

SPATIO-TEMPORAL DIFFERENCES IN THE USE OF AGRICULTURAL FIELDS BY MALE AND FEMALE WOOD TURTLES (*GLYPTEMYS INSCULPTA*) INHABITING AN AGRI-FOREST MOSAIC

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ABSTRACT.—Recent studies have highlighted negative effects of agricultural activity on populations of the Wood Turtle (*Glyptemys insculpta*). Mitigating effects of agriculture on this imperiled species will require a thorough understanding of sexual and spatio-temporal differences in the use of fields by turtles. We investigated these factors using radio-telemetry data collected at the north-eastern limit of the species' range in Nova Scotia, Canada. Males used hayfields more frequently and for a greater proportion of the active season than did females, exposing them to greater risk of machinery-related mortality. Maintaining 43 m riparian buffer zones would protect males 95% of the time, although such buffers would encompass less than 65% of female movements. The only two mortalities recorded in our study were males. Perhaps more importantly, these males were killed during the second harvest, illustrating that the recommendations of a previous study, which suggested that disc mower blades be raised only during the first harvest, might not apply throughout the species' range. Possible strategies for conserving Wood Turtles within agricultural landscapes are discussed.

Key Words.—agriculture; conservation; habitat use; haying; *Glyptemys insculpta*; mortality; movement; Wood Turtle

INTRODUCTION

Vehicle- and machinery-related mortality poses a serious threat to turtle and tortoise populations worldwide. Whereas numerous studies have examined the effects of road mortality on the structure and dynamics of turtle populations (Gibbs and Shriver 2002; Marchand and Litvaitis 2004; Steen and Gibbs 2004; Gibbs and Steen 2005; Steen et al. 2006), fewer studies have explored the effects of other sources of anthropogenic mortality, including agriculture. The North American Wood Turtle (*Glyptemys insculpta*) uses hay and corn fields for nesting, basking, foraging and migration in areas where agricultural activity borders natural riparian habitat, thereby exposing this species to significant risk from agricultural machinery (Saumure et al. 2007; Castellano et al. 2008). Understanding effects of agricultural activities on this species is critical, because turtle populations are particularly sensitive to novel sources of adult mortality (Compton 1999). In addition, Wood Turtle population declines continue to be reported throughout the species' range (Garber and Burger 1995; Ernst 2001; Daigle and Jutras 2005; Saumure et al. 2007). In Canada, the status

of the Wood Turtle was recently elevated to "threatened" (Committee on the Status of Endangered Wildlife in Canada. 2007. Available from http://www.cosewic.gc.ca/eng/sct5/index_e.cfm [Accessed 10 May 2009]).

In southern New Hampshire, Tuttle (1996) recorded four Wood Turtles that had been mutilated by agricultural machinery. In southern Québec, Saumure and Bider (1998) also demonstrated that agricultural activities can lead to increased rates of injury and negatively affect individual growth and recruitment. In a more recent study, Saumure et al. (2007) showed that agricultural activities not only increase rates of injury, but also dramatically reduce juvenile and adult survival. Such decreases in survival may help explain the observation of a 50% decline in the number of Wood Turtles at the same agricultural site over a seven-year period (Daigle and Jutras 2005; Saumure et al. 2007). In this study, we sought to explore the generality of these findings using radio-telemetry data collected on a population of Wood Turtles in eastern Nova Scotia, Canada. Our specific objectives were to examine sexual and spatio-temporal differences in the use of agricultural fields; as well as to determine whether conserving

riparian buffers along agricultural fields could reduce the risk of turtle injury and mortality.

MATERIALS AND METHODS

This study was conducted on the eastern mainland of Nova Scotia, Canada (*c.* 45° N) in the Saint Mary's River watershed (SMRW). The SMRW has been extensively managed for forestry and agriculture for over 150 years. Although the number of farms in the SMRW has declined over the past 40 years (L.H. Buckland-Nicks, unpubl. data), agricultural practices related to hay and cattle production persist along portions of the east and main branches of the river. For a further description of the study area, see McCurdy and Herman (1997). Haying is typically done biannually with rotary disc mowers. The first harvest is generally in late June or early July; whereas, the second harvest usually occurs in late August or early September.

