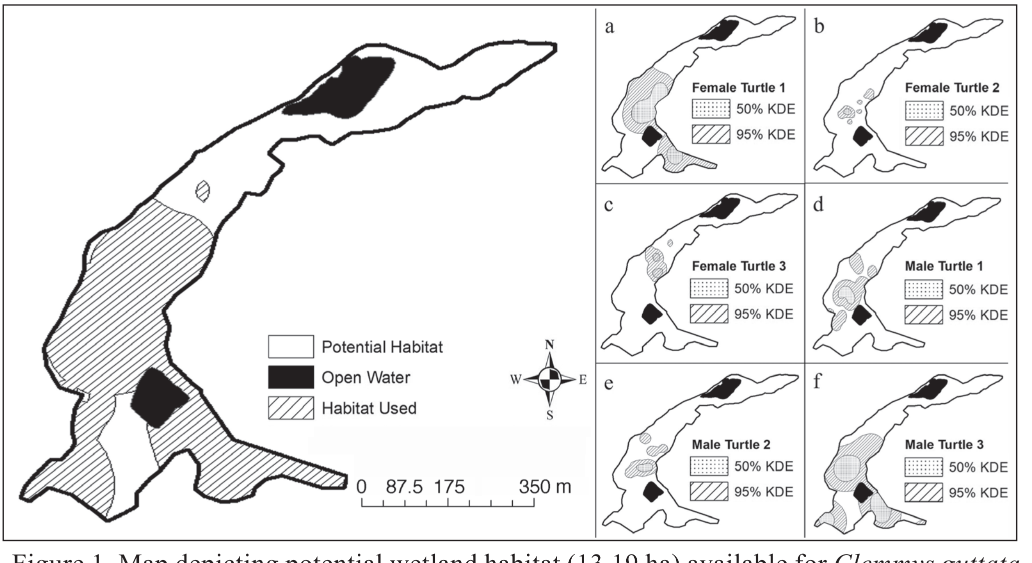

Figure 1. Map depicting potential wetland habitat (13.19 ha) available for *Clemmys guttata* (Spotted Turtle) at site 1, Hampshire County, WV, overall individual turtle (female [a–c] and male [d–f]) 50% and 95% kernel density estimates (KDE), and area used by the monitored population (main map, 95% KDE). Turtles were tracked using radio telemetry and relocated approximately weekly from spring 2018 to fall 2020.

Discussion

Our results suggest that space-use patterns vary among individual Spotted Turtles and across time at wetlands in West Virginia, consistent with studies in other portions of their geographic distribution (e.g., Buchanan et al. 2017, Chandler et al. 2019, Ernst 1970). We found that the amount of space used was positively correlated with the amount of habitat available, with mean home-range size of the sampled males being over 4 times larger in the comparatively large wetland complex present at site 1. Spatial and temporal variation in configuration, hydrology, and temperature (among other factors) of wetlands is influential for Spotted Turtle habitat selection (Buchanan et al. 2017, Litzgus and Brooks 2000, Roe 2023), and

