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Long-term comparison of relocated and resident box turtles, *Terrapene carolina carolina*

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ABSTRACT - The eastern box turtle, *Terrapene carolina carolina*, is a long-lived turtle species that is declining across much of its range. A mark-recapture study of this species was carried out for over thirty years at the Mason Neck National Wildlife Refuge in Virginia. During this time, box turtles were relocated to the reserve and became part of the study. Several individuals were recaptured more than ten years after relocation including one that was recaptured after almost 28 years. Overall, however, turtles relocated to the study area appeared not to fare as well as resident turtles. Significantly fewer relocated turtles were recaptured after their first winter at the new site (33.3 %) than resident turtles (51.5 %) though the survival rates for relocated and resident turtles were similar for subsequent years. Relocation can work as a rescue strategy for some individuals but it can also negatively impact relocated individuals. This study is the first to show long-term residency of relocated box turtles.

INTRODUCTION

The eastern box turtle, *Terrapene carolina carolina*, is declining across its range (Ernst & Lovich, 2009) and effective management techniques are required to protect populations that are in danger. In the case of habitat loss, one such technique is the relocation of individuals to reserves. However, studies highlighted below have shown that relocation programmes may not be effective rescue strategies for *Terrapene* spp.

The principles of population ecology tell us that a particular habitat can only support a given number of turtles and for this reason relocated turtles may have to disperse away from where they are released. Most adults have a homing tendency when displaced (Nichols, 1939) so these relocated box turtles may simply try to return to their home range, expending valuable time and energy in the process (Dodd, 2001). Belzer (1997) found that few relocated turtles established home ranges in the new site into which they were introduced in Pennsylvania. In New York, Cook (1996) found that many relocated *T. carolina* did establish home ranges but survivorship was lower for relocated individuals than for individuals that had not been relocated. Relocated *T. carolina* in North Carolina had larger home ranges, moved a greater average daily distance and were more likely to experience mortality or disappearance than resident box turtles (Hester et al., 2008).

Since 1980, a long-term, mark-recapture study of the eastern box turtle has been undertaken at the Mason Neck National Wildlife Refuge. Besides the established population, other eastern box turtles were relocated to this reserve during the 1980s and 1990s and the present study provided an opportunity to measure the long-term residency rates of these relocated turtles. Survivorship and recapture rates of relocated turtles are compared with those of resident turtles.

MATERIALS AND METHODS

The study area was a 30 ha tract of wildlife reserve (Elizabeth Hartwell Mason Neck National Wildlife Refuge, 38°67’ N, 77°10’ W, ~25-35 m asl) in Fairfax County, Virginia. Located within the Washington DC suburbs, the Mason Neck peninsula contrasts sharply with most of the metropolitan area in remaining largely undeveloped. The reserve contains an 83 ha freshwater tidal wetland marsh (the “Great Marsh”). A variety of habitats can be found on the reserve but it is generally a well-drained mixed deciduous upland forest.

The study site is an abandoned farm located at the end of a gravel road that bisects the reserve and located adjacent to the Great Marsh and the Potomac River. This area of the reserve is accessible only by permit except during the annual deer hunt. Since being ceded to the Federal Government in the 1960s, the farmland has undergone succession and is now mostly wooded. At the time of this study a few open areas remained including a small grass parking lot, a shooting range and a 3 ha (ca.) field that was mowed at three-year intervals.

The work done in this study conformed to the British Herpetological Society’s Ethical Policy and Guidelines (British Herpetological Society, 2017) and met all legal requirements. Between 1984 and 1993, seventy-eight *T. carolina* were relocated, primarily for mitigation reasons, to the Mason Neck National Wildlife Refuge study site from other locations (by authors CE and TB). Most of the relocated individuals had been found on or adjacent to roads and paths in the northern Virginia area, while others were relocated from George Mason University’s Fairfax campus which was then undergoing various construction and expansion projects. Some of these turtles were subsequently recaptured during the study.

