Herpetological Conservation and Biology 16(3):715–725.
Submitted: 16 September 2020; Accepted: 11 November 2021; Published: 16 December 2021.

Mortality of Eastern Box Turtles (*Terrapene c. carolina*) After a Growing Season Prescribed Fire

Scott W. Buchanan[1,3], Tanner K. Steeves[1], and Nancy E. Karraker[2]

[1]Rhode Island Department of Environmental Management, Division of Fish and Wildlife, 277 Great Neck Road, West Kingston, Rhode Island 02892, USA
[2]University of Rhode Island, Department of Natural Resources Science, 1 Greenhouse Road, Kingston, Rhode Island 02881, USA
[3]corresponding author, e-mail: scott.buchanan@dem.ri.gov

Abstract.—**Fire is a key natural process that has shaped ecosystem distribution and composition for hundreds of millions of years. Prescribed fire has become a common and important technique in habitat management. With its ability to alter physical and vegetative conditions, prescribed fire has the potential to change wildlife habitat characteristics in ways that benefit or harm populations of wildlife, but implications for reptiles are considered only infrequently. In May and June 2018, a prescribed burn was conducted in Rhode Island, USA. After reports of dead Eastern Box Turtles (*Terrapene c. carolina*), we initiated surveys in the burned area to gauge the extent of mortality and develop guidance to protect Eastern Box Turtle populations where prescribed fire is used. We found 49 dead Eastern Box Turtles across a 31.2 ha area, and based on the available evidence, we suspect that 47 of those were killed as a direct result of the prescribed fire. The post-burn mortality observed during this study is the latest among a growing list of observations of significant mortality of box turtles associated with fire, both wild and prescribed. We urge land managers to carefully consider the location, timing, and frequency of prescribed burns within the range of the Eastern Box Turtle and consider mechanical treatments as an alternative to meet habitat management goals, or prior to burning to reduce fire intensity in sensitive areas. Burning during the growing season is particularly problematic due to the high risk to box turtles active on the surface.**

Key Words.—fire ecology; habitat management; New England; prescribed burn; Rhode Island; turtles; wildfire

Introduction

Fire is a key natural process that has shaped ecosystem distribution and composition for hundreds of millions of years (Scott and Glasspool 2006; Pausus and Keeley 2009). In the 20th Century in the United States, fire regimes shifted dramatically from historic norms with fire suppression emerging as the predominant management strategy (Ryan et al. 2013). In many places, widespread suppression led to an increase in non-native, invasive plants and a build-up of fuels that increase the risk of high severity fire. Prescribed fire emerged in the mid-20th Century as a contrast to suppression, and today is an important tool used to manage agricultural lands and forest lands that provide wildlife habitat, especially in the southeastern and western U.S. Though used relatively infrequently compared to other regions, prescribed fire is applied in the northeastern U.S. (hereafter Northeast) to reduce the risk of high-severity wildfire, control invasive plants, and sustain or enhance wildlife habitat (Melvin 2018).

Prescribed fire has become a common and important technique in wildlife habitat management, but implications for reptiles are considered only infrequently (Bailey et al. 2006). With its ability to alter physical and vegetative conditions, prescribed fire has the potential to change habitat characteristics in ways that can benefit or harm populations of reptiles (Keyser et al. 2004; Morin 2005; Steen et al. 2013). Numerous studies have explored reptile responses to prescribed fire (Greenberg et al. 2017; Roe et al. 2017) but given all the variables that make each prescribed burn unique, an ability to predict population-level outcomes for most species remains elusive. Despite this uncertainty, the cost of prescribed fire to reptile populations is often perceived as neutral or outweighed by the benefits (Russell et al. 1999; Renken 2006). More empirical information is needed to help understand the range of potential outcomes that prescribed fire can produce, including examples of negative effects to populations.

The Eastern Box Turtle (*Terrapene carolina carolina*) is one of five subspecies of T. carolina (www.itis.gov) that occur throughout much of the eastern and central USA (Dodd 2001). Though they remain widely distributed, Eastern Box Turtles are listed as Vulnerable by the International Union for the Conservation of Nature (van Dijk 2011). The species has been extirpated from its historic range in Canada and is listed as a Species of Greatest Conservation Need in > 75% of Northeast state Wildlife Action Plans (Northeast Partners in Amphibian

Reptile Conservation 2010). Eastern Box Turtles are typically associated with mesic forests but use a variety of habitat types throughout the year. As a widespread species, risk from fire likely varies based on local conditions and vegetation types, yet both prescribed fire (Frese 2003; Platt et al. 2010) and wildfire (Bigham et al. 1965; Jones et al. 2017) are demonstrated sources of mortality for box turtles.

With many remaining Eastern Box Turtle populations demographically vulnerable to the loss of even a small number of adults (Heppell 1998), a greater understanding of the implications of prescribed fire on box turtle populations has been identified as an area of research need (Platt et al. 2010; Howey and Roosenburg 2013). In May and June 2018, a prescribed burn was conducted in Rhode Island, USA. After several anecdotal reports of dead Eastern Box Turtles, we initiated surveys in the burned area. Our goals were to quantitatively assess the extent of Eastern Box Turtle mortality within the burned area, and to use this information to help guide future habitat management at this site and at other sites being considered for similar habitat management in the Northeast.

