CONSERVATION PLAN *for the* **EASTERN BOX TURTLE** *in the* NORTHEASTERN UNITED STATES

Maine • New Hampshire • Vermont • Massachusetts • Connecticut • Rhode Island • New York • New Jersey • Pennsylvania • Delaware • Maryland • DC • Virginia • West Virginia

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Conservation Plan for the Eastern Box Turtle in the Northeastern United States

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Executive Summary

The *Conservation Plan for the Eastern Box Turtle in the Northeastern United States* aims to facilitate collaborative conservation at the regional level that addresses the numerous challenges facing the eastern box turtle (*Terrapene carolina carolina*) that were identified within the *Status Assessment for the Eastern Box Turtle in the Northeastern United States* (Erb and Roberts 2023). The fundamental goal of this Conservation Plan is to support the persistence and adaptive capacity of the eastern box turtle in the northeastern United States from Maine to Virginia.

Part I details the development of a conservation tool aimed at both guiding eastern box turtle conservation and bolstering collaboration at the regional level: a Conservation Area Network (CAN) for the eastern box turtle from Maine to Virginia. The Northeast Eastern Box Turtle CAN represents a collection of sites and landscapes — identified using an automated mapping protocol in combination with empirical information and expert knowledge — that are intended to support the long-term persistence and adaptive capacity of the species in the Northeast, while also identifying opportunities for management, collaboration, and data collection. The CAN identifies Focal Core Areas and Focal Landscapes which are intended to represent the highest priority sites (individual populations or subpopulations) and landscapes (multiple populations or subpopulations) for eastern box turtle conservation. Within a lower priority tier, Management Core Areas and Sampling Landscapes are identified to represent targets for agricultural mitigation, federal partnership, and sampling.

Part II includes a Conservation Action Plan that articulates a core set of six objectives that are needed to accompany the Northeast Eastern Box Turtle CAN in order to achieve the fundamental goal of the Conservation Plan. These objectives include (1) increasing collaboration at multiple levels, (2) addressing data-deficiencies, (3) implementing an adaptive conservation framework, (4) increasing strategic and experimental research, (5) combating illegal trade, and (6) reducing threats within Focal Core Areas and Focal Landscapes. Specific actions at multiple geographic scales (rangewide, regional, state, site) are proposed within each objective.

Part I. Conservation Area Network for the Eastern Box Turtle in the Northeastern United States

Introduction

The *Status Assessment for the Eastern Box Turtle in the Northeastern United States* (Erb and Roberts 2023) identified and described numerous conservation challenges facing the eastern box turtle (*Terrapene carolina carolina*) throughout the northeastern U.S., demonstrated a pattern of widespread habitat loss, and highlighted a need for coordinated and collaborative conservation at the regional level. Here, we detail the development of a conservation tool aimed at both guiding eastern box turtle conservation and bolstering collaboration at the regional level: a Conservation Area Network (CAN) for the eastern box turtle from Maine to Virginia. The Northeast Eastern Box Turtle CAN (NEBT CAN) represents a collection of sites and landscapes that are intended to support the **long-term multi-generational persistence and adaptive capacity** of the species in the Northeast, while also identifying **opportunities for management and collaboration**.

While distinctive in several aspects, the NEBT CAN adopts an approach similar to existing CANs for Blanding's turtle (Willey and Jones 2014), wood turtle (Jones et al. 2018), and spotted turtle (Willey et al. 2022) that is characterized by a standardized, objective methodology for prioritizing populations and landscapes, derived from empirical data, expert opinion (Appendices B, C), and regional data sources (e.g., Designing Sustainable Landscapes [McGarigal et al. 2018]). The NEBT CAN aims to ensure ecological, jurisdictional, and evolutionary representativeness by employing site and landscape selection processes that reflect ecoregional, state, and known genetic boundaries. The NEBT CAN also emphasizes site redundancy by including multiple sites within these ecological, jurisdictional, and evolutionary units, and site resilience by prioritizing larger populations within suitable, unfragmented landscapes.

As highlighted in the Status Assessment, currently there are data-deficiencies at multiple levels with respect to distribution (i.e., occurrence information), population information (e.g., size and demographics), and genetics (e.g., population units, levels of genetic diversity and inbreeding, etc), which each play a prominent role in the CAN. Therefore, in order to accommodate additional information at each of these levels, the NEBT CAN in its current form is intended to represent a "living" document that can, and should, be refined, updated, and improved at regular intervals; we view this CAN as "Phase 1" in a multi-phase process.

Methods

Geographic Distribution

We restricted this conservation planning project to the expected eastern box turtle distribution in the northeastern United States, from Maine to Virginia. We classified this area as all terrestrial land cover within 50 km of records representing likely eastern box turtle populations (Fig. 1). Hereafter, we refer to this area as the "region."

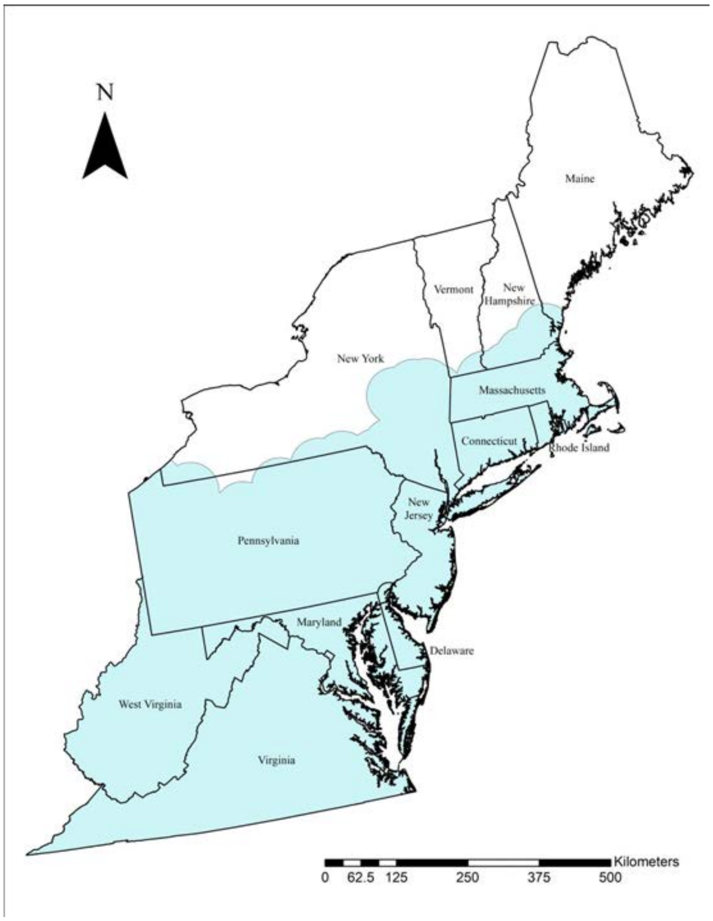

Figure 1. Map of the northeastern United States with a simplified delineation of the expected eastern box turtle distribution in blue.

Conservation Units

The NEBT CAN comprises conservation units that fall within two categories: "Core Areas" and "Landscapes" (Fig. 2). Core Areas are generally smaller in spatial scale and are intended to represent locations that support populations or subpopulations of eastern box turtles that interact with each other more frequently than turtles from other locations, and are characterized by differential demographic parameters. Core Areas are meant to encompass the needs of a local (sub)population for a generation or more and therefore encompass the potential resources/cover types used by turtles at these locations. Landscapes are generally larger in spatial scale and are intended to represent multiple (sub)populations/Core Areas, as well as the intervening land cover that may act as movement corridors or barriers, or data-deficient areas. Landscapes may or may not exhibit metapopulation dynamics.

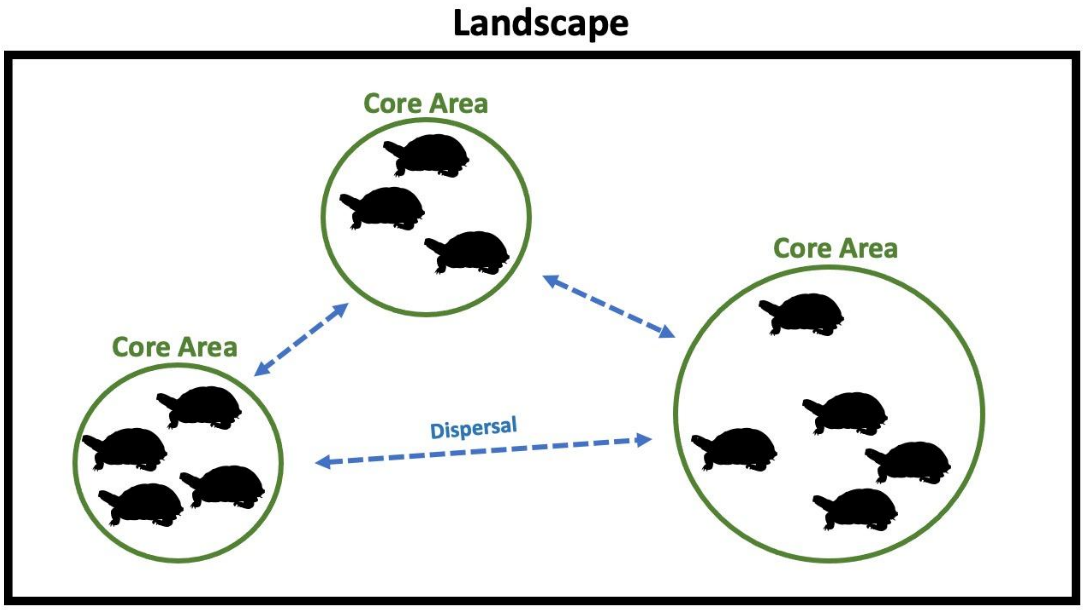

Figure 2. Diagram depicting distinction between the two types of conservation units represented within the Conservation Area Network: Core Areas and Landscapes. Core Areas are generally smaller in spatial scale and are intended to represent locations that support populations or subpopulations of eastern box turtles that interact with each other more frequently than turtles from other locations, and are characterized by differential demographic parameters. Landscapes are larger in spatial scale and are intended to represent multiple (sub)populations/Core Areas, as well as the intervening land cover that may act as movement corridors or barriers.

Framework

Conservation Units (Core Areas and Landscapes) fall within two tiers. Tier I represents the higher priority Core Areas and Landscapes where resources should be directed for conservation actions such as land protection (see Part II. Conservation Action Plan). Tier II represents Core Areas and Landscapes that are generally lower priority and either data-deficient or less likely to support robust/viable populations or subpopulations, but represent valuable opportunities for sampling, management, and/or collaboration. In some cases, individual Core Areas may fall within both tiers (i.e., locations that are a high regional conservation priority that also represent ideal locations for mitigation or partnership).

Tier I: Higher Priority

Focal Core Areas.— Focal Core Areas represent relatively unfragmented populations/subpopulations that, together, form a jurisdictionally and ecologically representative collection of priority conservation areas for eastern box turtles. Together, Focal Core Areas are intended to represent (sub)populations important to the long-term persistence, ecological representativeness, and evolutionary potential of the species in the northeastern United States.

Focal Landscapes.— Focal Landscapes represent landscapes that support high priority Core Areas with suitable intervening land cover such that connectivity among Core Areas is high, or intervening areas may support eastern box turtles.

Tier II: Lower Priority

Management Core Areas.— Management Core Areas represent locations of lower conservation priority that offer opportunities for agricultural mitigation, federal partnerships, and secondary conservation initiatives.

Sampling Landscapes.— Sampling Landscapes represent landscapes that have characteristics that suggest they could support viable/robust populations and/or metapopulations but are data-deficient (i.e., no recent occurrence record).

