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Home Range and Site Fidelity of Imperiled Ornate Box Turtles (Terrapene ornata) in Northwestern Illinois

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ABSTRACT. – The destruction of prairies has led to the decline of the ornate box turtle (Terrapene ornata) across much of its range. Land management agencies are considering translocation programs to restore populations to areas from which they have been extirpated. For these conservation efforts to be successful, long-term posttranslocation monitoring is necessary to ensure that translocated individuals behave and use habitat similarly to unmanipulated individuals. We conducted a 3-yr radiotelemetry study of a potential source population of ornate box turtles to provide baseline data on home range size and site fidelity pretranslocation. Adult males and females did not differ in minimum convex polygon home range size (mean 4.0 ha), 95% fixed kernel home ranges (mean 2.6 ha), or 50% fixed kernel home ranges (mean 0.4 ha). Both sexes showed high site fidelity to annual home ranges and to previously used overwintering sites, although distance between subsequent overwintering sites was less for females than for males. At our study site, ornate box turtles have relatively small home ranges and exhibit strong site fidelity. Translocation programs for this species should closely monitor movements of translocated individuals to assess whether they are successfully establishing new home ranges or attempting to return to their site of origin. Moreover, the high site fidelity exhibited by this species suggests that newly translocated individuals may be at increased mortality risk because they are unfamiliar with suitable overwintering and/or nesting sites in their new location. The results of our study will be used to ensure that sites to which animals are translocated are comparable to the site of origin in terms of home range size requirements and important habitat features. In addition, our data serve as a critical baseline to which the habitat use and movement patterns of monitored animals posttranslocation can be directly compared to assess the success of the translocation.

KEY WORDS. – Reptilia; Testudines; Emydidae; fixed kernel; habitat use; Illinois; minimum convex polygon; overwintering; radiotelemetry; sand prairie; Terrapene ornata

Habitat loss and fragmentation have led to the decline and extirpation of diverse taxa. In the central United States, native prairie habitats have been extensively fragmented and destroyed by development and conversion to agricultural land; it is estimated that native prairie habitat now covers only 3% of its original range (Bachand 2001). As native prairie is destroyed, species dependent on prairie habitat also decline. One such species is the ornate box turtle (Terrapene ornata), which inhabits sand prairie habitat in the central and southern United States and northern Mexico (Ernst and Lovich 2009). Ornate box turtles are state-listed as endangered, threatened, or of special conservation concern throughout their US range as a result of habitat loss and overcollecting for the pet trade (Converse et al. 2005); moreover, these causes of decline have resulted in small, isolated populations with restricted gene flow (Kuo and Janzen 2004; Richtsmeier et al. 2008). Furthermore, because box turtles locate mates visually, if populations fall below a threshold density, individuals may fail to encounter conspecific mates and reproduction may cease (Belzer 2002).

Ornate box turtles have recently been elevated to threatened status in Illinois due to habitat destruction and overcollecting (Illinois Endangered Species Protection Board 2010). We studied a population of ornate box turtles in northwestern Illinois in one of the state’s last remnants of native sand prairie. The ornate box turtle population at this site is believed to be one of the largest in the state. Nevertheless, vehicular roads and a popular recreational bike trail bisect the sand prairie at our study site and box turtles are therefore subject to road mortality and collection as pets (J.M. Refsnider, pers. obs.). Moreover, land management activities such as prairie burning and removal of encroaching woody vegetation may be affecting box turtles at the study site.

In contrast to our study site, other nearby box turtle populations are extremely small and isolated and it is unknown whether recruitment is occurring. Despite habitat restoration projects designed to restore sites historically occupied by ornate box turtles to habitat suitable for the species, intensive survey efforts have detected only a few old individuals and no evidence of recent recruitment (E. Britton and J. Strickland, unpubl. data, 2010). Therefore, if ornate box turtles are to be returned to historically occupied and currently suitable sites, management interventions
such as translocation or head-starting of captive-reared juveniles may be necessary. The large population at our study site could be an ideal source for these translocations or head-starting efforts to repopulate sites from which ornate box turtles have been effectively extirpated.