Materials and Methods

Study site.—The study site was located in Rhode Island, USA. We have withheld a more detailed location because Eastern Box Turtles are a coveted species in the illegal pet trade and are under intense pressure from poaching in the eastern U.S. (Sung and Fong 2018; Jay Pilgrim pers. comm.). Mean annual temperature in the area (Kingston, Rhode Island) is 10.5° C and mean annual precipitation is 134.3 cm. Mean monthly temperature is 12.9° C in May and 18.1° C in June. Mean monthly precipitation is 9.3 cm in May and 10.4 cm in June (http://www.ncdc.noaa.gov). The study area is classified as Ruderal Shrubland, Pitch Pine Woodland/Barrens, and Oak Forest (http://www.rigis.org). Shrubland units were composed primarily of Bayberry (*Myrica pensylvanica*), Highbush Blueberry (*Vaccinium corymbosum*), Roundleaf Greenbrier (*Smilax rotundifolia*), and European Larch (*Larix decidua*). The overstory in forested units was dominated by Pitch Pine (*Pinus rigida*) and oak (*Quercus* spp.), and the understory was composed primarily of Highbush Blueberry, Lowbush Blueberry (*Vaccinium angustifolium*), and Bear Oak (*Quercus ilicifolia*).

Prescribed burn.—A prescribed burn was carried out over three days on 30–31 May and 16 June 2018. The area of the burn was contiguous but burning was partitioned across 11 burn units of varying sizes ranging from 1.2 – 8.9 ha (Fig. 1). The stated goals of the burn were: (1) fuel hazard reduction through fuel reduction and overstory thinning; (2) maintenance and restoration of northeast Pine Barrens habitat; and (3) firefighter training in wildland fire. Estimates of burn severity and scorch height were made by fire professionals after the burn was completed.

Surveys and data collection.—We conducted two visual encounter surveys that yielded information on Eastern Box Turtle mortality. The surveys were held at different times of year but were mostly overlapping in the areas searched (Table 1). The first survey took place on 11 November 2018 and was intended solely to assess and quantify the extent of mortality associated with the prescribed burn. The second survey occurred 28–30 May 2019 and was intended to serve as the first survey of a newly initiated monitoring project to assess Eastern Box Turtle abundance and demography. Because we found a significant number of additional dead turtles during the second survey, we included them in this analysis. Significant logistical constraints prevented us from surveying all burn units, from re-surveying all previously surveyed burn units in May 2019, and from surveying additional unburned areas nearby. All surveys were conducted by 3–9 people, the majority of whom had previous experience conducting similar surveys. Surveys were conducted by surveyors forming a line along one edge of a burn unit standing 5–15 m apart and walking in a zig-zagging manner resulting

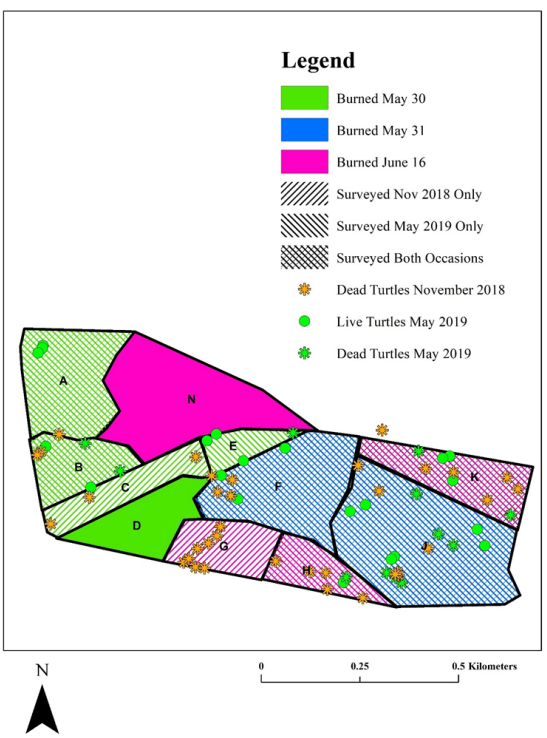

Figure 1. Study area in Rhode Island, USA, showing burn units, survey dates, and Eastern Box Turtles (*Terrapene c. carolina*) we detected, 2018–2019.

Table 1. Eastern Box Turtle (*Terrapene c. carolina*) survey summaries, Rhode Island, USA 2018-2019. Total search time (TST) includes time spent collecting data on turtles. For Combined Totals, each searched plot counted only once. Abbreviations are Nov = November, SST = search start time, SET = search end time, NO = number of observers, TSH = total search hours, NLT = number of living turtles, NDT = number of dead turtles, LTD = live turtle density (live turtles/ha), and TTD = total turtle density (live + dead turtles/ha).

Date	Burn unit	Area (ha)	SST	SET	TST (hh:mm)	NO	TSH (hh:mm)	NLT	NDT	LTD	TTD
17 Nov 2018	A	2.58	0913	1100	1:47	3	5:21	0	1	-	0.39
17 Nov 2018	B	2.47	0913	1115	2:02	3	6:06	0	3	-	1.21
17 Nov 2018	C	2.49	0915	1125	2:10	3	6:30	0	3	-	1.20
17 Nov 2018	K	3.42	1220	1313	0:53	6	5:18	0	5	-	1.46
17 Nov 2018	J	8.99	1315	1520	2:05	5	10:25	0	6	-	0.67
17 Nov 2018	F	5.60	1345	1500	1:15	4	5:00	0	3	-	0.54
17 Nov 2018	G	2.45	1540	1605	0:25	9	3:45	0	10	-	4.08
17 Nov 2018	H	2.03	1605	1630	0:25	9	3:45	0	5	-	2.46
17 Nov 2018	Incidental	-	-	-	-	-	-	0	1	-	-
28 May 2019	K	3.42	0930	1205	2:35	5	12:55	3	2	0.88	1.46
28 May 2019	H	2.03	1250	1455	2:05	5	10:25	1	1	0.49	0.99
28 May 2019	E	1.22	1345	1515	1:30	4	6:00	2	0	1.64	1.64
28 May 2019	F	5.60	0729	1110	3:41	5	18:25	4	1	0.71	0.89
28 May 2019	A	2.58	1620	1737	1:17	5	6:25	3	0	1.16	1.16
30 May 2019	A	-	0826	0926	1:00	6	6:00	0	0	-	-
30 May 2019	B	2.47	0933	1237	3:04	6	18:24	2	1	0.81	1.21
30 May 2019	J	8.99	1258	1617	3:19	6	19:54	6	6	0.67	1.33
29–30 May 2019	Incidental	-	-	-	-	-	-	1	1	-	-
2018 Subtotal	-	30.03	-	-	-	-	46:10	0	37	-	1.23
2019 Subtotal	-	26.31	-	-	-	-	98:28	22	12	0.91	1.24
Combined Totals	-	31.25	-	-	-	-	144:38	22	49	0.70	2.27