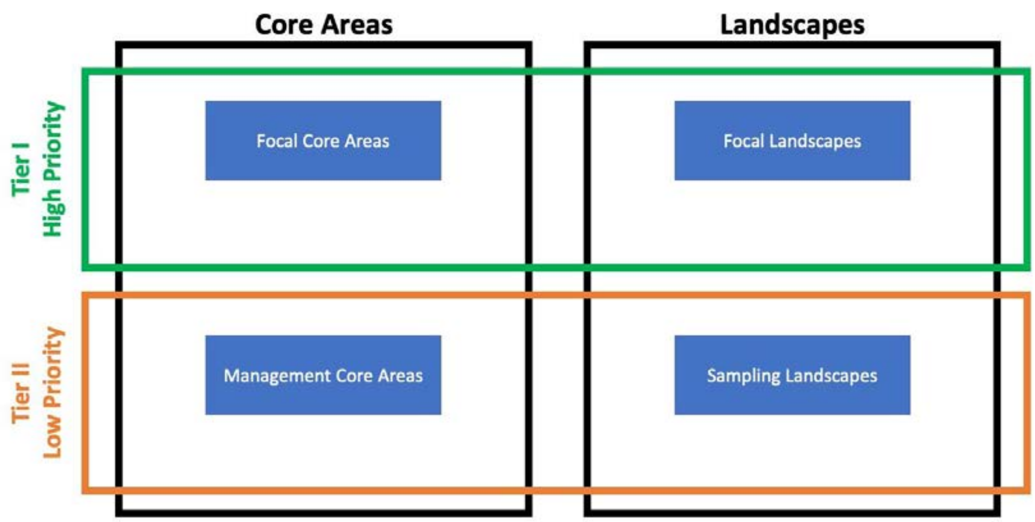

Figure 3. Venn diagram illustrating which types of conservation units (Core Areas and Landscapes) fall within each priority Tier.

Delineation

We developed standardized and biologically meaningful methodologies for objectively mapping Core Areas and Landscapes throughout the northeastern United States. These methods draw from NatureServe guidelines (NatureServe 2021), state agencies guidelines (MassWildlife 2021), and communication with state agency biologists. These delineated areas are not intended to be used for regulatory purposes.

Core Areas

Unlike many freshwater species, eastern box turtles are not tied to features of the landscape that are easily delineated, such as lotic and lentic wetlands. Therefore, we used buffers around eastern box turtle occurrences as the basis for Core Areas. Our step-by-step processes for mapping Core Areas (Fig. 4) was as follows:

1. Buffered occurrences by 1050 m (2100 separation distance)
    a. This approximate maximum separation distance is used by MassWildlife (MassWildlife 2021) and was derived from Willey (2010). While this distance reflects populations at the northern edge of the species range, where home ranges are larger, we applied this distance throughout the range for consistency. Eastern box turtles are more abundant and likely undersampled throughout much of the Northeast, thus a larger connection distance, despite smaller home range sizes, most likely still accurately reflects the spatial footprint of the average population.
2. Split buffered occurrence polygons by primary and secondary roads
    a. Data source: Census Bureau TIGER/Lines
    b. Although turtles may occasionally cross these roads, they are likely to induce avoidance behavior and/or significant mortality upon crossing such that individuals separated by these roads could be considered separate subpopulations from both management and ecological perspectives.
3. Split polygons by rivers that represent barriers to movement (classified as "small" or larger)
    a. Data source: "Northeast Aquatic Habitat Classification System" RCN grant datalayer (rcngrants.org)
4. Removed wetlands not categorized as ephemeral palustrine wetlands or riverine.
    a. Data source: National Wetland Inventory (NWI)
    b. We considered ephemeral wetlands as those classified as temporarily flooded, seasonally saturated, temporarily saturated, seasonally flooded/saturated, or continuously saturated.

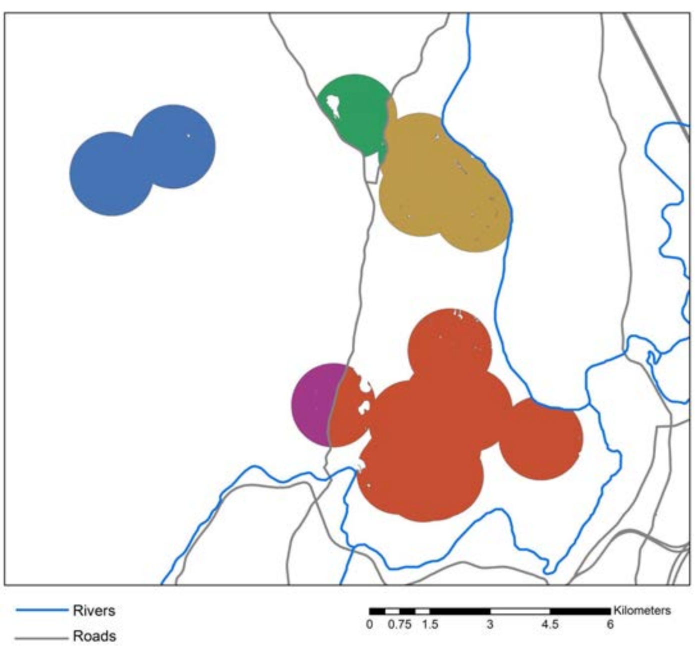

Figure 4. Map depicting examples of delineated Core Areas.

Landscapes

Focal Landscapes.— We delineated focal landscapes using major barriers to movement — highways and rivers (Step 3 and 4 above). This provided a biologically meaningful, logistically feasible, and standardized method for delineating landscapes that did not use occurrence records to define landscape boundaries and therefore was not biased by sampling effort and other potential deficiencies in the occurrence database (Fig 5a).

Sampling Landscapes.— We delineated sampling landscapes by dividing the region into 25 km^2 quadrats (Fig. 5b). The use of quadrats is a well-established method often used by natural history atlas projects. While 10-km quadrats are more conventional, we use 5 km to provide a finer scale understanding of data-deficient areas.

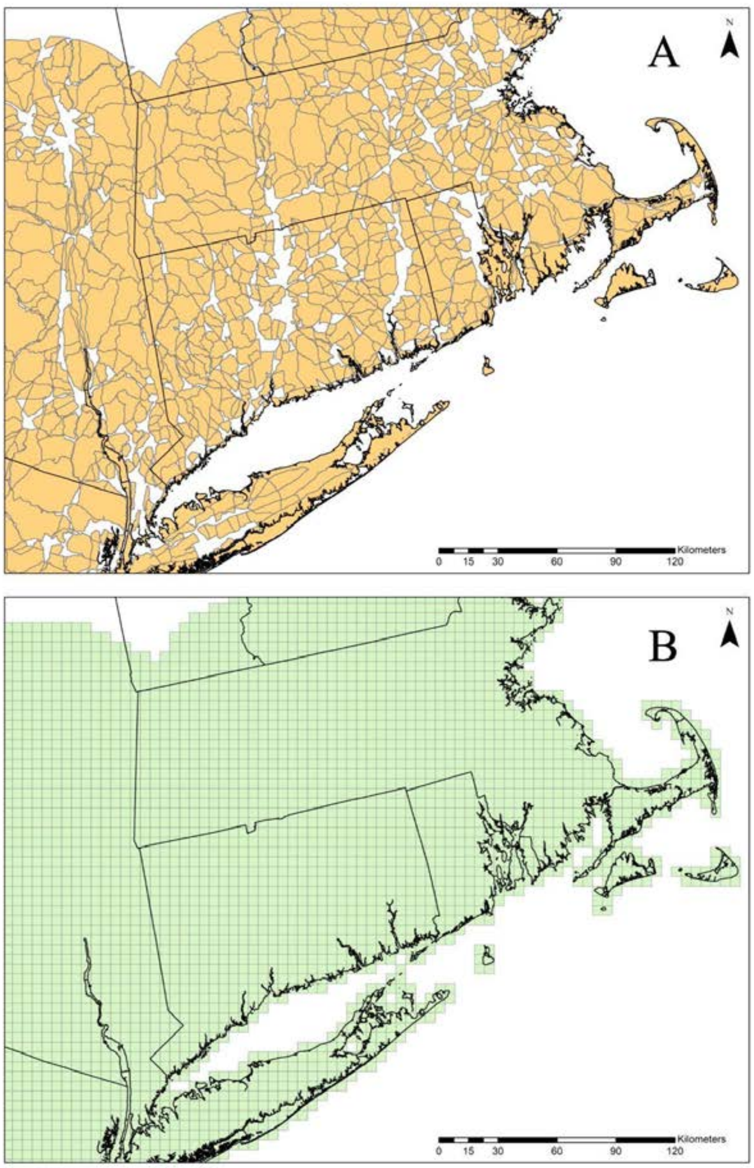

Figure 5. Examples of delineated Focal Landscapes (A) and Sampling Landscapes (B)

Prioritization

Important Variables

We identified a set of variables that we determined were relevant to eastern box turtle ecology and conservation and could be used to compare and prioritize locations for conservation efforts. These variables varied in conceptual scale (i.e., Core Area or Landscape) and were categorized under 8 broad classes:

Class I. Site Size

1. Total amount of undeveloped land within the boundaries of a delineated Core Area

Class II. Core Area Fragmentation

1. Proportion forest/early-successional (i.e. grassland, shrub) cover
2. Mean impervious surface cover
3. Road density
4. Mean traffic rate
5. Mean distance of each raster cell to road

Class III. Core Area Habitat Abundance and Quality

1. Mean habitat suitability (model results)
2. Proportion forest/early-successional cover

Class IV. Landscape Integrity

1. Proportion forest/early-successional (i.e. grassland, shrub) cover
2. Road density
3. Mean impervious surface cover
4. Mean traffic rate
5. Proportion agricultural cover
6. Mean habitat suitability (model results)

Class V. Core Area Population Information

1. Relative abundance
2. Population size estimate
3. Age structure (% of the total animals caught on site that are subadults or younger)

Class VI. Landscape Population Information

1. Total number of occurrences
2. Density (occurrences/ha)

Class VII. Conservation Context

1. Proportion of land conserved within Core Area
2. Proportion of land conserved within Landscape

Class VIII. Vulnerability to Development

1. Projected probability of development within Core Area
2. Projected probability of development within Landscape

All variables were calculated using ArcGIS (Environmental Systems Research Institute, Inc., Redlands, CA) or R statistical software (R Core Team 2022). We used the National Land Cover Database (NLCD; citation) to estimate the proportion of forest/early-successional cover, road density, mean impervious surface cover, mean traffic rate, and proportion of agricultural cover. We determined the protected status of land using the Protected Areas Database (PAD-US; USGS GAP 2020). We used the habitat suitability model results developed in association with this project (Appendix A) and the North Atlantic Landscape Conservation Cooperative (NALCC) Designing Sustainable Landscapes (DSL) Eastern Box Turtle Suitability Model (McGarigal et al. 2016) to estimate mean habitat suitability. We used the NALCC DSL Projected Probability of Development datalayer (McGarigal et al. 2017) to estimate vulnerability to development

Expert Survey & Variable Weighting

On September 22, 2021, we distributed a survey to 34 biologists with expert knowledge of the ecology and conservation of the eastern box turtle across the northeastern U.S. (Appendix B). Survey recipients were associated with federal and state agencies, academic institutions, and nonprofit organizations. We asked recipients to distribute the survey to additional experts in the Northeast. The survey outlined the goals of the CAN and asked respondents to (1) rank the relative importance of each broad class of variables (see previous subsection) and (2) rank the relative importance of each variable within each class. Respondents could provide a score of 1–5, where 1 = "not important" and 5 = "very important." We used survey responses to develop weights reflecting the relative importance of each variable class as well as each variable within each class. We calculated weights by dividing the mean score for each class or variable by the sum of mean scores across classes or variables within a class.