We caught 27 adult Wood Turtles (14 females, 13 males) opportunistically from June 2005 to May 2007 and fitted with 30-g Model AI-2F Holohil transmitters (Holohil Systems Ltd., Carp, Ontario, Canada). Transmitters weighed between 1.9 and 3.0% of turtle body mass. We sighted turtles one to five times a week from 18 April to 18 October 2007 and the coordinates of each location were recorded to an accuracy of *c.* 5 m using Garmin G76 units (Garmin Ltd., Oregon, USA). Although juvenile and hatchling Wood Turtles are known to use agricultural fields (Tuttle and Carroll 2005a; Tuttle and Carroll 2005b; Saumure et al. 2007), we decided to track only adults because understanding and mitigating causes of juvenile and hatchling mortality would have little impact on population persistence if the proximate causes of adult mortality are not identified and adequately addressed (Heppell et al. 1996; Compton 1999). To determine the size of riparian buffer that would be needed to protect Wood Turtles from agricultural machinery, we calculated the percentage of telemetry locations falling within hypothetical riparian buffers ranging from 0–400 m at 10 m intervals. All spatial analyses were done in ArcView 9.2 (ESRI, Redlands, California, USA).

RESULTS

We never observed turtles in corn fields; however, 14 of 27 turtles were observed within hayfields at least once. Although there was no significant difference between the proportion of males (0.54) and females (0.50) that used hayfields at least once, the number of instances in which males were observed in fields (*n* = 43) was more than double that of females (*n* = 21) when all individuals were combined. Furthermore, males used hay fields for more than a month longer than did females. Specifically, males occupied fields from 8

June to 19 August (73 days); whereas, females used fields only between 10 June and 17 July (38 days). Use of hayfields by females appeared to be largely associated with nesting activity. Females crossed fields during seasonal migrations to and from nesting beaches located along the river, and basked and foraged in a hayfield adjacent to the primary nesting beach between nesting attempts.

Five mortalities occurred as a result of agricultural activities from 2005–2007. In mid-July 2005, three adults (two female, one male) were killed in a single hayfield during the first harvest. We recorded two mortalities due to agricultural activities during 2007. The first was a male that was followed via radio-telemetry and was struck and killed by the tire of a disc mower during the second harvest in mid-August (Fig. 1). We found a second dead male nearly 2 km away along the margin of a hayfield in April 2008, before the first harvest had taken place. Although this turtle did not bear a transmitter, its location, coupled with the fact that its carapace was found in several irregular pieces, suggests that this individual was also struck by a disc mower during the second harvest. Our estimates of mortality are likely underestimates given the density of adults at our study site, and the reluctance of farmers to report wildlife mortalities.

Females were much more terrestrial than were males (Fig. 2). Most of these terrestrial excursions by females were associated with use of forested and regenerating stands in upland areas during the summer. During this time, females were occasionally observed nearly 400 m from the nearest water body. In fact, riparian buffers would need to be expanded to 235 m to encompass 95% of all female locations. For males, less than 0.01% of observations were further than 100 m from water.



FIGURE 1. Male Wood Turtle hit by the tire of a disc mower during the second harvest in the Saint Mary's River watershed, Nova Scotia, Canada, 2007. (Photographed by Reid Tingley).