in slightly overlapping transects in the same direction. Surveyors scanned the ground in front and to the sides and scrutinized microhabitats until an entire burn unit had been searched. For each transect we recorded the number of observers and total time searched (we did not pause the clock while collecting data on individual turtles). For each dead turtle, we recorded time of detection, geographic coordinates, sex (male, female, or unknown), straight-line carapace length, age class (subadult or adult), and we photographed the turtle in its original position. We also noted whether the turtle was found in a clearly burned area, and if the carcass contained evidence of exposure to fire. All dead turtles were collected to avoid replicate observations. For each live turtle, we recorded similar data as for dead turtles and notched them along marginal scutes. For all turtles, we used secondary sexual characteristics to determine sex and recorded ambiguous individuals as unknown.

Results

The total area of the prescribed burn was approximately 43 ha (Fig. 1). Dry bulb daily high air temperatures during the burn ranged from 20.0°–29.4° C. Maximum daily scorch height ranged from 3–11 m (Table 2). Fire severity was greatest on 16 June (Appendix Table 1). The November 2018 survey covered approximately 30 ha and resulted in the detection of 37 dead Eastern Box Turtles. Nearly all dead turtles (36/37; 97.3%) exhibited evidence of exposure to fire (i.e., charring on scutes and/or bones; found among charred vegetation). The only carcass that did not show evidence of exposure to fire was found incidentally outside of the area of the prescribed burn (Table 1; Appendix Table 2). Several carcasses were found with soft tissue intact or with eggshells inside the body cavity (Fig. 2; Appendix Table 2).

The May 2019 survey covered 26.3 ha and resulted in the detection of 22 live (0.84 live turtle/ha), and 12 dead Eastern Box Turtles. Nearly all dead turtles (11/12; 91.6%) exhibited evidence of exposure to fire. Four live turtles (4/22; 18.2%) exhibited injuries in the form of missing carapacial scutes. Sex ratio of live adult turtles was 52.6% (10/19) female, and 47.4% (9/19) male. We classified two live turtles as unknown sex because of ambiguous secondary sexual characteristics, and one live turtle as a subadult.

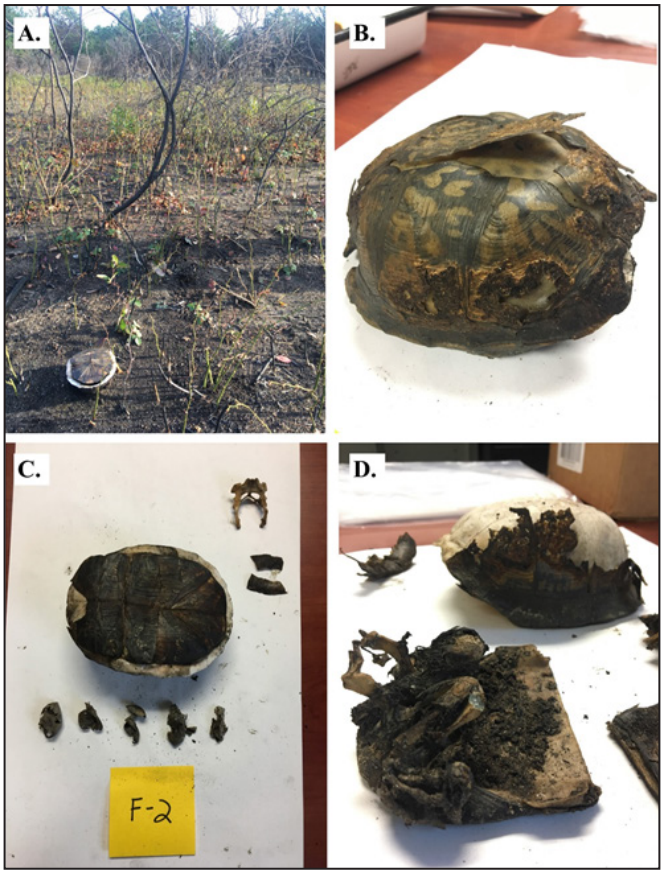

Figure 2. Photographs following a prescribed burn in Rhode Island, USA, showing (A) a typical scene in which we found Eastern Box Turtle (*Terrapene c. carolina*) carcasses among scorched vegetation, (B) a typical carcass with burned scutes, (C) a carcass containing eggs demonstrating recent mortality, and (D) a carcass with flesh remaining demonstrating recent mortality. (Photographed by Scott Buchanan).