Focal Core Area Prioritization

Attribution.— We attributed Core Areas with variables outlined above. We excluded Class V (Core Area Population Information) because this information was available for very few locations. Variables specified at the conceptual level of the Core Area were calculated within the boundaries of the Core Area. Variables specified at the Landscape conceptual level were calculated at 1-, 3-, and 5-km buffers around each Core Area and then averaged to obtain a value reflecting multiple spatial scales. We chose to use multiple spatial scales because it is currently unclear what spatial scales are most important for each variable.

FCA Ranking Metric.— After Core Areas were attributed, we developed a single composite ranking metric reflecting the important variables outlined above that would be used to rank Core Areas according to their potential to support robust, resilient, and viable populations. We excluded Classes VI (Conservation Context) and VII (Vulnerability to Development) because there was uncertainty about both the importance of these classes to prioritization and how they should be prioritized if included (e.g., should more or less vulnerable sites be prioritized). Following Conservation Plans for Blanding's Turtle (Willey and Jones 2014) and Wood Turtle (Jones et al. 2018), we calculated this FCA ranking metric with the following process:

1. All variables were scaled 0–1, with 0 representing the smallest value and 1 representing the largest
2. Metrics that are considered to negatively impact eastern box turtles were subtracted from 1, such that large values for all variables indicated beneficial conditions for eastern box turtles with respect to that variable
3. Each variable was multiplied by its respective weight
4. Variables were summed to produce an overall score for each class
5. Classes were rescaled 0–1
6. Each class was multiplied by its respective weight
7. Class values were summed to produce the overall metric

Core Areas with larger metric values were considered higher conservation priority.

Focal Landscape Prioritization
Attribution.— In ArcMap, we removed Core Areas from candidate Focal Landscapes, leaving only the area encompassing intervening land cover. We then removed non-temporary palustrine wetlands (see step 4 for Core Area mapping protocol) and attributed the resulting polygons with the Landscape Integrity (Class IV) variables.

Focal Landscape Ranking Metric.— We followed the same process as described for the FCA Ranking Metric above (i.e., scaling, weighting variables, etc) to obtain a single Landscape Integrity score for the intervening land between FCAs within each candidate Focal Landscape. Next, we calculated the weighted-average FCA Ranking Metric score for all FCAs within each candidate Focal Landscape, such that larger sites received more weight. Last, we calculated final Focal Landscape Ranking Metric scores by taking the weighted average of Landscape Integrity (of intervening area between FCAs) and the average FCA Ranking Metric at a ratio of 3:1 in favor of FCA Ranking Metric averages (Fig. 6). We gave more weight to FCA scores because we wanted to prioritize landscapes with known populations with higher likelihood of persistence.

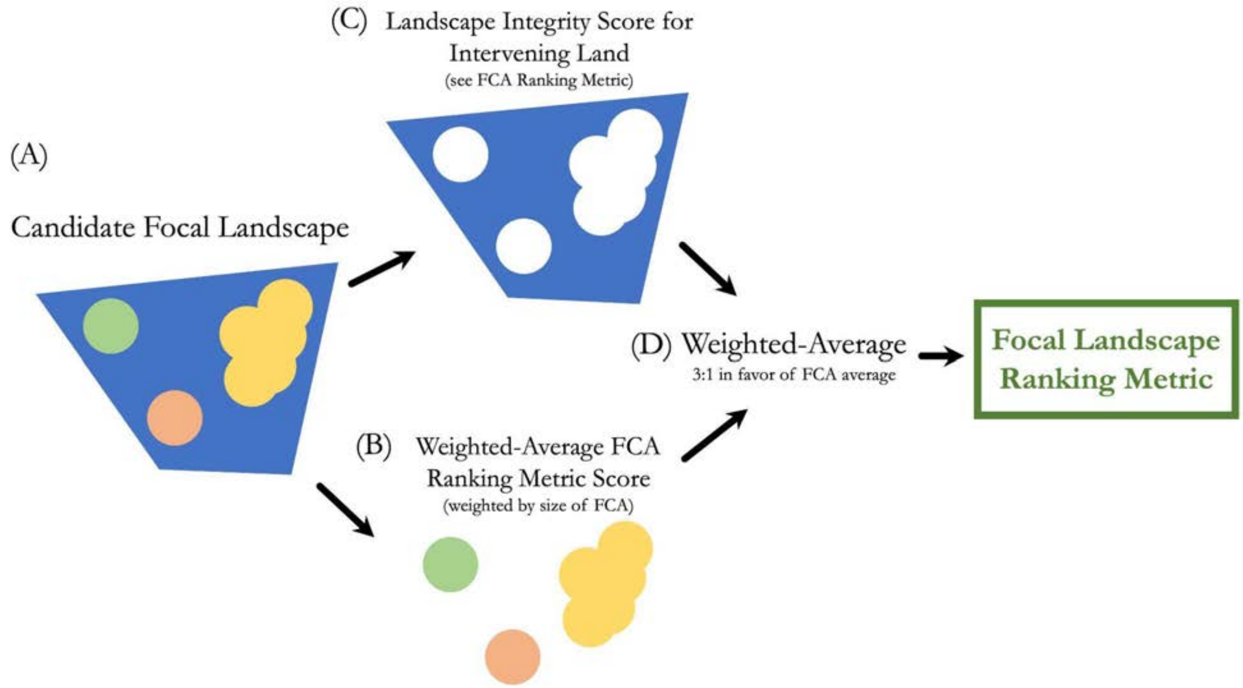

Figure 6. Diagram showing Focal Landscape Ranking Metric calculation process. Colored circular-shaped polygons depict Focal Core Areas (FCAs) and angular blue polygons depict the boundary of a Focal Landscape.

Sampling Landscape Prioritization

Attribution and Ranking Metric.— Similar to the process for Focal Landscapes, we attributed quadrats (Fig. 5b) with Class IV Landscape Integrity variables. We followed the following steps to create the Sampling Landscape Ranking Metric:

1. All variables within the Landscape Integrity Class were scaled 0–1, with 0 representing the lowest value and 1 representing the largest
2. Variables that are considered to negatively impact eastern box turtles were subtracted from 1, such that large values for all variables indicated beneficial conditions for eastern box turtles with respect to that variable
3. Each variable, except habitat suitability, were multiplied by their respective weight
4. All variables, except habitat suitability, were summed to produce an overall score for each class, which was then scaled 0–1 again
5. We then averaged the value produced in step 4 with habitat suitability values to produce the Sampling Landscape Ranking Metric (Fig. 7)

We averaged habitat suitability values with a combined score for land cover variables (instead of including habitat suitability within the combined land cover score) in order to emphasize the influence of climate on habitat suitability and therefore sampling suitability. This aspect of the ranking metric acted to lower the relative rank of locations where populations are less common to climate or other factors, such as high elevation areas and locations at the edge of the distribution.

The NALCC DSL layer generally overpredicts suitable habitat at high elevations and at the northern extent of the species range. Therefore, instead of using the mean of both the species distribution model (Appendix A) and NALCC DSL habitat models to represent habitat suitability, we only used species distribution model values. We removed all quadrats that overlapped with occurrence records.

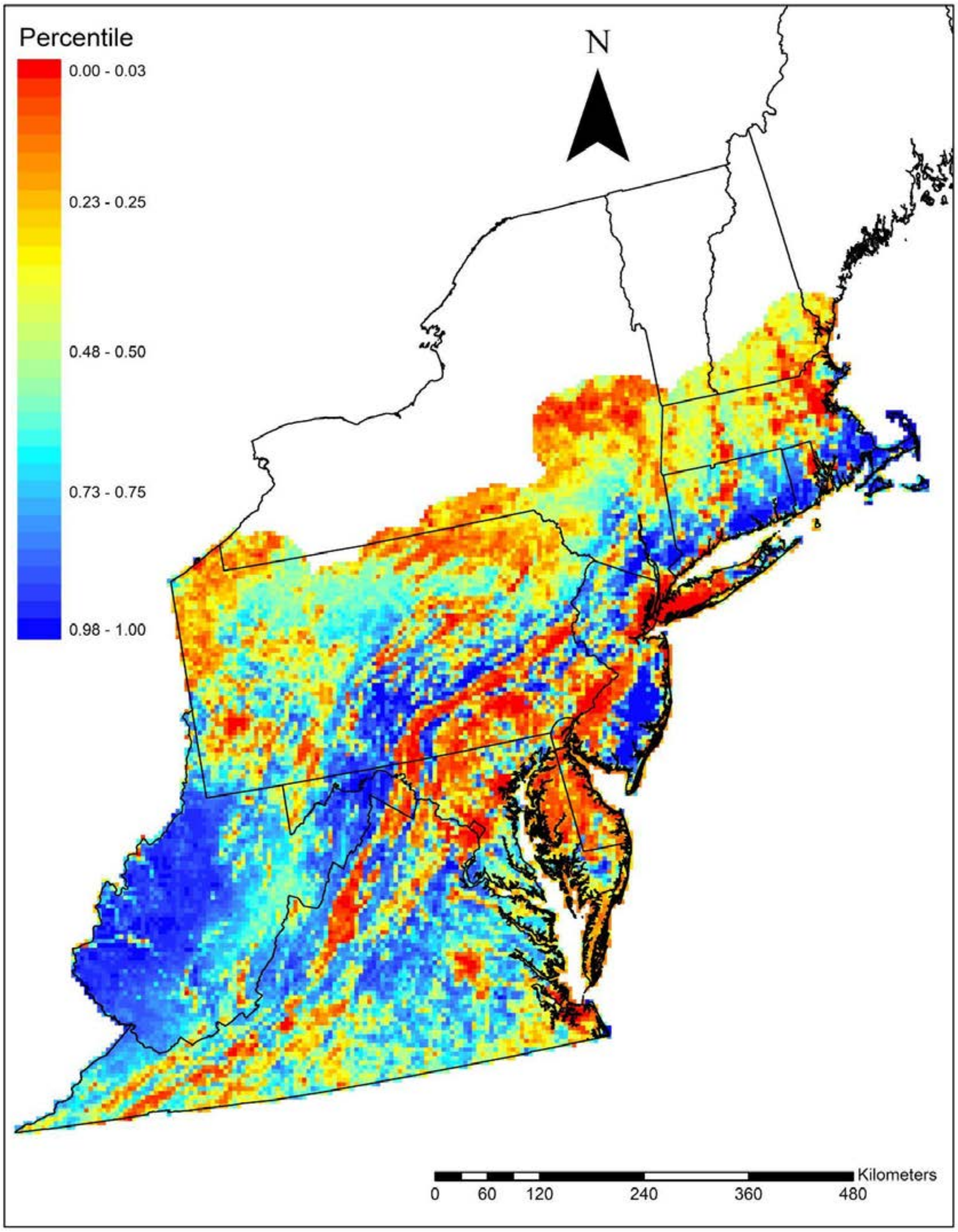

Figure 7. Sampling landscapes across the potential eastern box turtle range in the northeastern United States. Colors represent percentile of the expert-derived sampling landscape ranking metric scores (see Sampling Landscape Prioritization Section above).

Management Core Area Prioritization

Agricultural Mitigation Opportunities.— Our goal with this category of Core Areas was to identify locations that are potentially impaired by agriculture, but are not so degraded that any level of agricultural mitigation would be unlikely to improve the outlook of the resident population. Therefore, we developed a metric that prioritized larger sites with lower road density and proportions of agriculture and forest/early-successional cover closer to 0.5. Below we outline the steps for creating this metric.

1. For proportion agriculture and proportion forest/early-successional cover:
    a. Subtract 0.5 from all values and take the absolute value
    b. Subtract 0.5 from step 1a values and take the absolute value
2. Scale all values from 0–1 (lowest values = zero, highest = 1)
3. Average all of these values

Federal Partnership Opportunities.— Federal Partnership Opportunities represented all Core Areas that overlap with U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, and Department of Defense properties.

Selection Processes

We conducted systematic processes for selecting Core Areas or Landscapes for inclusion in the Conservation Area Network. Each Tier category followed a distinct selection process.