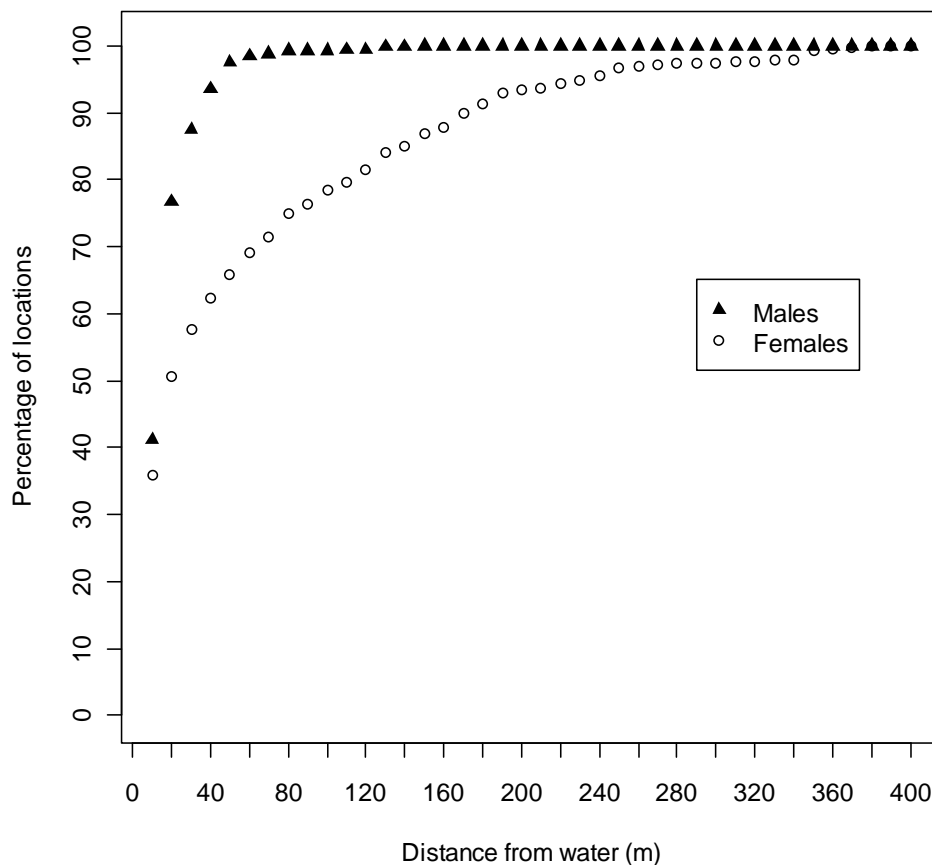


FIGURE 2. Accumulation curve showing the percentage of locations within different-sized riparian buffers for male and female Wood Turtles in the Saint Mary's River watershed, Nova Scotia, Canada, in 2007.

A buffer zone of 43 m would protect male Wood Turtles 95% of the time.

DISCUSSION

Our results suggest that male Wood Turtles may be at greater risk of agriculture-related mortality than females at this particular study site. Males occupied hayfields more often and for more than a month longer than did females. Our buffer-based analyses indicated that this increased risk was due to males frequently occupying riparian areas that incorporated agricultural fields. A more detailed analysis of spatio-temporal habitat use in the studied population also found that males frequently selected flat, low-elevation, riparian scrub-shrub habitats throughout the year (Tingley et al., unpubl. data). Burns (2007) documented more severe injuries among males in our study area, although predators cannot be ruled out as a source of some of these injuries. Furthermore, Burns (2007) found that severity of injury was not correlated with the amount of agricultural land present in various-sized buffers. However, many agricultural fields in the GIS database used by Burns have long been abandoned, and this temporal lag between the two databases may

have weakened the relationship between injury severity and agricultural land-use (Burns 2007).

Although our buffer-based analyses indicated that expanding riparian buffers to 43 m would protect male Wood Turtles from agricultural machinery 95% of the time, such buffers on private agricultural lands are unlikely without financial compensation for farmers (Compton 1999; Saumure et al. 2007). Furthermore, addressing the management needs of female turtles would require the designation of extensive riparian buffers that would incorporate nearly every hay and corn field in our study area. A review of the literature suggests that such broad riparian buffers would be required in many areas of the species' range (Table 1). However, in the current study, males and females frequently inhabited narrow (c. 10 m) scrub-shrub ecotones bordering hayfields, suggesting that maintaining riparian buffer strips may substantially reduce mortality (Saumure et al. 2007). Indeed, the existence of such ecotones in our study area may help explain why we recorded less mortality than did Saumure et al. (2007), who worked in a region where these habitat features were rare.