Between the two surveys, we found 49 dead Eastern Box Turtles across a 31.2 ha area (1.6 dead turtles/ha), of which 47 (1.5 dead turtles/ha) appeared to have died as a direct result of the prescribed burn. Of those for which we could determine sex, 51.6% (16/31) were female, and 48.4% (15/31) were male. We classified four dead adults as unknown sex and 14 of the dead turtles as subadults. The number of dead turtles we found per hectare was highest (2.9 turtles/ha) in units that were burned on 16 June, compared to units burned on 30 May (0.9 turtles/ha) and 31 May (1.1 turtles/ha). Density of live and dead turtles combined across the entire area surveyed was 2.27 turtles/ha (Table 1).

Discussion

Based on the available evidence, we suspect that 47 of the 49 dead turtles were killed as a direct result of the prescribed fire. It is possible that some of the carcasses we found with charring were already dead prior to the fire, but given high adult survivorship, mostly structurally intact shells, and the fact that scutes

Table 2. Prescribed burn variables and the number and density of Eastern Box Turtles (*Terrapene c . carolina*) dead on site, Rhode Island, USA, 2018-2019. Burn units D, E, and N were not surveyed in November 2018, and units D and N were not surveyed in May 2019. Abbreviations are TAB = total are burned, TAS = total area searched, DBT = dry bulb temperature (low and high), WBT = wet bulb temperature (low and high), RH = relative humidity (low and high), SH = scorch height, DTF = number of dead turtles found (2018 and 2019), and DDT = density of dead turtles.

Date	Plots burned	TAB (ha)	TAS (ha)	DBT (°C)	WBT (°C)	RH (%)	SH (m)	DTF	DDT (per ha)
30 May 2018	A, B, C, D, E	11.69	8.76	20.0/22.8	15.6/17.8	53/79	3.0	8	0.9
31 May 2018	F, J	14.59	14.59	20.6/21.1	15.0/16.7	55/76	6.0	16	1.1
16 June 2018	G, H, K, N	16.51	7.90	23.3/29.4	17.2/19.4	39/54	11.0	23	2.9

were found with almost all carcasses (suggesting recent death), we find this unlikely. In fact, we suspect that fire-related mortality almost certainly exceeded our count of dead turtles given that we did not search all burn units, and that the probability of box turtle detection is low, especially for subadults (Refsnider et al. 2011; Erb et al. 2015; Melvin and Roloff 2018). The fact that we continued to find additional dead, burned turtles when surveying burn units a second time lends credence to this. Finally, undetected turtles injured during the fire may have retreated beneath soil or other cover or moved outside of the burned area (e.g., Harris et al. 2020), and then died. The post-burn mortality observed during this study is the latest among a growing list of observations of significant mortality of box turtles associated with fire, both wild and prescribed (Platt et al. 2010; Jones et al. 2017; Harris et al. 2020). At least two recent, well-designed studies have demonstrated reduced annual survivorship in populations of Eastern Box Turtles subjected to prescribed fire (Harris et al. 2020; Roe et al. 2019). Delayed maturity, slow growth, and low subadult survivorship combine to make box turtle populations particularly susceptible to additive mortality, especially among adults. Even slight decreases in adult survivorship can result in a negative population growth trajectory, leading to extirpation (Congdon 1993; Heppell 1998).

We documented a density of 1.5 dead turtles/ha attributable to the prescribed burn, which was higher than that (0.1 dead turtles/ha) recorded during the first year of a study in New York, USA (unpubl. data). The New York study occurred in an area not impacted by fire that contained a robust (0.75 live turtles/ha) box turtle population, not markedly different from the population in Rhode Island (0.84 live turtles/ha), and surveys were conducted using the same methods as in this study. In Rhode Island, we documented the highest density of dead turtles on day three (16 June), which was the hottest and driest day of burning. Both anecdotal accounts and estimates of scorch height indicated that fire intensity and severity was greatest on day 3. These observations are consistent with other accounts suggesting that greater fire intensity increases risk to populations of box turtles (Platt et al. 2010; Roe et al. 2019), but we cannot confirm this explanation as we do not have pre-fire data on densities and distributions of turtles. Despite this date coinciding with peak nesting season in the Northeast, there was no indication that mortality was greater among females (seven dead females) compared to males (eight dead males) or subadults (eight dead subadults); however, subadult numbers should be viewed with caution because of size-related issues with detectability. There is little doubt that box turtles are more susceptible to fire during their activity season as compared to the dormant season (Platt et al. 2010; Wiley 2010) but determining how this susceptibility changes throughout the activity season and the relative risk to females, males, and subadults are areas for future study. Understanding how susceptibility to fire varies throughout the geographic range of the species is another area for future investigation.

Mortality likely occurred quickly for many of the turtles, but some may have endured injuries and died at a later time (Melvin and Roloff 2018). In a study of 11 radio-tracked Eastern Box Turtles in Ohio, USA, four (36%) were injured during prescribed burns. Three of these turtles eventually died, and time of death ranged from 1–4 mo after the burn (Cross 2016). In Tennessee, 17/118 (14.4%) radio-tracked Eastern Box Turtles exhibited pre-existing carapacial damage presumed to be caused by fire (Harris et al. 2020). Similarly, a Kentucky, USA, study found that 4/20 (20%) Eastern Box Turtles found in an area recently treated with prescribed fire exhibited missing carapacial scutes (Howey and Roosenburg 2013). The study also compared all turtles found in burned sites (injured and apparently uninjured) with those from nearby unburned sites and found that burn site turtles weighed less and had a poorer body condition index. In North Carolina, USA, Eastern Box Turtles in areas managed with prescribed fire exhibited smaller home ranges than those in nearby areas not managed with fire (Roe et al. 2020), however, growth rates and body condition did not differ between sites (Roe et al. 2019). It is clear that fire can impact Eastern Box Turtle populations, but additional study is needed that elucidates the legacy effects of injuries (e.g., health, fecundity, survivorship) and longer-term ecological effects (e.g., habitat selection, resource availability) of populations subjected to fire.