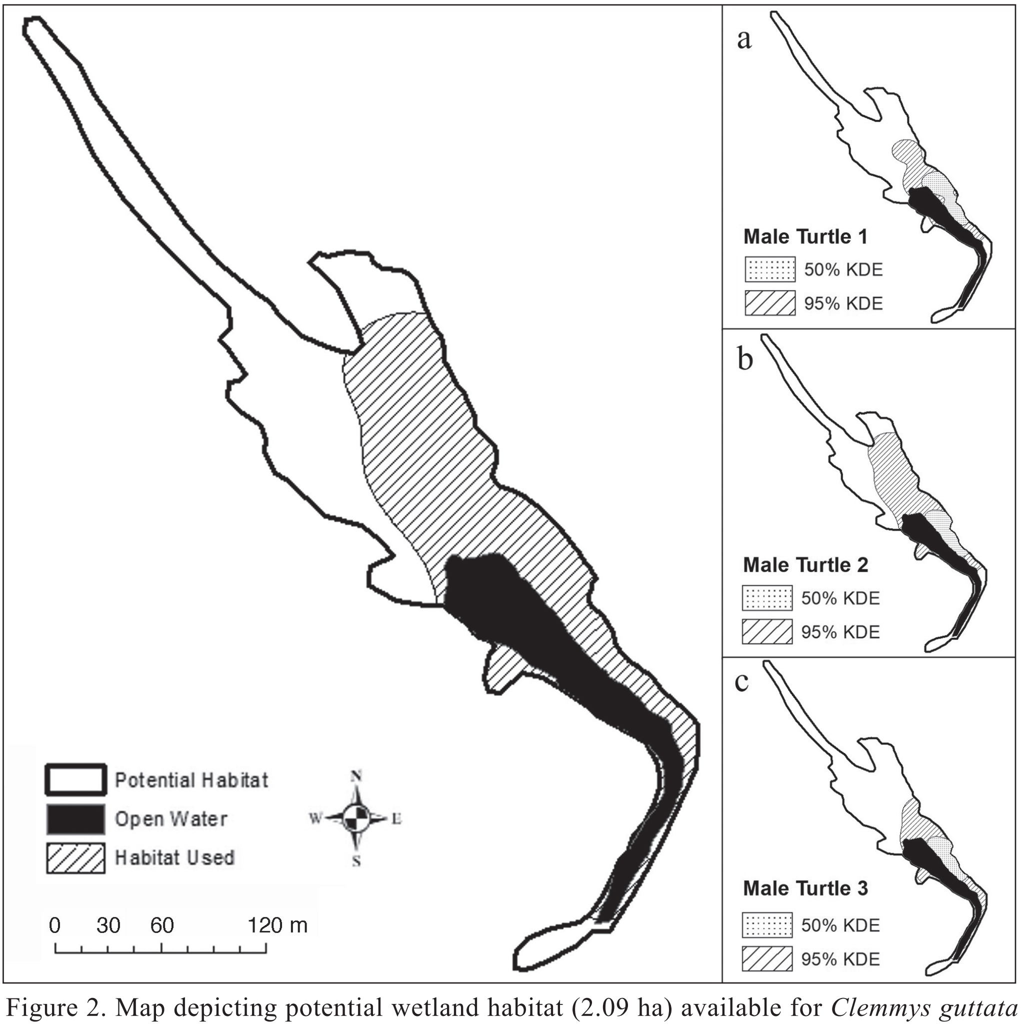

Figure 2. Map depicting potential wetland habitat (2.09 ha) available for *Clemmys guttata* (Spotted Turtle) at site 2, Jefferson County, WV, overall individual turtle (male [a–c]) 50% and 95% kernel density estimates (KDE), and area used by the monitored turtle population (main map, 95% KDE). Turtles were tracked using radio telemetry and relocated approximately weekly from spring 2019 to fall 2020.

thus we would expect individual home-range sizes to fluctuate across space and time in response to changing habitat availability and quality. Furthermore, interspecific competition likely influences local habitat selection of Spotted Turtles (Chaudhry et al. 2023). While these factors make it difficult to fully delineate the area required for long-term population persistence, our study does identify areas heavily used by the populations and thus provides locations to target for habitat conservation and restoration. Additional research using a more robust sampling design, including tracking more individuals and relocating turtles more frequently, would refine our understanding of spatiotemporal habitat-use patterns and potential space-use differences between males and females at these sites. For example, while mean home-range size was much higher for males than females at site 1, this result is likely influenced by sample size, as the result was not consistent among individuals and most previous studies suggest that mean home-range size for Spotted Turtles is either similar between sexes or larger for females (e.g., Buchanan et al. 2017, Chandler et al. 2019, Litzgus and Mousseau 2004). In addition, systematic monitoring of wetland hydrology throughout the duration of the study period would allow for a better characterization of habitat use in relation to habitat availability.

Currently, abundance of Spotted Turtles at site 2 appears to be much lower than at site 1 (Mota 2022). It is unknown if the Spotted Turtle population at site 2 originated from the 6 turtles translocated in 1985, which if so, would account for the smaller population size due to limited time to reproduce. However, if the Spotted Turtle population at site 2 originated from a naturally occurring population of Spotted Turtles that existed prior to the translocation, our results potentially suggest that carrying capacity could be lower due to less available habitat or lower habitat quality. While our study suggests that Spotted Turtles at site 2 have been able to meet their life-history needs within the ~2.09 ha patch of contiguous habitat, the amount of habitat currently available may be too low to support a robust population. In contrast, site 1 consists of a larger wetland complex with diverse microhabitat characteristics and hydroperiod dynamics, and this system is likely much more suitable for supporting a robust Spotted Turtle population over time (Roberts et al. 2023).

Our study demonstrates that knowledge of site-specific habitat use by Spotted Turtles is important when developing conservation and management plans, as patterns of habitat use vary across sites and may not fully align with perceived habitat availability or quality. Assessing site-specific habitat use can assist with identifying areas of "core habitat" or areas of greatest importance for the population as well as areas in need of habitat restoration. Further research is needed to improve our understanding of how intraspecific and interspecific competition interact with habitat quantity and quality to influence patterns of space use and population carrying capacities of Spotted Turtles to inform conservation actions for this declining species.

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