Translocations are a controversial management strategy, particularly for reptiles, and are often considered a last-resort option due to risks such as outbreeding depression, disease transfer, and reproductive failure (Reinert 1991). To increase the likelihood of success, translocation programs should match habitat characteristics at the translocation site with those of the source site so that translocated individuals are less likely to leave the translocation site in search of more favorable habitat (Griffith et al. 1989). Moreover, translocated populations must be monitored for several years to determine whether individuals are using their new habitat comparably with the source habitat, displaying similar movement patterns to what was observed at the source site, and reproducing successfully (Dodd and Seigel 1991).

The objectives of our study were to collect baseline data on home range size, movement patterns, and site fidelity in a potential source population of ornate box turtles. Secondarily, we sought to identify potentially important habitat features and vegetation types used by the study population. Baseline data for the source population prior to removing any individuals for translocation will allow us to compare the behavior of individuals in translocated populations to that of the source population, and thereby assess a key aspect of the success of the translocation program. In addition, by collecting baseline data from the source population pretranslocation, we will be able to monitor the source population for changes in demography and recruitment in response to removal of individuals for translocation.

**METHODS**

We studied a population of ornate box turtles in sand prairie habitat in Carroll County, Illinois, for 3 yrs during 2008–2010. The study site is described in detail in Bowen et al. (2004) and consists of approximately 1 km of shoreline extending approximately 400 m inland along the eastern bank of the Mississippi River. The sand prairie is dominated by needlegrass (*Spira sp.*) and interspersed with patches of prickly pear cactus (*Opuntia humifusa*), aromatic sumac (*Rhus aromatica*), and spiderwort (*Tradescantia sp.*). A strip approximately 10 m wide immediately bordering the river is dominated by deciduous trees, black raspberry (*Rubus occidentalis*), and poison ivy (*Toxicodendron radicans*). Isolated raspberry patches and red cedar (*Juniperus virginiana*) are scattered throughout the study site. The site is bisected by a bicycle path and a 1-lane road and the eastern edge is bordered by railroad tracks.

Turtles were initially located and captured by hand during visual encounter surveys in May of each year. All turtles were sexed, measured (straight and curved carapace length and width; plastron length and width), and marked with a unique combination of notches filed into the marginal scutes (modified from Cagle 1939). Due to a long-term mark–recapture study of this population (e.g., Kuo and Janzen 2004), many individuals included in this study had already been marked; therefore, we know that the notches used to identify individuals are visible in adults for ≥ 10 yrs. We affixed radio-transmitters (model R1850, Advanced Telemetry Systems, Isanti, MN) to vertebral scutes 2 and 3 using 5-min epoxy. Transmitters weighed 11.2 g, or up to 4% of adult body mass. All turtles were held overnight to ensure that the glue used to attach the transmitters had completely dried before being released at the site of capture.

We used ground-based radiotelemetry and monitored turtles using a receiver (R2179, Advanced Telemetry Systems) and a 3-element yagi antenna. In each year of the study, turtles were tracked 2–5 times weekly in May and June, approximately weekly from July to October, and several times between November and April to ascertain overwintering locations. Turtles were tracked at different times of the day to minimize diel effects on locations of individuals. In May 2009, we recaptured all radio-marked turtles, held them overnight to replace transmitters, and released them within 24 hrs at the site of capture. Locations of turtles were confirmed visually except when individuals were burrowed underground or tracked to dense patches of poison ivy; in these circumstances turtle locations were estimated to within 5 m. For each radio-location, we recorded geographic coordinates using a handheld global positioning system unit (GPSmap 76, Garmin, Olathe, KS), whether the turtle was visible aboveground or not visible and belowground, and its activity (e.g., walking, eating, resting on surface, partially hidden in a burrow, etc.).

Radio-locations were plotted on 2001 aerial photographs in ArcView 3.2 (ESRI, Redlands, CA). For each individual, we estimated home range sizes using the minimum convex polygon (MCP) method and the fixed kernel method (using both 50% and 95% fixed kernels) in the Animal Movement Extension for ArcView 3.2 (Alaska Biological Center, US Geological Survey, Anchorage, AK). Kernels were smoothed using least-squares cross-validation (Seaman and Powell 1996) and we recorded the number of activity centers in each individual’s 50% fixed kernel using this smoothing method. MCPs were calculated for each individual in each year they were tracked, as well as an overall MCP including all radio-locations; 95% and 50% fixed kernels were calculated by pooling all radio-locations for an individual. We estimated site fidelity for individuals tracked during multiple years of the study in 2 ways. First, we determined home range fidelity by calculating the percent overlap between subsequent annual MCPs using the Geoprocessing feature in ArcView 3.2 with the following formula:

\[
\text{Overlap} = \frac{\text{Area}_{\text{overlap}}}{\text{Area}_{\text{year1MCP}} + \text{Area}_{\text{year2MCP}} - \text{Area}_{\text{overlap}}} \times 100.
\]