Focal Core Areas

The selection process for Focal Core Areas aimed to incorporate the Core Areas with the highest conservation value throughout the Northeast while also providing adequate representation across important jurisdictional, ecological, and evolutionarily relevant boundaries. We chose Core Areas for inclusion as Focal Core Areas within the CAN using a step-by-step process where sites were sequentially selected within categories according to established rules.

1. Top 5 Core Areas across the region.
2. Top 5 Core Areas in each state. We selected new additional sites if the top sites were already selected in step 1.
3. Within each state, we selected the top Core Area within each Environmental Protection Agency (EPA) Level 3 Ecoregion (Fig. 8a). We did not select a new site if one was already selected.
4. Within each state, we selected the top Core Area within ecoregion within each of the two coarse genetic groupings (Fig. 9) established by Kimble et al. (2014). We did not select a new site if one was already selected.
5. Core Areas were removed or included based upon expert (state and Northeast Eastern Box Turtle Steering Committee biologists) knowledge of populations and landscapes.

Additional rules:

- Included additional supplementary top state Core Areas (step 2 above) when members of the top 5 Core Areas determined by expert opinion to be functionally the same site (e.g., very close). In such cases, the next highest ranked site was included.
- Core Areas were included as "Supporting" Corea Areas if they were known or suspected by experts to be connected to Core Areas already selected.

Notes:

- Due to the relatively small size of the District of Columbia, only one site was selected in this jurisdiction

The following selection steps were not applied, but should be considered when sufficient data is available:

- Genetic clusters: incorporate genetic clusters as a category in which to select sites to ensure representativeness.
- Genetic diversity: sites with exceptionally high genetic diversity
- Genetic uniqueness: sites with exceptionally unique genetic composition
- Population size: sites with high population estimates
- Survey returns: sites with high survey returns

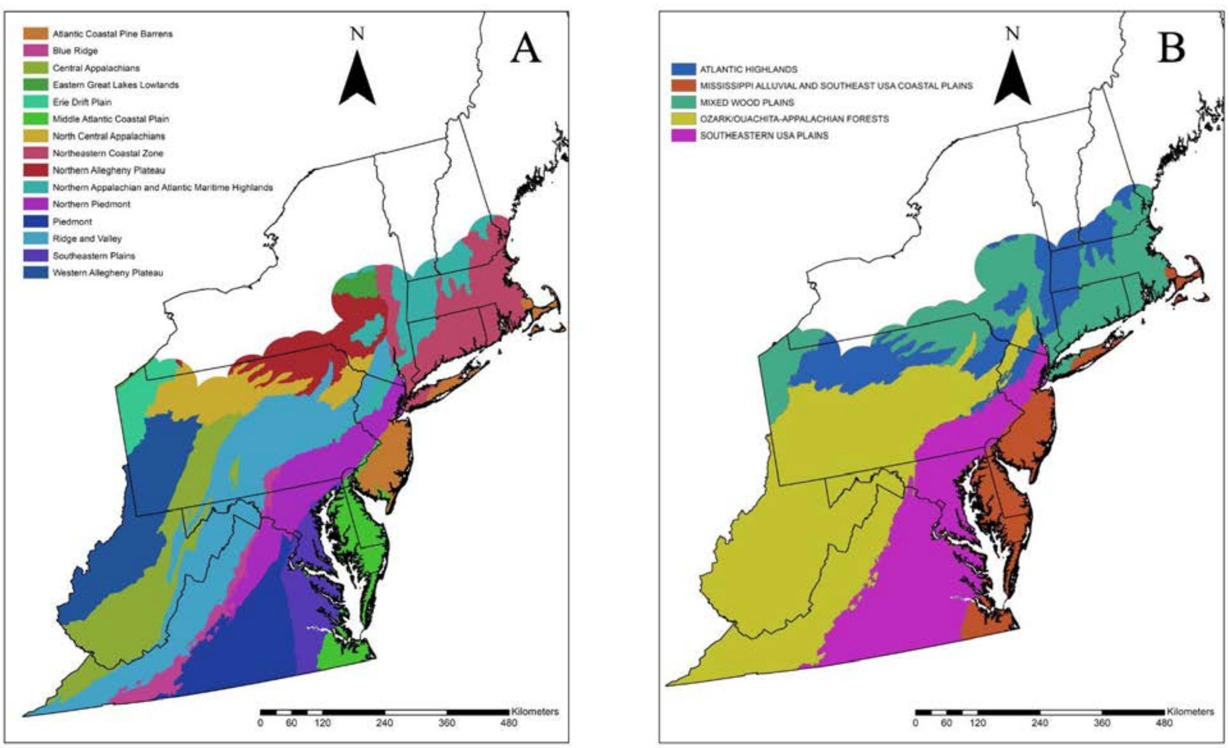

Figure 8. Environmental Protection Agency Level III (A) and II (B).

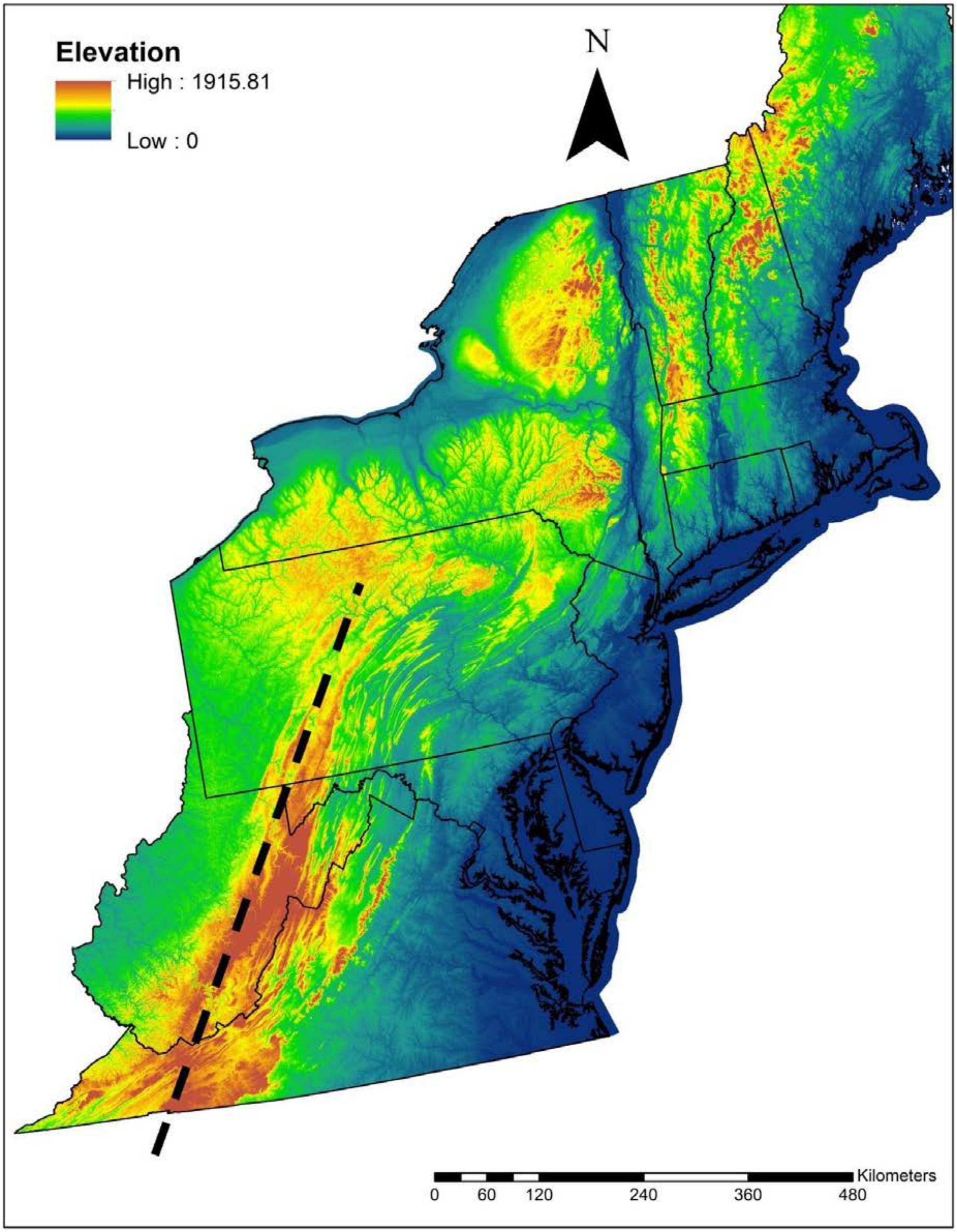

Figure 9. Elevation (m) across the northeastern United States. The black dashed line represents the approximate boundary between eastern and western populations identified by Kimble et al. (2014).

Focal Landscapes
The selection process for Focal Landscapes included:

1. Top landscapes in each state: 8 landscapes in Pennsylvania, 8 in West Virginia, 6 in Virginia, and 4 in the remaining states.
2. Top (one) landscape within each EPA Level 2 Ecoregion (Fig. 7b) not already selected in Step 1 above.
3. Landscapes were removed or included based upon expert (state and Northeast Eastern Box Turtle Steering Committee biologists) knowledge of populations and landscapes.

Rules followed for steps 1 and 2:

- Landscapes were only selected within ecoregions if they were above the 25th percentile of landscapes in the region
- Landscapes were not considered if unsuitably high elevations made up the majority of landscape
- We did not select landscapes in the District of Columbia due to small size or New Hampshire due to very few occurrence records in the state
- We did not consider small landscapes <1730 ha (the area equal to approximately 5 buffered occurrences). We also did not consider landscapes if (1) they did not contain a Core Area or (2) Core Areas were a very small proportion of the total area (≤ 5%) and the landscape contained ≤ 5 Core Areas.
- We generally did not consider Landscapes that did not have a record in the state (i.e., Landscapes that overlapped with state boundaries, with records in one state, but not the other)

Notes:

- We selected more landscapes in Pennsylvania, West Virginia, and Virginia because these states had more than double the land area (within the distribution) than any other state. However, we only selected six landscapes in Virginia because many potential landscapes did not contain records.

Sampling Landscapes
We include all Sampling Landscapes above the 75th percentile (after Landscapes with records are removed) as "high priority" sampling landscapes. However, states are encouraged to use the entire Sampling Landscape datalayer to achieve state-specific sampling goals.

Management Core Areas
Agricultural Mitigation Opportunities.— We selected the top 2% of Core Areas with respect to the Agricultural Mitigation Opportunity Ranking Metric.

Federal Opportunities.— We selected all Core Areas that overlapped with federal lands owned by the U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, and Department of Defense.

Results

We collected 21,386 occurrence records from across the region. After applying a minimum separation distance of 100 m between records, there were 15,008 records. The Core Area delineation process yielded 6,099 Core Areas across the northeastern U.S. (Table 1). One hundred and fifty one FCAs, 88 Focal Landscapes, 114 Agricultural Mitigation Opportunities, 551 Federal Partnership Opportunities, and 2,579 Sampling Landscapes were identified (Table 1). After applying a 100 m separation distance, the number of records per state ranged 24–4,520 (Table 2). Core Areas in West Virginia generally had higher Ranking Metric scores than other states, while the District of Columbia and Delaware generally had lower scores (Fig. 10). The proportion of areas that were mapped as Core Areas and designated as FCAs ranged 0.03–1.0 (Fig. 11). Massachusetts had a considerably higher FCA to total suitable land area ratio than other states (Fig. 12). Massachusetts and West Virginia generally had more records per unit of suitable land than other states (Fig. 13). Focal Core Areas are generally more protected from development compared to other Core Areas within respective states, although there was some variation among states and depending upon GAP status (Fig. 14). Virginia and Rhode Island have the lowest proportion of suitable (i.e., >75th percentile) Sampling Landscapes with no record (Fig. 14), suggesting that these states may have the greatest relative need for sampling geared toward understanding eastern box turtle distribution. Delaware and Massachusetts have the highest proportion of suitable Sampling Landscapes with no record (Fig. 15), suggesting that these states may have low relative need for sampling geared toward understanding eastern box turtle distribution.