Although the activity season for Eastern Box Turtles varies depending on latitude, proximity to coast, elevation, and inter-annual variation in temperature, evidence from several studies provides guidance that can be used to protect populations in areas slated for prescribed burns. In a study in coastal Long Island, New York, active periods and habitat use were evaluated to determine times at which mowing of fields could be conducted with minimal risk to Eastern Box Turtles (Walden and Karraker 2018). Turtles entered brumation as early as 11 October and as late as 16 December and exhibited an estimated 90% probability of entering brumation when weekly mean temperature reached 8.3° C. Turtles brumated between 0–7.5 cm beneath the soil surface at an average depth of 4.3 cm (standard error ± 2.3 cm), as measured from the top of the carapace. Turtles emerged as early as 11 March and as late as 12 May.

At a low elevation site in northeastern Virginia, USA (Boucher et al. 2017), Eastern Box Turtles entered into hibernacula in December and emerged in March and

April, brumating at depths of 0.7–15 cm, as measured from the top of the carapace. Prescribed burns that take place outside of local surface activity seasons would likely avoid the worst impacts to Eastern Box Turtles, but because turtles may overwinter with their carapace exposed or just below the soil surface, some proportion of the population could be impacted by prescribed burns, and the magnitude of that impact will depend on fire intensity.

Prescribed fire is an important habitat management tool that can be used to advance conservation objectives. Moreover, fire is a disturbance necessary to maintain certain ecosystems (Van Lear and Harlow 2002), some of which are globally rare. Under certain conditions, prescribed fire that accomplishes habitat management objectives is likely compatible with the sustained, long-term management of box turtle populations and those of other reptiles. It is imperative, though, that habitat managers fully grasp the potential for disastrous impacts to box turtle populations when using prescribed fire during the activity season of box turtles. We urge land managers to carefully consider the location, timing, and frequency of prescribed burns within the range of the Eastern Box Turtle, and consider mechanical treatments coupled with slash pile burning as an alternative to meet habitat management goals, or prior to burning to reduce fire intensity in sensitive areas. Burning during the growing season is particularly problematic due to the high risk to box turtles active on the surface. In the Northeast, growing season burns are also inconsistent with historic fire regimes in which most wildfires occur during the fall and spring dormant periods (Ryan et al. 2013), and fire return intervals are measured in decades or centuries (Malamud et al. 2005).

Acknowledgments.—We thank Robin Weber and Maureen Dewire for assistance in project coordination. We also thank those who aided in field data collection, including Sam Adesemolu, Jen Brooks, Liam Corcoran, Hannah Dallas, Eric Diaz, Mary Gannon, Noah Hallisey, Ryan Healey, Lesley Howard, Zachary Hulmes, Felicia Page, Emma Paton, and Gabrielle DeMeillon. All work was carried out by the Rhode Island Division of Fish and Wildlife and adhered to state rules and regulations for wildlife scientific data collection.

Literature Cited

Bailey, M.A., J.N. Holmes, K.A. Buhlmann, and J.C. Mitchell. 2006. Habitat Management Guidelines for Amphibians and Reptiles of the Southeastern United States. Technical Publication HMG–2, Partners in Amphibian and Reptile Conservation, Montgomery, Alabama, USA. 88 p.

Bigham, R., J.L. Hepworth, and R.P. Martin. 1965. A casualty count of wildlife following a fire. Oklahoma Academy of Science Proceedings 45:47–50.

Boucher, T.P., C.H. Ernst, and J.M. Orr. 2017. Pre-and post winter hibernation ecology of the Eastern Box Turtle, *Terrapene carolina carolina*. Herpetological Bulletin 2017:1–5.

Congdon, J.D., A.E. Dunham, and R.C. Van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's Turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7: 826–833.

Cross, M.D. 2016. Spatial ecology of Eastern Box Turtles (*Terrapene c. carolina*) in the Oak Openings region of northwestern Ohio. Ph.D. Dissertation, Bowling Green State University, Bowling Green, Ohio, USA. 116 p.

Dodd, C.K. 2001. North American Box Turtles: A Natural History. University of Oklahoma Press, Norman, Oklahoma, USA.

Erb., L., L.L. Willey, L.M. Johnson, J.E. Hines, and R.P. Cook. 2015. Detecting long-term population trends for an elusive reptile species. Journal of Wildlife Management 79:1062–1071.

Frese, P.W. 2003. Tallgrass prairie amphibian and reptile assemblage. Fire Mortality. Herpetological Review 34:159.

Greenberg, C.H., C.E. Moorman, C.E. Matthews-Snoberger, T.A. Waldrop, D. Simon, A. Heh, and D. Hagan. 2017. Long-term herpetofaunal response to repeated fuel reduction treatments. Journal of Wildlife Management 82:553–565.

Harris, K., J.D. Clark, R.D. Elmore, and C.A. Harper. 2020. Direct and indirect effects of fire on Eastern Box Turtles. Journal of Wildlife Management 84:1384–1395.

Heppell, S.S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia 1998:367–375.

Howey, C.A.F., and W.M. Roosenburg. 2013. Effects of prescribed fire on the Eastern Box Turtle (*Terrapene carolina carolina*). Northeastern Naturalist 20:493–497.