The tract was searched with special emphasis given to areas where turtle captures were abundant during previous research. The study ran for three years (2011-2013) with the field season beginning in April and ending before the annual deer hunt in November. Since the annual activity cycle for this turtle had already been established (Ernst & Lovich, 2009), field work was concentrated in the spring when, historically, most captures occurred (Boucher, unpublished data). At this time of year, the turtles, passing though and flattening the invasive Japanese stiltgrass (*Microstegium vimineum*), could be tracked easily. The hottest part of summer (late June to the end of August), when few turtles are found (Boucher, 1999), was avoided.

For individual identification we used a method modified from Ernst et al. (1974), in which turtles were marked with notches on various marginal scutes. These were assigned numbers (Fig. 1) and the sum of those filed was the individual turtle number.

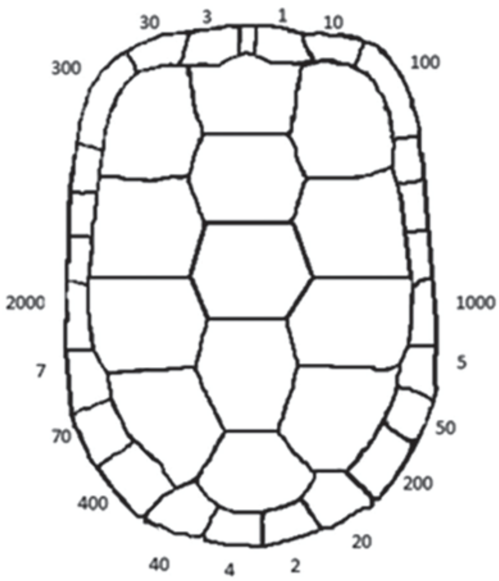

Figure 1. System for marking box turtles by filing marginal scutes. The turtle's unique identifying number is determined by finding the sum of the numbers assigned to the marked scutes.

Sex was determined by visual inspection of the turtle using several sexually dimorphic traits, e.g. carapace/plastron shape, tail size, hind leg claws, eye colour (Ernst & Lovich, 2009). The IBM SPSS Statistics 19 package was used for all statistical tests and differences were treated as statistically significant when the probability of them occurring by chance was 5 % or less (p≤0.05).

RESULTS

The adult sex ratio favoured males in both the relocated and resident turtles (Table 1) and there was no significant difference in adult sex ratio between the two samples (proportion test, z = -0.03, p = 0.976). At the time juveniles were introduced to the reserve they made up 15.4 % (12 of 78) of the relocated population and 14.5 % (62 of 428) of the resident population caught during the same period (Table 1) with no significant difference between the two samples (proportion test, z = -0.21, p = 0.834).

Table 1. Comparison of resident turtles and relocated turtles, adult (10 years+) sex ratio, and juveniles (<10 years) proportion of population, 1984-1993

	Adult sex ration (M:F)	% Juveniles
Resident	1.35:1 (n=366)	14.5 (n=62)
Relocated	1.36:1 (n=66)	15.4 (n=12)

Relocated turtles had a 43.6 % (34 of 78) recapture rate. By comparison, resident turtles that were originally captured during the same period had a 55.0 % recapture rate. The difference in recapture rates for relocated and resident turtles is not significant (z = -1.86, p = 0.063).

Resident turtles were also recaptured more frequently and over a greater period than relocated turtles. Resident turtles were recaptured a mean of 2.1 times (range = 0 - 38) compared to 1.6 times (range = 0 - 21) for relocated turtles. For turtles that were recaptured, mean difference between first and last capture for resident turtles was 3034.5 days (range = 1 - 10,586; n = 237) while for relocated turtles it was 2512.8 days (range = 7 - 10,217; n = 34).

The survivorship at the study site, based on raw recapture rates, through the first ten years is shown in Figure 2. The only year with a significant difference in survival was the first year (proportion test, z = 2.96, p = 0.003). Survival through each subsequent year was similar for resident and relocated individuals (Table 2). Once a relocated *T. carolina* persisted through the first winter, its likelihood of being recaptured at the study site was similar to that of resident turtles.