Second, we determined overwintering site fidelity by measuring the distance between an individual’s hibernacula during subsequent years.
All statistical analyses were conducted in SAS 9.2 (SAS Institute, Cary, NC). We compared mean 50% and 95% fixed kernel home range sizes and number of activity centers between females and males using t-tests with years pooled for each individual. We compared mean MCP size, percentage of annual MCP overlap between years, and mean distance between subsequent overwintering sites with a 1-way analysis of variance in the MIXED procedure; in this analysis, we included individual identity as a random effect because we had multiple years of data for some individuals. To determine whether estimates of home range fidelity were correlated with those of overwintering site fidelity, we regressed each individual’s mean percentage of home range overlap against mean distance between subsequent overwintering locations using the GLM procedure. Finally, because individual home ranges can be underestimated if too few locations are obtained (e.g., Anich et al. 2009), we regressed individual MCP (years pooled) against both the number of years tracked and the total number of radio-locations obtained using the GLM procedure. All values are reported as means ± standard deviation (SD).

RESULTS

We collected 1228 radio-locations of 24 adult ornate box turtles during 2008–2010. The number of radio-locations obtained per individual ranged from 24 to 93 (mean 51). We radio-tracked 4 females and 5 males in 2008–2010; 1 additional male and 13 females were radio-tracked in 2009–2010 only. One adult male tracked in 2008 was found depredated in September 2008, the only instance of mortality in this study. We observed 11 instances of both male and female radio-marked box turtles copulating (5 observations in spring and 6 in fall).

Mean MCP home ranges were 4.3 ± 5.0 ha SD for females and 3.1 ± 2.0 ha SD for males (Fig. 1, top). Ninety-five percent fixed kernel home ranges were 2.4 ± 0.8 ha SD for females and 2.8 ± 1.0 ha SD for males and 50% fixed kernel home ranges were 0.4 ± 0.1 ha SD for both sexes (Fig. 1, bottom). Activity centers averaged 1.9 ± 0.8 ha SD for females and 1.7 ± 0.5 ha SD for males. There were no significant differences in any home range estimate between the sexes (all p values > 0.40). Estimates of MCP home range size were not correlated with either the number of years an individual was tracked ($F_{1,22} = 0.07, p = 0.79, r^2 = 0.003$) or the total number of radio-locations obtained for an individual ($F_{1,22} = 0.28, p = 0.60, r^2 = 0.01$).

The percentage overlap of annual MCP home ranges was 35.6% ± 16.8% SD for females and 41.8% ± 11.1% SD for males and was not significantly different between the sexes ($F_{1,9} = 1.98, p = 0.19$; Fig. 2). However, females showed significantly stronger fidelity to overwintering sites than males, with an average distance between subsequent overwintering sites of 11.9 ± 22.6 m compared to 88.6 ± 113.2 m for males ($F_{1,8} = 6.79, p = 0.03$). Among-year fidelity to home range was not correlated with among-year fidelity to overwintering site (that is, individuals with higher overlap among annual MCP home ranges did not have shorter distances between subsequent overwintering sites; $F_{1,18} = 0.01, p = 0.93, r^2 = 0.04$).

DISCUSSION

Habitat loss and fragmentation have resulted in population declines across broad taxonomic groups and restoring declining populations can be difficult and expensive. Translocation is one mechanism for population restoration, yet unease exists regarding its implementation, particularly for reptiles. In this study, we collected
baseline data essential for assessing translocation success in a population of ornate box turtles prior to any removal of individuals.