Jones, M.T., L.L. Willey, J.D. Mays, and C.K. Dodd. 2017. Florida Box Turtles on Egmont Key: a preliminary reassessment. American Turtle Observatory, New Salem, Massachusetts, USA. 28 p.

Keyser, P.D., D.J. Sausville, W.M. Ford, D.J. Schwab, and P.H. Brose. 2004. Prescribed fire impacts to amphibians and reptiles in shelterwood-harvested oak-dominated forests. Virginia Journal of Science 55:159–168.

Malamud, B.D., J.D.A. Millington, and G.L.W. Perry. 2005. Characterizing wildfire regimes in the United States. Proceedings of the National Academy of Sciences 102:4694–4699.

Melvin, M.A. 2018. 2018 National prescribed fire use survey report. Technical Report 03-18, Coalition of Prescribed Fire Councils, Inc., Newton, Georgia, USA. 23p.

Melvin, T.A., and G.J. Roloff. 2018. Reliability of postfire surveys for Eastern Box Turtles. Wildlife Society Bulletin 42:498–503.

Morin, K.C. 2005. Herpetofaunal responses to prescribed fire in upland pine communities of northeast Florida. M.S. Thesis, University of Florida, Gainesville, Florida, USA. 67 p.

Northeast Partners in Amphibian Reptile Conservation (NEPARC). 2010. Northeast amphibian and reptile species of regional responsibility and conservation concern. Publication 2010–1, NEPARC. 20 p. http://www.pwrc.usgs.gov/neparc.

Pausus, J.G., and J.E. Keeley. 2009. A burning story: the role of fire in the history of life. Bioscience 59:593–601.

Platt, S.G., H. Liu, and C.K. Borg. 2010. Fire ecology of the Florida Box Turtle (*Terrapene carolina bauri* Taylor) in Pine Rockland Forests of the lower Florida Keys. Natural Areas Journal 30:254–260.

Refsnider, J.M., T.S. Mitchell, H.M. Streby, J.T. Strickland, D.A. Warner, and F.J. Janzen. 2011. A generalized method to determine detectability of rare and cryptic species using the Ornate Box Turtle as a model. Ecology, Evolution, and Organismal Biology 35:93–100.

Renken, R.B. 2006. Does fire affect amphibians and reptiles in eastern U.S. oak forests? Pp. 158–166 *In* Fire in Eastern Oak Forests: Delivering Science to Land Managers, Proceedings of a Conference. General Technical Report NRS-P-1, U.S. Department of Agriculture, Forest Service, Northern Research Station, Newton Square, Pennsylvania, USA.

Roe, J.H., A.L. Kish, and J.P. Nancy. 2020. Variation and repeatability of home range in a forest-dwelling terrestrial turtle: implications for prescribed fire in forest management. Journal of Zoology 310:71–82.

Roe, J.H., K.H. Wild, and C.A. Hall. 2017. Thermal biology of Eastern Box Turtles in a Longleaf Pine system managed with prescribed fire. Journal of Thermal Biology 69:325–333.

Roe, J.H., K.H. Wild, and M.S. Chavez. 2019. Responses of a forest-dwelling terrestrial turtle, *Terrapene carolina*, to prescribed fire in a Longleaf Pine ecosystem. Forest Ecology and Management 432:949–956.

Russell, K.R., D.H. Van Lear, and Guynn, D.C., Jr. 1999. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin 27:374–384.

Ryan, K.C., E.E. Knapp, and J.M. Varner. 2013. Prescribed fire in North American forests and woodlands: history, current practice, and challenges. Frontiers in Ecology and the Environment 11 e15–e24. https://doi.org/10.1890/120329.

Scott, A. C., and I. J. Glasspool. 2006. The diversification of Paleozoic fire systems and fluctuations in atmospheric oxygen concentration. Proceedings of the National Academy of Sciences 103:10861–10865.

Steen, D.A., L.L. Smith, L.M. Conner, A.R. Litt, L. Provencher, J.K. Hiers, S. Pokswinski, and C. Guyer. 2013. Reptile assemblage response to restoration of fire-suppressed Longleaf Pine Sandhills. Ecological Applications 23:148–158.

Sung, Y.H., and J.J. Fong. 2018. Assessing consumer trends and illegal activity by monitoring the online wildlife trade. Biological Conservation 227:219-225.

van Dijk, P.P. 2011. *Terrapene carolina*. International Union for Conservation of Nature Red List of Threatened Species. www.iucnredlist.org.

Van Lear, D., and R. Harlow. 2002. Fire in the eastern United States: influence on wildlife habitat. Pp. 2–10 *In* The Role of Fire in Nongame Management and Community Restoration: Traditional Uses and New Directions, Proceedings of a Workshop. General Technical Report NE-288, U.S. Department of Agriculture, Forest Service, Newtown Square, Pennsylvania, USA.

Walden, M., and N. Karraker. 2018. Hibernal phenology of the Eastern Box Turtle, *Terrapene carolina carolina*: William Floyd Estate, Fire Island National Seashore. Natural Resource Report NPS/NCBC/NRR-2018/1595, U.S. National Park Service, Fort Collins, Colorado, USA.

Wiley, L.L. 2010. Spatial ecology of Eastern Box Turtles (*Terrapene c. carolina*) in central Massachusetts. Ph.D. Dissertation, University of Massachusetts, Amherst, Massachusetts, USA. 200 p.