Table 1. Summary of Conservation Area Network Core Areas and Landscapes.

State	Core Areas Mapped	Tier I (Higher Priority): Focal Core Areas	Tier I (Higher Priority): Focal Landscapes	Tier II (Lower Priority): Management Core Areas: Agricultural Mitigation	Federal Partnership: Total	Federal Partnership: USFWS	Federal Partnership: USFS	Federal Partnership: NPS	Federal Partnership: DOD	Tier II (Lower Priority): Sampling Landscapes
Connecticut	362	13	5	0	5	3	0	1	1	108
Delaware	124	9	5	0	10	6	0	3	1	1
District of Columbia	10	1	0	0	10	0	0	10	0	0
Maryland	337	19	7	4	39	9	0	24	8	101
Massachusetts	453	19	7	0	18	9	0	5	4	65
New Hampshire	4	4	0	0	0	0	0	0	0	0
New Jersey	363	12	5	2	33	19	0	10	4	131
New York	184	19	8	2	11	0	0	4	8	90
Pennsylvania	1,117	20	12	32	52	7	0	41	8	396
Rhode Island	19	10	8	0	1	1	0	0	0	46
Virginia	1,473	12	7	49	260	18	97	105	57	812
West Virginia	1,653	13	24	25	112	6	67	41	2	829
Total	6,099	151	88	114	551	78	164	244	93	2,579

Table 2. State-based summary of records and area of Core Areas, Focal Core Areas, suitable landscape conditions, and the potential distribution within the northeast. Estimates of suitable conditions come from Chapter 6 of the Status Assessment (Erb and Roberts 2023).

State	Records	Records/Core Area	Core Area (ha)	Focal Core Area (ha)	Suitable (ha)	Potential Distribution (ha)
Connecticut	678	1.9	136,706	7,812	833,264	1,177,116
Delaware	254	2.1	44,530	8,563	203,133	505,081
District of Columbia	24	2.4	4,773	597	2,741	17,042
Maryland	494	1.5	101,517	6,356	1,150,704	2,373,887
Massachusetts	2701	5.8	248,177	49,337	883,665	1,527,027
New Hampshire	36	9	1,627	1,627	228,557	492,239
New Jersey	649	1.8	139,213	9,540	1,078,947	1,918,783
New York	350	1.9	67,761	13,670	836,897	1,657,737
Pennsylvania	2081	1.9	416,131	13,047	2,430,207	5,743,140
Rhode Island	72	3.7	7,106	4,517	137,556	278,675
Virginia	3127	2.1	605,579	30,618	3,579,147	9,895,148
West Virginia	4520	2.8	758,419	50,199	3,593,294	4,781,492

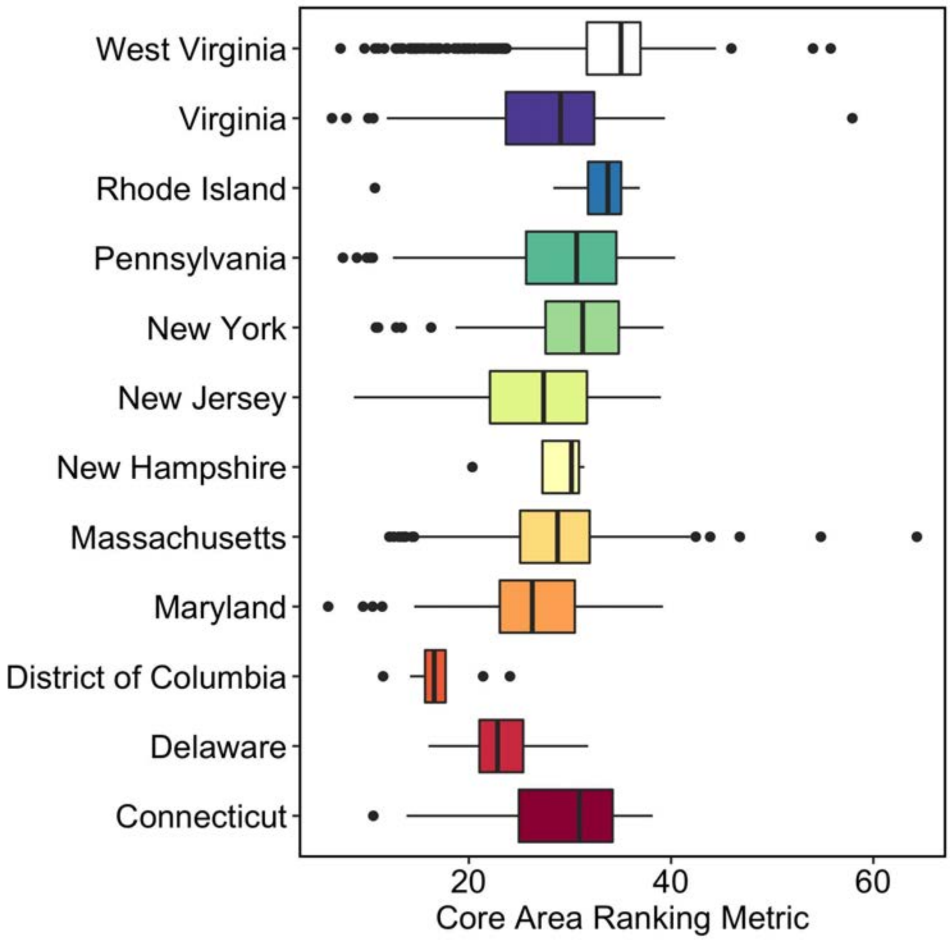

Figure 10. Boxplots of Core Area Ranking Metric scores for all Core Areas within each state.

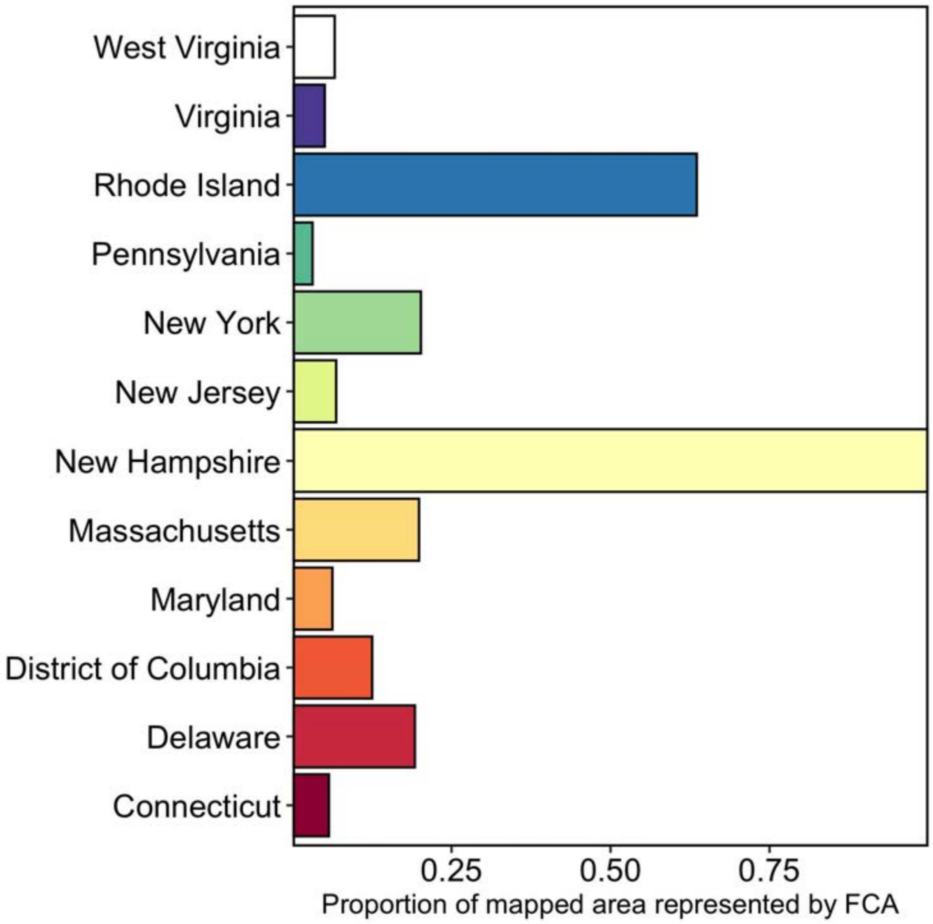

Figure 11. Proportion of mapped Core Areas that were designated at a Focal Core Area in each state.

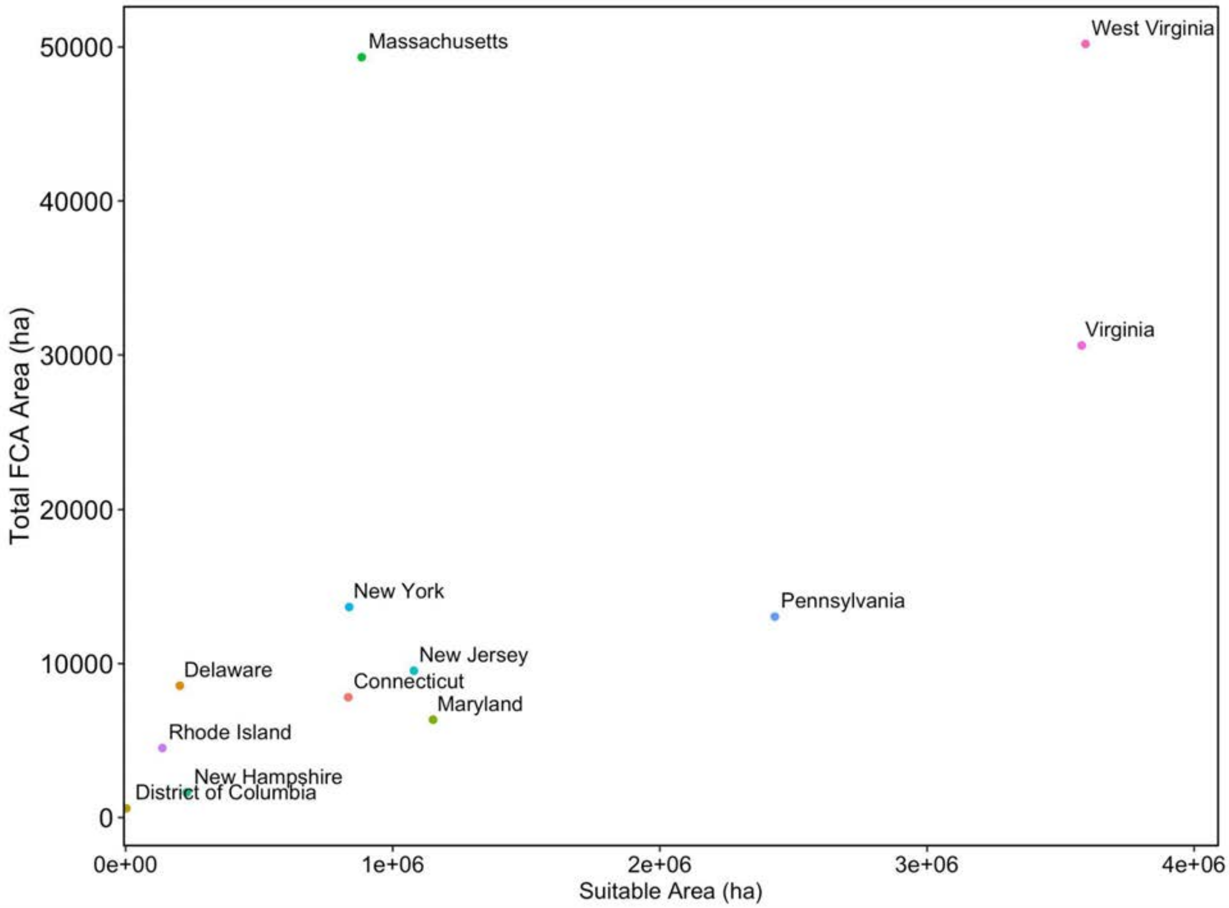

Figure 12. Area (ha) of Core Areas selected as Focal Core Areas in relation to the amount (ha) of land modeled as unimpaired in Chapter 6 of the Status Assessment for the Eastern Box Turtle in the Northeastern United States (Erb and Roberts 2023).