Home range sizes of female and male box turtles were similar, regardless of the home range estimator used. Home ranges in our study population were similar to those of an Iowa population (Bernstein et al. 2007), but smaller than in a Wisconsin population (Doroff and Keith 1990) and larger than in a New Mexico population (Nieuwolt 1996; Curtian 1997; Bernstein et al. 2007) and to overwintering sites (Metcalf and Metcalf 1979; Doroff and Keith 1990; Converse et al. 2002; Bernstein et al. 2007). In our study population, 82% of overwintering locations were within 15 m of an individual’s hibernaculum of the previous year, and 57% were within 5 m. Estimates of home range size were not larger for individuals for which we had more radio-locations or tracked over more years (e.g., Anich et al. 2009); therefore, we are confident that we acquired sufficient radio-locations for all individuals to accurately assess home range sizes.

That radioed turtles of both sexes were observed mating indicates that the attachment of radio-transmitters did not preclude reproductive behavior in either sex. More importantly, however, our observations of reproductive behavior indicate that the turtles in our study population occur at sufficiently high density that individuals encounter conspecifics with which to mate (e.g., Belzer 2002). Indeed, home ranges of both sexes overlapped extensively (Fig. 1), which suggests that individuals likely regularly encounter potential mates within their home ranges. Although none of the radio-marked turtles was observed nesting, 8 juvenile box turtles (approximately 3–4 yrs old based on growth annulus counts) were encountered, suggesting that recruitment is occurring in this population.

Our results for home range size and among-year site fidelity have important implications for potential translocation programs for this species. This study provides baseline data on home range and activity-center size and similar parameters collected for individuals posttranslocation could be compared to this baseline to assess the success of the translocation and its effects on normal behavior (e.g., Dodd and Seigel 1991). For example, posttranslocation individuals displaying sustained, large activity centers compared to pretranslocation baseline levels may be at increased mortality risk due to unusual movement patterns and landscape use (but see Kiester et al. 1982). In addition, the strong site fidelity exhibited by ornate box turtles in our study indicates that individuals maintain familiar home ranges among years and that within those home ranges they habitually return to sites in which they have successfully overwintered previously. Similar fidelity to nest sites has been observed in other populations (Bernstein et al. 2007). Individuals translocated to a novel area are unfamiliar with locations that provide suitable conditions for hibernation or nest development and may be at increased risk of overwintering mortality or nest failure compared to unmanipulated animals (reviewed in Reinert 1991; Germano and Bishop 2008). Importantly, we recommend that posttranslocation monitoring for ornate box turtles be conducted using radiotelemetry, as detectability using traditional visual encounter surveys is extremely low for this species (Refsnider et al. 2011).

Finally, we observed several particular vegetation features used by box turtles at our study site. On hot afternoons, we often observed turtles sheltering under red cedar trees. Although cedars are one of the woody species

Figure 2. Annual minimum convex polygon home ranges (black outlines) and overwintering sites (white plus signs) for a representative female (top) and male (bottom) ornate box turtle (Terrapene ornata) radio-tracked during 2008–2010 in a sand prairie in Carroll County, Illinois.
that encroach on prairie habitat and, therefore, are targeted for removal by management efforts, isolated cedars scattered across the landscape appear to be important for thermoregulation by box turtles. We recommend that a few individual trees be left intact. We also observed extensive box turtle use of a narrow riparian zone. The riparian zone was heavily vegetated at ground level and thereby provided both shelter and easily accessible moisture (in the form of dew) on hot days. The importance of water sources during hot weather has been demonstrated in other box turtle populations, especially those near the limit of the species’ thermal tolerance (Converse and Savidge 2003; Plummer 2003) and should be considered habitat features essential to box turtle populations. In addition, box turtles fed heavily on raspberry fruits when they were available; patches both within and outside the riparian zone were used extensively, and individuals’ core areas tended to include raspberry patches. In light of the apparent importance of scattered cedar trees and raspberry patches to box turtles at our study site, we recommend that sites considered for translocation of this species include at least some scattered shade trees and patches of raspberry plants.

In conclusion, we found that male and female box turtles in a western Illinois sand prairie had home ranges of similar sizes and displayed high fidelity to annual home ranges and to overwintering sites. Our findings will be useful in ensuring that sites to which turtles are translocated are comparable to the site (or sites) of origin in terms of home range size requirements and important habitat features. In addition, our data serve as a critical baseline to which the habitat use and movement patterns of monitored turtles posttranslocation can be directly compared to assess the success of the translocation.

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**Literature Cited**


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