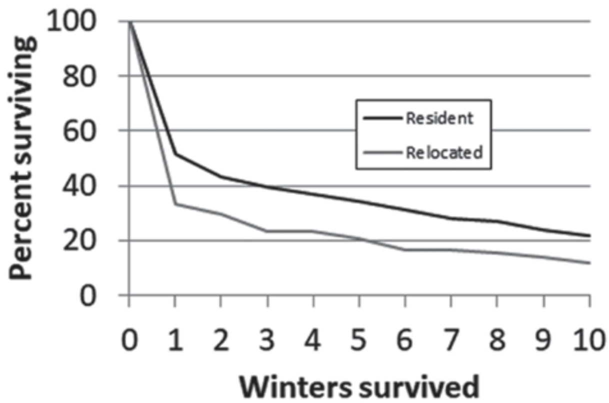

Figure 2. Survivorship of resident and relocated turtles

Table 2. Survivorship through each winter following year of original capture

Winter	1*	2	3	4	5	6	7	8	9	10
Resident % persistence	51.5	84.2	90.9	93.5	92.5	91.2	89.6	96.7	88.8	90.3
Relocated % persistence	33.3	88.5	78.3	100	88.9	81.3	100	92.3	91.7	81.8

*Significant difference between resident and relocated turtles (proportion test)

Table 3. Recapture rate, mean number of recaptures, and mean number of days between first and last capture for resident and relocated turtles

	Recapture rate	Mean no. of recaptures*	Mean period (days) between first and last capture
Resident			
Juveniles	37.8% (14/37)	0.49	1757.7
Adult females	58.1% (100/172)	2.42	3221.9
Adult males	55.9% (123/220)	2.06	3027.4
Relocated			
Juveniles	30.8% (4/13)	0.46	3393.8
Adult females	39.3% (11/28)	2.25	2261.0
Adult males	51.4% (19/37)	1.49	2065.3

* The mean value for the number of times each individual was recaptured

Table 4. Relocated turtles with survivorship of more than ten winters at the study site

Number	Sex	Date of release	Last date of recapture	Winters survived
239	**M**	**7 June 1984**	**28 May 2012**	**28**
74	M	17 May 1988	16 Sept. 2012	24
402	F	6 June 1984	14 June 2003	19
157	M	7 Sept. 1992	21 May 2011	19
260	M	22 June 1984	7 Sept. 2002	18
296	F	11 June 1985	22 Sept. 2001	16
398	M	20 Sept. 1987	23 May 2003	16
331	F	30 July 1985	17 May 1997	12
1034	M	7 August 1992	26 April 2003	11

Among relocated turtles, we recaptured more males than either females or juveniles (Table 3) but for resident turtles, females recapture rates were higher and occurred over a longer period. Relocated juveniles had a lower recapture rate and lower mean number of recaptures than either males or females but were recaptured over the longest mean time interval. Some relocated turtles were found at the study area long after relocation (Table 4), up to almost 28 years later in one case.

Some relocated turtles had injuries. If the recapture rate is recalculated separately for uninjured and injured turtles, then the recapture rate is lower for uninjured, relocated turtles (39.6 %, n=53) than for injured, relocated turtles (52.0 %, n=25). Uninjured, relocated turtles were recaptured a mean number of 1.9 times while injured, relocated turtles were recaptured a mean number of 1.0 times. The difference was not significant (two-sample t-test, p = 0.17).

DISCUSSION

Survivorship is difficult to measure in an open *T. carolina* population. If an individual turtle is never recaptured it could be that: a) the turtle had died, b) the turtle had emigrated, or c) it had remained in the area but had avoided detection. It was impossible in this study to distinguish between death and emigration unless a dead turtle was found. Much more likely than finding a dead turtle was the possibility that a turtle was released and simply never seen again and consequently 'survival' estimates in this study are conservative. An alternative approach to estimate survival, not employed in the present study, is to use CMR models (Dodd, 2016; McDiarmid et al., 2012).