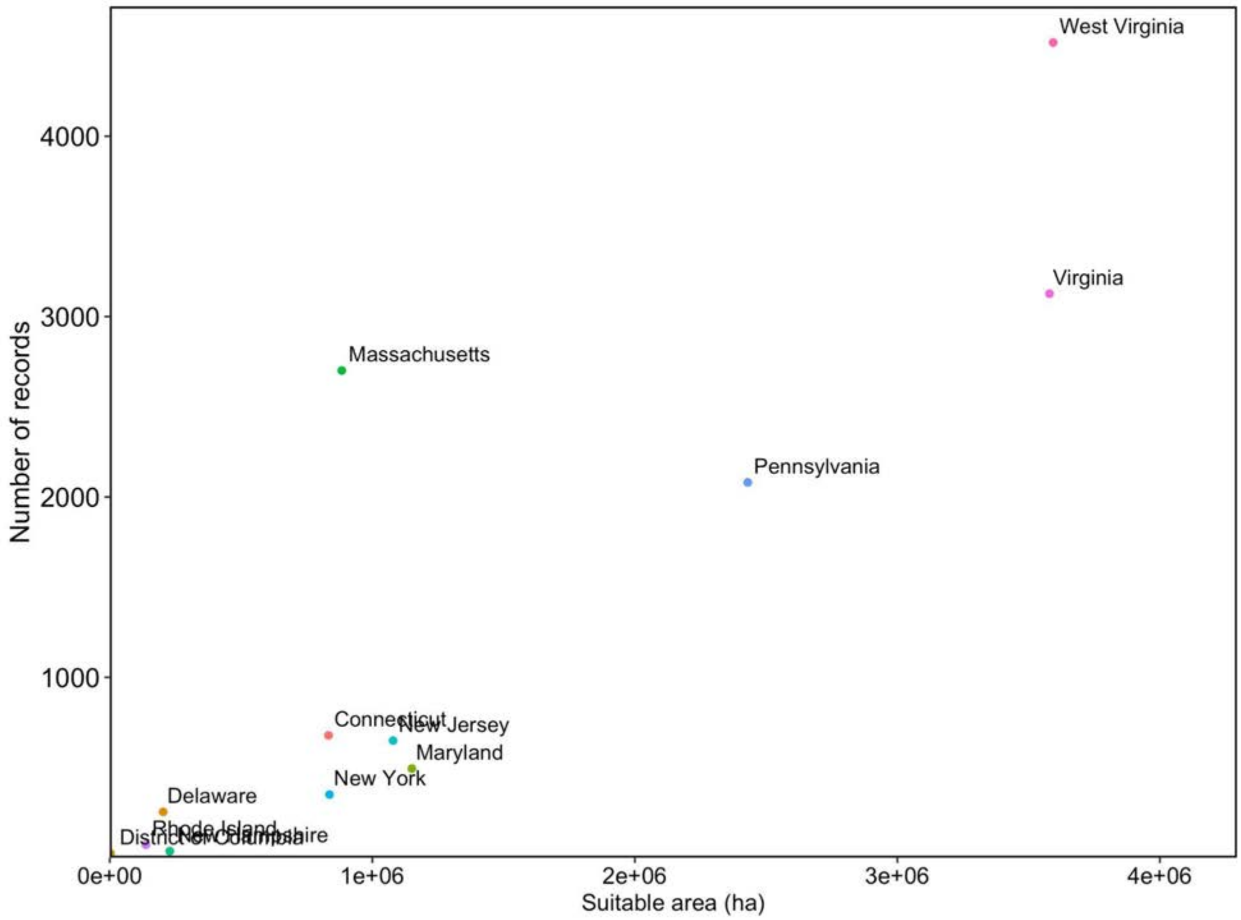

Figure 13. Number of records in relation to the amount (ha) of land modeled as unimpaired in Chapter 6 of the Status Assessment for the Eastern Box Turtle in the Northeastern United States (Erb and Roberts 2023).

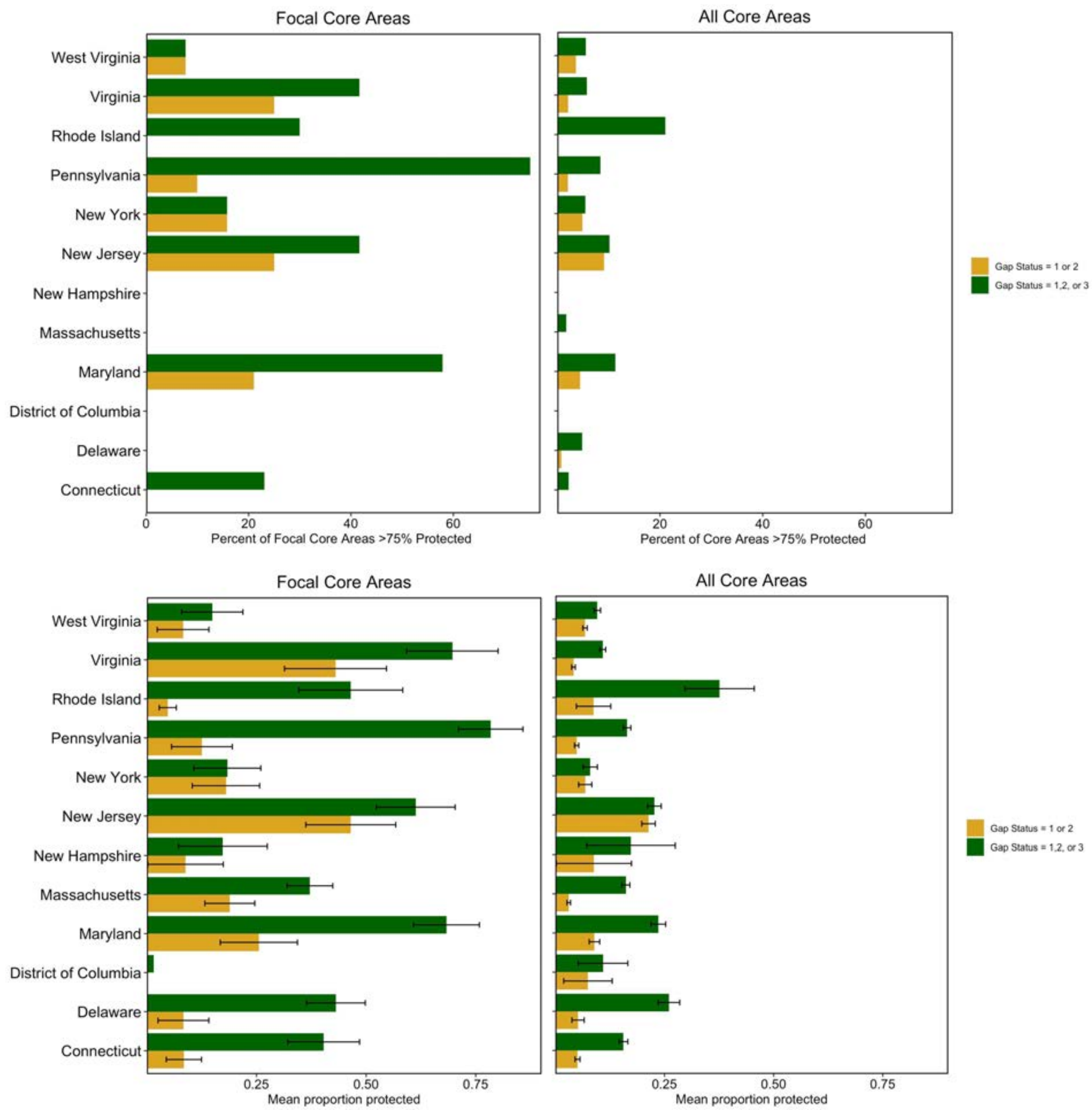

Figure 14. Summary of protectedness by state. Percent of Focal Core Areas >75% protected (top left), percent of all Core Areas >75% protected (top right), mean proportion of Focal Core Areas protected (bottom left), and mean proportion of all Core Areas protected (bottom right). Calculations were made using GAP status 1 and 2 only (yellow) as well as GAP status 1, 2, and 3 (green). Gap statuses 1 and 2 indicate areas protected for biodiversity while 3 indicates protected areas that can be subject to resource extraction and other uses. Error bars represent standard error.

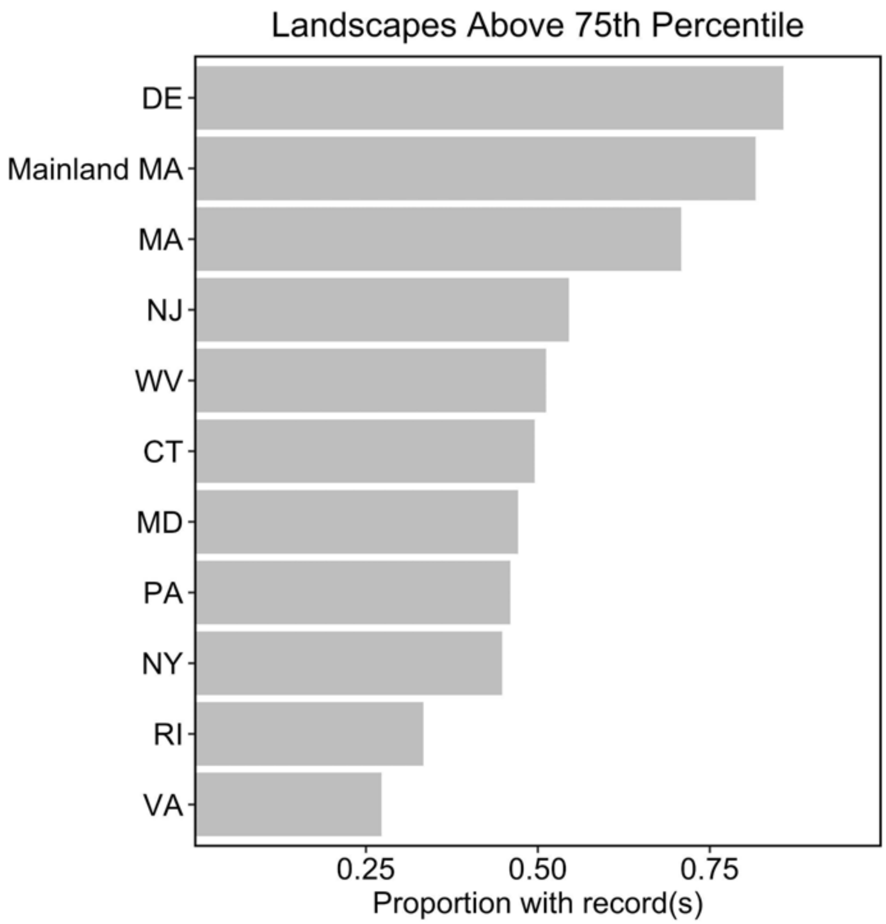

Figure 15. Proportion of Sampling Landscapes above the 75th percentile (i.e. relative suitable) containing a record. Mainland MA represents Massachusetts without the islands of Nantucket or Martha's Vineyard.