Scott Buchanan is a Biologist with the Rhode Island Division of Fish and Wildlife, USA, where he leads the Herpetology Program. He received his B.Sc. in Ecology and Natural Resources from Rutgers University, New Brunswick, New Jersey, USA, his M.Sc. in Ecology from Montclair State University, Montclair, New Jersey, USA, and his Ph.D. in Biological and Environmental Science from the University of Rhode Island, Kingston, Rhode Island, USA. His work focuses on the conservation and management of amphibians and reptiles in Rhode Island and the northeast United States. (Photographed by Sarah McClutchy).

Tanner Steeves is a Wildlife Biologist for the Wildlife Division of the Connecticut Department of Energy and Environmental Protection, USA. He received a B.Sc. in Wildlife Management from the University of New Hampshire, Durham, New Hampshire, USA, and a M.Sc. in Biodiversity and Conservation Biology from the University of Connecticut, Storrs, USA. His work focuses on the conservation of wildlife through habitat management on public lands. (Photographed by Tanner Steeves).

Nancy Karraker is an Associate Professor in the Department of Natural Resources Science at University of Rhode Island, USA, where she teaches Herpetology, Wetland Ecology, and Wildlife Trafficking. She received a B.Sc. and M.Sc. in Wildlife Ecology and M.A. in English from Humboldt State University, Arcata, California, USA, and a Ph.D. in Conservation Biology from SUNY College of Environmental Science and Forestry, Syracuse, New York, USA. Her research focuses on the conservation of amphibians, reptiles, and wetlands in Southeast Asia and the USA. (Photographed by David Fastovsky).

Appendix

Appendix Table 1. Estimates (made by fire professionals) of fire severity by vegetation type for each day of prescribed burn, Rhode Island, USA 2018. Abbreviations are U = unburned, S = scorched, LS = low severity, MS = moderate severity, and HS = high severity

	May 30					May 31					June 16				
Vegetation Type (%)	U	S	LS	MS	HS	U	S	LS	MS	HS	U	S	LS	MS	HS
Substrate	35	40	25	0	0	10	45	45	0	0	10	25	50	15	0
Herbaceous	0	25	65	10	0	0	10	30	55	5	0	10	10	70	10
Low woody	60	35	5	0	0	20	30	40	10	0	10	15	15	25	35
High woody	65	20	10	5	0	50	30	10	10	0	10	15	15	20	20
Trees	90	10	0	0	0	45	50	5	0	0	25	65	5	5	0

Appendix Table 2. Individual Eastern Box Turtles (*Terrapene c. carolina*) found during surveys, Rhode Island, USA, 2018–2019. The abbreviations SCL = straight-line carapace length and Nov = November.

Turtle ID	Date	Time	Burn unit	Disposition	Sex	SCL (mm)	Annuli	Charring on scutes?	Notes
A1	11 Nov 2018	0913	A	Dead	F	120.8	15+	Possibly	Scrub shrub; plastron and carapace 2m apart; near deer stand
B1	11 Nov 2018	1000	B	Dead	F	NA	15+	Yes	Lowlying grass; near standing water
B2	11 Nov 2018	1044	B	Dead	M	143.1	15+	Yes	Clearly burned area; low briars; 20 m from road
B3	11 Nov 2018	1054	B	Dead	F	132.1	15+	Yes	Six eggs found inside shell; low briars; next to burned area; 15m from road
C1	11 Nov 2018	0916	C	Dead	J	NA	10–11	Yes	Found in well burned slash pile
C2	11 Nov 2018	1124	C	Dead	F	142.4	20+	Yes	Found in well burned slash pile
D1	11 Nov 2018	1402	D	Dead	F	130.2	15+	Yes	Found while turning around searching unit F; <2m from road; found in clearly burned area
F1	11 Nov 2018	1407	F	Dead	M	122.5	15+	Yes	In large burn area; found on bare scorched earth; obviously burned
F2	11 Nov 2018	1411	F	Dead	F	127.0	20+	Yes	Eggs inside shell; in large burn area; found on scorched earth; obviously burned
F3	11 Nov 2018	1445	F	Dead	J	NA	6	NA	Found in large burn area; many small bones; only a few scutes found
G1	11 Nov 2018	1542	G	Dead	J	NA	4	NA	Found in burn area in briar patch
G10	11 Nov 2018	1555	G	Dead	J	NA	3	NA	Found in burn area; scrub shrub
G2	11 Nov 2018	1542	G	Dead	J	NA	8–10	NA	Found in burn area in briar patch
G3	11 Nov 2018	1542	G	Dead	J	NA	6–7	Yes	Found in burn area in briar patch
G4	11 Nov 2018	1544	G	Dead	M	NA	9–10	Yes	Heavily burned area; among unidentified young trees in leaf litter
G5	11 Nov 2018	1547	G	Dead	M	134.3	15+	Yes	Found in burn area in briar patch
G6	11 Nov 2018	1552	G	Dead	J	NA	4	Yes	Scrub shrub; evidence of charing on bones and scutes
G7	11 Nov 2018	1550	G	Dead	M	125.7	10+	Yes	Found in burn area in briar patch; carapace falling apart in chips but evidence of hot fire on chips
G8	11 Nov 2018	1550	G	Dead	J	NA	3–4	Yes	Found in burn area in briar patch
G9	11 Nov 2018	1555	G	Dead	M	141.7	20+	Yes	Found in burn area in briar patch
H1	11 Nov 2018	1610	H	Dead	F	115.8	15+	Yes	Found in burnt scrub shrub; eggs present
H2	11 Nov 2018	1613	H	Dead	F	108.2	15+	Yes	Scrub shrub; soft tissue inside shell

Appendix Table 2 (continued). Individual Eastern Box Turtles (*Terrapene c. carolina*) found during surveys, Rhode Island, USA, 2018–2019. The abbreviations SCL = straight-line carapace length and Nov = November.