Cook (2004) found that all *T. carolina* that established home ranges at the release site did so within three years of being released. In this study, only 23.1 % of relocated turtles persisted at least three winters after being released as compared to 39.4 % for resident turtles. Some relocated turtles, however, survived and were found at the study area long after relocation. Based on these individuals, assuming they are a true representation, then *T. carolina* relocation seems to be of limited value as a conservation measure as only a third survived the first winter and less than a quarter persisted long enough to establish home ranges. Nevertheless, this is preferable to a 0 % survival rate for turtles that are not relocated.

An examination of factors that determine whether a turtle will establish a home range at its release site could be a useful conservation tool. Females might be more sedentary or less likely to disperse from a release site than males even though studies have shown that female home ranges are larger (Ernst & Lovich, 2009). Lower recapture rates and mean number of recaptures for juveniles (Table 3) can be explained by lower juvenile survivorship and the fact that small turtles are more difficult to find and recapture. Younger juveniles at Mason Neck often remain concealed in the leaf litter (C. Ernst personal observation). That juveniles had the longest mean time interval between release and last recapture (Table 3) is expected because juveniles have more possible years of survival ahead of them. Juveniles may also be less likely to disperse far from the release site because of their small size. They are slower than adults and have a shorter stride (Marvin & Lutterschmidt, 1997). *Terrapene carolina* juveniles also have smaller home ranges than adults (Ernst & Lovich 2009).

One of the goals of relocating turtles is to establish or strengthen breeding populations. Little information has been reported on reproduction by relocated *T. carolina* though they have been observed laying eggs (Cook, 2004). Some of the relocated turtles in this study may have reproduced after their release at the Mason Neck National Wildlife Refuge and their genes may now contribute to the Mason Neck population. One relocated male and one relocated female were found courting resident turtles, six years after relocation in the case of the male and two years after relocation for the female.

Complicating the issue of lower persistence by relocated turtles compared to resident turtles at our research site, is that relocated turtles were more likely to have been originally found with injuries than residents. It is possible that this influenced the lower recapture rate for relocated turtles, especially if injured individuals later died from their injuries. This does not, however, appear to be the case. Injured turtles appear to be more subject to recapture. It could be that their injuries limit their ability to disperse. Only 67.9 % of relocated turtles (53 of 78) were found without injury compared to the 90.2 % reported for the Mason Neck population (Boucher & Ernst, 2004). The nature of the injuries was also often more serious for relocated turtles. Some appeared to have injuries from vehicle encounters which was not surprising since many were found along roads. Vehicle injuries are rare on the wildlife reserve which has limited vehicular access though one resident reserve turtle was injured when struck by a mower. It seems likely that *T. carolina* on the Mason Neck National Wildlife Refuge are less susceptible to injury than *T. carolina* from most of the rest of northern Virginia because the reserve and surrounding land on the Mason Neck peninsula form a large area of undeveloped protected land.

Terrapene carolina relocation may work as a rescue measure for some individual turtles. This study is the first to provide evidence of long-term residency of relocated box turtles, including one individual that was recaptured almost 28 years after relocation. Relocation should not, however, be treated as a mitigation or conservation measure that has no negative impact on relocated animals. Only a third of relocated animals were recaptured after their first winter at the new location. Managers involved in relocation decisions should question whether the effort of relocation is justified when only a third of the relocated animals survive their first winter at the new site. Releases may also have negative impacts on the resident population if the population density is increased to the point that resident and released turtles are in competition for limited resources, or if the released turtles introduce diseases. Relocating animals into large, semi-natural enclosures at the new location could help them to acclimatise, particularly if the enclosures provide habitat for successful hibernation and overwintering such as deep leaf litter, soil that is well drained and easily burrowed into, and a protective canopy.

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