Part II. Conservation Action Plan

The Northeast Eastern Box Turtle Working Group's (NEEBTWG) fundamental goal in the development of this Conservation Plan is to support the persistence and adaptive capacity of the eastern box turtle in the northeastern United States, encompassing the area from Maine to Virginia. The Northeast Eastern Box Turtle Conservation Area Network (NEBT CAN; Part I) provides a core strategy and distinct spatially-explicit elements (Focal Core Areas and Landscapes, Sampling Landscapes, and Management Core Areas) to guide efforts to address these goals. This Conservation Action Plan serves to articulate a core set of six objectives that are needed to accompany the NEBT CAN in order to achieve the fundamental goal of this plan. These objectives include (1) increasing collaboration at multiple levels, (2) addressing data-deficiencies, (3) implementing an adaptive conservation framework, (4) increasing strategic research, (5) combating illegal trade, and (6) reducing threats within Focal Core Areas and Focal Landscapes. Target timelines are provided for the *initiation* of each objective. Specific actions at multiple geographic scales (rangewide, regional, state, site) are proposed within each objective.

Objective 1. Increase Collaboration at Multiple Levels

Initiation timeline: <5 years (before 2028)

Expand Collaborative Network

Collaboration represents the foundation of the recent proliferation of regional turtle conservation in the Northeast (Willey and Jones 2014, Egger 2016, Jones et al. 2018, Erb 2019; Willey et al. 2022; northeastturtles.org) and will be necessary to ensure effective landscape-scale and long-term conservation for the eastern box turtle in the decades to come. Expanding collaboration at multiple levels — including local, regional, and rangewide scales — should represent an immediate priority in order to generate interest and concern for the species, and tackle the challenges of data collection and population monitoring of this widespread generalist. Among numerous benefits, establishing rangewide partnerships will help provide a better understanding of global status (and therefore relative regional responsibility), support the identification of emerging and potential threats, and allow an opportunity to share protocols and resources (BMPs, etc). With proper training and permits, local partnerships with land trusts, NGOs, local governments (e.g., towns and counties), universities, nature centers, and other entities (e.g., the North American Box Turtle Conservation Committee and The Box Turtle Connection) offer an important opportunity to increase the capacity to monitor and understand individual populations and landscapes, and in some cases protect and manage habitats.

Intra-agency collaboration among departments represents another important and sometimes overlooked form of collaboration with the potential to improve the conservation outlook for eastern box turtle. For example, increased communication of priorities and coordination of efforts among biologists and land managers (foresters, burn crews, and other habitat managers) will reduce the likelihood that agency programs will play a role in population decline. Increased communication with outreach and land protection staff about the regional outreach materials and CAN priorities will also prove valuable.

Management Structure

To guide future conservation for the species in the Northeast, we propose a management structure consisting of two primary teams: the Northeast Eastern Box Turtle Steering Committee and the Northeast Eastern Box Turtle Working Group. This structure largely represents a continuation of the current system for this RCN-funded project. The Steering Committee will represent state biologists and biologists from other organizations and agencies that are actively involved in funded projects or regional conservation decision-making processes. The Steering Committee will meet monthly during actively funded periods to track progress toward objectives, share progress, establish regional goals, and potentially discuss sensitive data. During unfunded periods, the Steering Committee will aim to convene annually or biannually. The Working Group will consist of Steering Committee members and additional personnel involved in eastern box turtle conservation and monitoring throughout the region, but not serving in a leadership role. The Working Group will meet less frequently (e.g., quarterly, biannually) than the Steering Committee during funded periods. If there is interest outside of the Northeast, this management structure could become rangewide in scope by expanding to include biologists across the broader species (or subspecies) range.

Pursuit of Funding

Regional and rangewide funding opportunities dedicated to collaboration among state agencies and other entities, such as Regional Conservation Needs grants and Competitive State Wildlife Grants, should represent a priority in the near-term for implementing at least a portion of the actions outlined in this document, and furthering eastern box turtle conservation more generally. Pursuit of subregional by partners should be encouraged, particularly when the CAN and CAP represent core components of the proposal. If possible, the Steering Committee should consider providing guidance for subregional funding proposals when solicited.

Conservation Symposia

Conferences and symposia play an important role in promoting collaboration by offering opportunities to make new connections, share experiences, develop professional relationships, and generate new ideas that might not otherwise occur. Steering Committee and Working Group members should consider attending and contributing to specialized meetings such as the Box Turtle Conservation Workshops organized by the North American Box Turtle Conservation Committee and the 2023 Conservation Symposium for Emydine Turtles. In particular, future regional eastern box turtle projects should consider providing financial and/or logistical support for the next

Conservation Symposium for Emydine Turtles and aim to find ways to increase focus on eastern box turtle without detracting from other species.

Regional Database/Repository

Surveys.— There is a clear need for a secure, centralized data repository that is not controlled by a single individual or entity, and can be accessed for future regional analyses. Such a database was recently developed for Blanding's turtles in the Northeast, and may soon include other species such as the wood turtle and spotted turtle. The Steering Committee should explore the possibility of including eastern box turtle within this regional data repository and/or providing funding through future efforts to support this task.

Genetics.— This project collected hundreds of genetic samples and analyses produced numerous complex technical data files. Thus, in addition to managing the survey and occurrence datasets, there is also a clear need to develop a system for housing both electronic genetic data (including results) and physical samples. Plans should consider incorporating a capacity to also house future samples, which could reach several thousand samples if tissue collection efforts are similar to those of other regional conservation projects in the region (Jones et al. 2018).

Federal Partnerships

Encourage Monitoring on Federal Lands.— Federal lands offer an excellent opportunity to increase both distributional and population-level information throughout the region. The NEBT CAN has identified areas within federal lands that support eastern box turtles — these sites should represent opportunities for population monitoring with the aim of understanding relative abundance, population size, and demographic information. The standardized survey protocol should be provided to in-house biologists when possible. Department of Defense properties in particular could represent priorities for monitoring because several are known to support robust, regionally-significant eastern box turtle populations and qualified teams of biologists are typically available. A continuation of this regional conservation effort should consider developing a strategic federal outreach plan with the aim of sharing the population monitoring protocol and educating/training staff about the importance of understanding their population and contributing to the regional initiative.

NRCS Working Lands for Wildlife.— Currently, the Natural Resources Conservation Service (NRCS) Working Lands for Wildlife Northeast Turtles project primarily focuses on Blanding's, wood, and spotted turtles. The inclusion of eastern box turtle within this program would introduce much-needed management-oriented resources for the species in the Northeast. As highlighted in the Northeast Wood Turtle Conservation Plan (Jones et al. 2018), the additional expansion of the geographic scope of this project, which currently only encompasses ME, NH, VT, MA, RI, CT, and NY, to include the entire Northeast, would broadly benefit turtle conservation.

State Partnerships

Increase Interagency Awareness and Collaboration.— State agency collaboration represents the backbone of this regional effort (as well as those for other at-risk turtles in the northeast) and the NEEBTWG should aim to continue to foster a high level of collaboration among state agencies. Efforts by state biologists to share the products associated with this project both within and among agencies will help increase awareness and collaboration. A draft presentation that provides an overview of the Status Assessment (Erb and Roberts 2023) and this Conservation Plan has been provided to the state leads for this purpose.

Outreach

In conjunction with a future funded effort, the Steering Committee should consider increasing the scope and capacity of the regional outreach program, with particular emphasis on a dissemination strategy for recently developed materials (e.g., anti-poaching postcard, management guidelines, etc.). State wildlife agencies should consider directing outreach toward land trusts, landholding and purchasing agencies, and state DOTs with the goal of education around basic biology and ecology of turtles, the threats they face, and the specific actions these entities can implement to help mitigate threats.

Objective 2. Address Data-Deficiencies

Initiation timeline: 0-5 years (before 2028)

Consistent Element Occurrence Tracking by State Agencies

Effective conservation planning is driven by consistent and robust data collection. Currently, due to the varying levels of priority for conserving eastern box turtle across the region, there are considerable inconsistencies among state agencies with respect to tracking of element occurrences. Some states do not actively track eastern box turtle records (e.g., Maryland and Virginia) or do so at a relatively low priority level. Increased tracking (and funding for such efforts) of eastern box turtles will dramatically improve the understanding of the fine-scale distribution within the species in the region and, in conjunction with population monitoring (below), should represent the *highest priority* action for this objective.

Population Monitoring

The current RCN-funded project supported the development of an Eastern Box Turtle Population Monitoring Protocol (see Status Assessment, Chapter 3), but largely relied upon volunteer effort for data collection (although some additional funding for surveys was provided in 2022). Therefore, there is an immediate and pressing need for increased standardized population sampling across the entire region with the goal of (1) collecting a large sample of Rapid Assessment sites to assess relative abundance and habitat relationships, and (2) establishing a smaller number of ecologically representative long-term Demographic Assessment sites intended for estimating population size and demographic trends. While a volunteer-based sampling strategy has proven useful, there is a distinct need for a funded, regional sampling effort that employs experienced biologists to sample across a representative range of ecological and jurisdictional contexts. We also recommend additional actions, including refining the monitoring protocol (e.g. continue to compare circular plots vs. feature surveys), considering new sampling methods (e.g. Royle and Turner 2022), identifying environmental gradients of interest for sampling (e.g., development, agriculture, road density), and sampling within Focal Core Areas and Focal Landscapes. In general, state lands could represent a priority for sampling because they represent some of the best opportunities for management and land protection. In conjunction with consistent element occurrence tracking by state agencies (above), should represent the *highest priority* action for this objective.

Regionwide Citizen Science Programs

Public engagement and citizen science programs offer promise for large-scale data collection, particularly for understanding the fine-scale distribution of eastern box turtles throughout the region. For example, from 2020-2021, the West Virginia Division of Natural Resources (WV DNR) developed and implemented an eastern box turtle citizen science program that reported 6,045 verified records from across the state, including two county records. This effort more than quadrupled the number of records within the WV DNR database. We recommend the expansion of similar state-based eastern box turtle citizen science programs throughout the region, particularly within data-deficient states and Sampling Landscapes identified in the Conservation Area Network. However, data sensitivity should be emphasized, and no citizen science efforts should jeopardize data security.

Genetic Sampling

A small genetic sampling effort and analysis was conducted in conjunction with this RCN-funded project, although this effort was limited in geographic scope and primarily focused on understanding genetic structure for the purpose of repatriation (see Status Assessment, Chapter 5). A previous effort by Kimble et al. (2014) aimed to characterize genetic structure across the subspecies range, but their samples were heavily biased toward the western portion of the range, with relatively few samples from the northeastern U.S. We recommend the continuation of genetic sampling with the goal of developing a geographically and ecologically representative dataset that will facilitate a more refined understanding of genetic differentiation, population clusters, patterns of relatedness, landscape connectivity, and (sub)population genetics (genetic diversity, allelic richness, etc). Research focused on understanding genetic diversity and/or where selection is occurring (Andrews et al. 2016), will be particularly important in achieving the overarching goal of maximizing adaptive capacity.

Collaboration.— There are several studies that have collected genetic data for eastern box turtle in the northeastern U.S., including Martin et al. (2013), Kimble et al. (2014), the Turtle Survival Alliance, and other projects. In addition to widespread genetic sampling, future efforts should consider collaborating with other entities with data in order to increase the scope and statistical power of analyses. Collaboration at the rangewide level may also prove valuable.

Identifying and Tracking Disease
Climate change and land-use change are likely to increase the severity and geographic scope of this threat (e.g., Price et al. 2019) in decades to come. Disease-induced population declines have been reported at a number of individual populations (e.g., Adamovicz et al. 2018), but currently there is very little data about prevalence or how, and at what scale, diseases are influencing populations. Thus, understanding disease prevalence within populations and establishing a sustainable surveillance strategy aimed at detecting trends over time should represent an important consideration. Understanding current patterns of disease prevalence and individual recovery in wild populations may also be helpful in informing decision-making frameworks regarding repatriation of confiscated turtles. In addition, we recommend incorporating spread prevention and screening methods into the regional population monitoring protocol to reduce the potential of spreading disease via project sampling and to document potential cases as they occur.