Turtle ID	Date	Time	Burn unit	Disposition	Sex	SCL (mm)	Annuli	Charring on scutes?	Notes
H3	11 Nov 2018	1617	H	Dead	J	NA	4	NA	Found in burned area on bare ground
H4	11 Nov 2018	1622	H	Dead	J	NA	6–7	Yes	Found in burned area; found in grass
H5	11 Nov 2018	1627	H	Dead	F	129.6	15+	Yes	Found in scorched area; scorched scutes
J1	11 Nov 2018	1321	J	Dead	M	136.8	15+	Yes	Pine forest edge; in burned area
J2	11 Nov 2018	1328	J	Dead	M	130.1	20+	Yes	Pine forest
J3	11 Nov 2018	1357	J	Dead	F	131.1	15+	Yes	Pine forest
J4	11 Nov 2018	1440	J	Dead	M	137.3	15+	Yes	Scrub shrub; turtle was clearly burned while alive; soft tissue still remaining inside shell
J5	11 Nov 2018	1445	J	Dead	J	NA	6	Yes	Scrub shrub; many bones; evidence of charing on one scute
J6	11 Nov 2018	1447	J	Dead	M	140.6	15+	Yes	Scrub shrub; turtle was clearly burned while alive; soft tissue still remaining inside shell
K1	11 Nov 2018	1225	K	Dead	F	132.2	15+	Yes	Forest edge; 5 eggs inside shell
K2	11 Nov 2018	1235	K	Dead	M	154.5	15+	Yes	Found in burn area; shrub pine duff; very large turtle
K3	11 Nov 2018	1245	K	Dead	F	142.3	20+	Yes	Pine forest
K4	11 Nov 2018	1251	K	Dead	M	NA	20+	Yes	Found in burned area; pine forest
K5	11 Nov 2018	1301	K	Dead	F	129.1	20+	Yes	Found in pine forest; slightly burned area; obvious charring on body
L1	11 Nov 2018	1245	L	Dead	M	151.3	NA	NA	Found incidentally; pine forest; found in pine litter; no strong evidence of turtle being burned
AN	29 May 2019	1628	A	Alive	F	132.6	15+	No	-
BH	29 May 2019	1658	A	Alive	F	137.9	25+	No	-
AO	29 May 2019	1717	A	Alive	F	125.5	20+	No	-
BI	30 May 2019	0937	B	Alive	M	137.5	13	No	-
BQ	30 May 2019	1154	B	Alive	M	125.6	11	Yes	Rear vertebral and costal scutes missing; ossified injury
AC	28 May 2019	1415	E	Alive	M	135.4	20+	Yes	Rear vertebral scute missing
AH	28 May 2019	1447	E	Alive	F	142.3	15+	No	-
AI	29 May 2019	0755	F	Alive	M	135	20+	No	-
AJ	29 May 2019	0910	F	Alive	M	151.9	20+	No	-
AK	29 May 2019	0938	F	Alive	M	134.3	12	No	-
AL	29 May 2019	1007	F	Alive	F	113.2	10	No	-
BC	28 May 2019	1319	H	Alive	M	137	11	No	-
BJ	30 May 2019	1307	J	Alive	F	141	15+	No	-
BK	30 May 2019	1410	J	Alive	F	130	15+	Yes	Rear vertebral scute missing

Appendix Table 2 (continued). Individual Eastern Box Turtles (*Terrapene c. carolina*) found during surveys, Rhode Island, USA, 2018–2019. The abbreviations SCL = straight-line carapace length and Nov = November.

Turtle ID	Date	Time	Burn unit	Disposition	Sex	SCL (mm)	Annuli	Charring on scutes?	Notes
BL	30 May 2019	1423	J	Alive	U	136.7	20+	Yes	Two left rear costal scutes missing
BM	30 May 2019	1452	J	Alive	F	134.4	15+	No	-
BN	30 May 2019	1521	J	Alive	F	131	15+	No	-
BO	30 May 2019	1533	J	Alive	J	118	9	No	-
AV	28 May 2019	1023	K	Alive	M	130	15+	No	-
AW	28 May 2019	1044	K	Alive	U	139	15+	No	-
AX	28 May 2019	1115	K	Alive	M	144	15+	No	-
AM	29 May 2019	1143	-	Alive	F	126.7	20+	No	-
B4	30 May 2019	1224	B	Dead	U	NA	12	Yes	Found in burned area
F4	29 May 2019	0743	F	Dead	J	139.8	11	NA	No evidence of fire-related mortality
H6	28 May 2019	1324	H	Dead	F	135.5	20+	Yes	Found in burned area
J7	30 May 2019	1326	J	Dead	F	128.9	15+	Yes	Found in burned area
J8	30 May 2019	1345	J	Dead	F	NA	20+	Yes	Found in burned area
J9	30 May 2019	1445	J	Dead	U	NA	15+	Yes	Found in burned area
J10	30 May 2019	1552	J	Dead	J	NA	10	Yes	Found in burned area
J11	30 May 2019	1558	J	Dead	U	NA	12	Yes	Found in burned area
J12	30 May 2019	1604	J	Dead	J	NA	7	Yes	Found in burned area
K6	28 May 2019	1138	K	Dead	M	129.4	15+	Yes	Found in burned area
K7	28 May 2019	1230	K	Dead	M	141.1	15+	Yes	Found in burned area
-	30 May 2019	1239	-	Dead	U	NA	15+	Yes	Found in between units A and B, charred bone fragments