Raising the blades on disc mowers to 100 mm would

Table 1. Terrestrial movements made by Wood Turtles in various regions of North America. Data are presented for both sexes combined.

Location	Maximum distance (m)	95% quantile (m)	Source
Pennsylvania, USA	600	300	Kaufmann (1992)
Maine, USA	599	243	Compton (1999)
Michigan, USA	> 500	200 ^a	Remsburg et al. (2006)
Ontario, CAN	> 500	-	Foscarini and Brooks (1997)
Ontario, CAN	449	-	Greaves (2007)
Nova Scotia, CAN	389	182	This study
Québec, CAN	300	200	Arvisais et al. (2002)
Pennsylvania, USA	250	40 ^b	Ernst (2001)
New Hampshire, USA	231	175	Tuttle and Carroll (2003)

^a 200 m encompassed 92.5% of all locations.

^b Turtles were not followed by radio-telemetry. Movement distances are therefore likely to be underestimates.

also likely reduce the probability of Wood Turtle mortality (Saumure et al. 2007). Raising mower blades has been shown to increase yields, reduce wear on machinery, and decrease soil erosion (reviewed by Saumure et al. 2007). However, our observation of a male being struck by the tire of a disc mower reinforces the fact that raising mower blades will not guarantee Wood Turtle survival. Nevertheless, we suggest that raising mower blades, as recommended by Saumure et al. (2007) has merit and will likely reduce machinery-related mortality within Wood Turtle populations.

We do, however, offer a caveat to the recommendations of Saumure et al. (2007), who suggested that the blades on disc mowers be raised only during the first harvest. Most turtles at their study site had returned to the river by the second harvest. At our study site, both males and females used hayfields most frequently in June and July, but males continued to use hayfields well into August. Furthermore, although two females and one male were killed during the first harvest in 2005, in 2007, two males were struck by disc mowers during the second harvest. However, these divergent patterns between the sexes are not necessarily consistent throughout the species' range. In some populations, females frequently occupy hayfields throughout the summer (Tuttle and Carroll 2003; Foscarini and Brooks 1997). Regardless of whether sex-specific differences in the propensity to use hayfields exist, it is evident from these observations that agricultural activities during the second harvest may increase injury and mortality of Wood Turtles, and that these activities should be modified accordingly.

Our study did not address spatio-temporal patterns in the use of hayfields by juveniles or hatchlings, but previous research suggests that agricultural activities during both the first and second harvests may be pertinent to the survival of these life stages as well. Castellano et al. (2008) reported that hatchling Wood Turtles in New Jersey used corn fields for up to 68 days following emergence. In a New Hampshire population

of Wood Turtles, juveniles and hatchlings often occupied hayfield edges, and one hatchling remained in a hayfield for 26 days (Tuttle and Carroll 2005a; Tuttle and Carroll 2005b). Saumure et al. (2007) also documented the death of two juveniles due to streambank erosion caused by agricultural activities.

Unfortunately, a more thorough understanding of sexual and spatio-temporal variation in mortality risk is hampered by a paucity of long-term studies, coupled with the rarity and stochasticity of mortality events. We argue that a close cooperation between farmers and wildlife biologists will therefore be critical to the conservation of Wood Turtles within agricultural landscapes. The results of our recent landowner outreach program are certainly testament to this notion; the two primary hay farmers in our study area have agreed to raise the blades on their disc mowers to 100 mm on the first two passes closest to the river beginning in 2009. Although raising disc mower blades has numerous advantages for farmers (Saumure et al. 2007), farmers are often reluctant to change their practices due to perceived forage losses. Outreach programs should therefore be adopted in other areas of the Wood Turtle's range where there are conflicts between conservation and landowner needs.

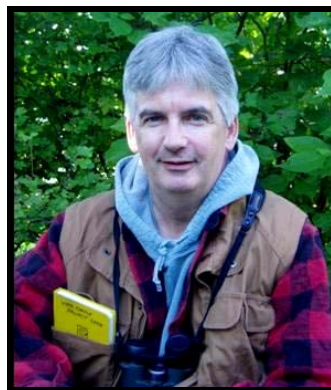
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