Objective 3. Implement an Adaptive Framework

Initiation timeline: 5–10 years (2028–2033)

Update the Conservation Plan and Conservation Area Network
The Conservation Area Network is intended to function as a "living" document with periodic updates, such that regional conservation for the eastern box turtle follows an adaptive framework. We view this as an *essential* feature of the Conservation Plan that will allow for the incorporation of new data that may shift conservation priorities across the region. We recommend that the Conservation Area Network updates and associated sampling efforts eventually occur at regular intervals ranging 5–10 years. However, the next regional collaborative effort should occur within 5 years in order to increase data collection to inform the distributional data gaps, increase the number of rapid assessments, and establish baseline data for long-term demographic assessment sites.

Future updates to the Conservation Plan and Conservation Area Network should (re)consider and/or prioritize:

1. **Incorporating new information/data**. Types of important information/data include occurrence records, survey data, population size, demographic parameters, genetic results, regional datalayers (e.g., National Land Cover Database, Designing Sustainable Landscapes), and findings from technical and peer-viewed literature.
2. **Spatial representation**. As new data is collected and the general understanding of the species is improved (e.g., via analyses generated by regional collaboration), it may be necessary to refine methods for delineating Core Areas and Landscapes of the Conservation Area Network. For example, this may involve adjusting the Core Area mapping buffer distances (larger, smaller, or regionally varying).
3. **New selection criteria**. Ranking metrics and selection criteria should be revisited and updated to include new information (e.g., ensuring representation of new genetic populations clusters identified) and/or improve current methods (e.g., future analyses may

reveal more nuanced relationships with development that may warrant adjusting ranking metrics).

4. **Conservation benchmarks**. Once data-deficiencies are sufficiently addressed, specific conservation benchmarks should be established that clearly defines a vision for conservation "success" at the regional level.

Adaptive Management

We encourage the adoption of an Adaptive Management (Schreiber et al. 2004, Williams et al. 2009) framework for all habitat management that occurs within Conservation Area Network Core Areas, with particular emphasis on pre- and post-management data collection with respect to both population and environmental (habitat) change. The NEEBT Steering Committee should consider developing basic habitat monitoring protocols for tracking change over time.

Objective 4. Strategic and Experimental Research

Initiation timeline: 0–15 years (before 2038)

Population Estimates and Long-Term Trends

High-precision estimates of population size will be critical for understanding long-term population trends. Therefore, establishing initiatives geared toward capture-mark-recapture at regionally important populations, ecologically representative areas, and along environmental gradients (e.g., different land-use types), should represent an immediate priority. Efforts to understand the persistence and importance of small/low density populations for metapopulation dynamics and gene flow will be valuable. Prior to future intensive monitoring efforts, the Steering Committee should also consider testing and assessing feasibility of utilizing spatial capture-recapture (Royle and Turner 2022) within the regional monitoring protocol.

Land Use and Landscape Ecology

As highlighted in the Status Assessment, there is a pressing need to understand population responses to anthropogenic land use. With the accumulation of standardized population monitoring data, research efforts should prioritize studies that aim to understand the relative effect of land use types (and their most relevant spatial scales) on demographic parameters. Conservation planning efforts will also benefit from a greater understanding of thresholds in suitable habitat and degree of fragmentation and habitat loss from urbanization, agriculture, and other factors.

Population Vital Rates and Viability

In addition to understanding population trends, there should be an emphasis on estimating population vital rates along environmental gradients of interest, with the specific goal of understanding how anthropogenic threats influence population viability.

Effects of Conservation-Oriented Management Practices

There is growing concern that management practices aimed at enhancing biodiversity and rare ecosystems, such as prescribed burning and forest management, may have severe population-level effects on eastern box turtles (Buchanan et al. 2021, Jones et al. 2021). Currently there are separate efforts underway in Massachusetts (a partnership between MassWildlife, USGS Cooperative Unit, and UMass Amherst) New Jersey (New Jersey Fish and Wildlife) and Pennsylvania (The Mid-Atlantic Center for Herpetology and Conservation, East Stroudsburg University) to quantify the effects of prescribed fire at individual and population levels and identify potential practices for mitigating negative outcomes. Rapidly developing a thorough understanding of this potential threat will require a high level of collaboration across the region not only among biologists, but also land managers and burn crews, which operate on fairly unpredictable schedules. Any collaborative effort should be centered around a key set of well-grounded fundamental research questions/objectives that are aimed at maximizing conservation value and yielding actionable guidelines. In the absence of an ongoing collaborative effort, or when adhering to protocols are not possible, opportunistic collection of data before and after prescribed burns using the regional population monitoring protocol and/or other methods (e.g., radio telemetry), should still present an important opportunity.

General questions related to prescribed fire might include:

- Are there correlative patterns of eastern box turtle population density or abundance at historically burned vs unburned sites?
- What specific fire characteristics pose the greatest risk of mortality of eastern box turtles? For example, does altering fire intensity (reaction intensity, fireline intensity, temperature, heating duration, radiant energy), burn area, fire height, severity (loss of or change in organic matter aboveground and belowground), season of year, frequency, flame angle, flame depth, and scorch height reduce the risk to eastern box turtles?
- What are the short- and long-term health effects for individuals that survive fires?
- Does fire affect disease prevalence?
- Does fire change habitat selection (e.g., nesting and overwintering sites)?
- How does weather (particularly temperature) influence mortality during burns in early spring and late fall?
- Does susceptibility to fire vary by sex and age?
- Do population- and individual-level effects vary regionally?
- Does recruitment change after fire events?

Genetics

As mentioned in the Genetic Sampling subsection above (Objective 2), a key goal should be to increase the general understanding of genetic differentiation, population clusters, patterns of relatedness, landscape connectivity, and population genetics (genetic diversity, allelic richness, etc). Research focused on understanding genetic diversity and/or where selection is occurring (e.g. Martin et al. 2020) will be particularly important in achieving the overarching goal of maximizing adaptive capacity.

Illegal Collection

Research is clearly needed regarding the illegal trade of turtles. Specifically it will be important to develop an understanding of the magnitude of the problem, trends in the illegal trade market over time, disease risk, methods of illegal collection, and geographic origin of wild turtles, among other important questions. We highlight three important potential areas for future research below.

Determining Geographic Location through Genetic Analysis.— We recommend continued, intensive genetic sampling to improve the understanding of genetic differentiation across the region and species range as well as the accuracy of efforts to determine geographic origin of confiscated turtles. In particular, researchers should aim to develop a more precise understanding of the spatial scale of genetic differentiation (i.e., the distance within which (sub)population genetics are not significantly different and therefore demographically independent) and how this scale may vary geographically.

Illegal Trade Market.— Successful deterrence of illegal trade will require a solid understanding of the market trends (see Tracking Confiscations, Objective 5). It will be particularly important to further refine the baseline understanding of the extent of illegal turtle trade, estimate valuation trends (via online markets), and understand how price may vary by demographics (female, male, juvenile) and other factors (coloration, etc).

Disease and Confiscations.— Numerous diseases are often present within groups of confiscated turtles and therefore represent a potential threat to recipient facilities and wild populations (if repatriation is under consideration). Increased research regarding disease presence and diversity associated with confiscations will be critical in guiding the decisions and protocols related to confiscation management (see Managing Confiscations, Objective 5).

The Collaborative to Combat the Illegal Trade in Turtles (CCITT; see Objective 5) Research Working Group is working toward addressing a number of research needs including those highlighted above. The NEEBT Working Group should aim to support the CCITT Research Working Group where possible.

Climate Change

The potential future effects of climate change on eastern box turtles remain largely unknown. Researchers should explore thoughtfully-crafted approaches to understanding the potential effects of climate change on habitat suitability, demographic parameters (e.g., sex ratio, recruitment), range shifts (expansion or contraction), future subspecies range dynamics, and other aspects of eastern box turtle ecology. In addition, considering climate change forecasts suggest that much of the northeast is expected to receive increased precipitation, research geared toward understanding the effect of flooding on overwintering survival and nest success may prove valuable.

Objective 5. Combat Illegal Trade

Initiation timeline: long-term (2023–)

Support the Collaborative to Combat the Illegal Trade in Turtles

The Collaborative to Combat the Illegal Trade in Turtles (CCITT) was formed in 2018 with the mission of "advancing efforts to better understand, prevent, and eliminate the illegal collection and trade of North America's native turtles" and is made up of state, federal, tribal, academic, and NGO biologists as well as law enforcement personnel. Their stated priority is to "build professional relationships between law enforcement, biologists, and social scientists to address needs associated with illegal trade in turtles." CCITT has Working Groups dedicated to confiscation and repatriation, data and research, human dimensions, law enforcement, and regulatory and judicial matters. The NEEBT Working Group supports CCITT and aims to collaborate, where needed, with CCITT on efforts that will benefit eastern box turtles, including the actions listed below.

Improving Regulatory Guidelines

Differences in possession rules among states (Erb and Roberts 2023) have made rangewide and even regional enforcement challenging. Currently, the Association of Fish and Wildlife Agencies (AFWA) and the Judiciary and Regulatory Working Group of CCITT are collaborating to update state herpetofaunal regulatory guidelines (originally developed by the Partners in Amphibian and Reptile Conservation [PARC]), with the goal of closing major loopholes and increasing ability of law enforcement to enforce state regulations.

Coordination and Education within Judicial System

Commercial poachers often receive lenient penalties often because judges are not aware of the severity of the problem. With the goal of stricter penalties for illegal commercial collection, the CCITT Judiciary and Regulatory Working Group is also working to educate judges and prosecutors about the significant ecological implications of illegal turtle collection and the breadth of the problem. Another goal is to establish a precedent for providing restitution to state agencies (or other entities) for care, repatriation, and other needs for confiscated turtles, the cost of which can be very high.

Law Enforcement Education and Protocols

Increased consistency and education regarding optimal operating enforcement procedures will be critical in reducing illegal trade. Thus, there is a clear need to collaborate with law enforcement to (a) develop protocols for chain of custody, biosecurity, and supporting prosecution and (b) establish standardized educational materials. The Law Enforcement Working Group of CCITT is leading efforts around both of these topics and the NEEBT Working Group should provide support when possible.

Tracking Confiscations

An effective response to illegal trade will require consistent and standardized data collection, which among many purposes, will help provide an understanding of short- and long-term confiscation trends, needs for funding and staff time, and potential geographic collection hotspots. Therefore it is imperative that greater attention is devoted to establishing a streamlined system for tracking turtle confiscations at state, national, and international levels.

Managing Confiscations

The process of managing turtles after confiscation can be extremely burdensome on state and federal agencies, which currently lack the resources and infrastructure to house and care for large numbers of turtles (single confiscations can include >100 turtles, and occasionally thousands). To address this issue, the Confiscation and Repatriation Working Group of CCITT, Association of Zoos and Aquariums, and the Turtle Survival Alliance are working to establish a network of facilities that are capable of housing confiscated turtles. The Confiscation and Repatriation Working Group is also developing protocols for guiding biologists and law enforcement through confiscation cases, with particular attention to turtle health, chain of custody of evidence, and timely transfer to care facilities. In addition to these efforts, the Working Group should consider incorporating use of Passive Integrated Transponders (PIT tags) into protocols where possible to reduce false identification rates.

Potential for Repatriation

Repatriation of healthy, disease-free turtles to the precise location of collection represents the ideal outcome following confiscation. Unfortunately, this is very rarely possible given that little is typically known about origin or history of care. Thus, when developing protocols for repatriation it will be critically important to carefully weigh the risks and ethical considerations associated with different outcomes, including releasing turtles to non-origin populations (which could result in outbreeding depression), releasing turtles with diseases or potentially harboring disease, and euthanization, among others. In developing such protocols, it will be particularly important to seek input, feedback, and consensus from a geographically representative audience consisting of a diverse range of expertise.

Stable Isotopes.— In addition to ongoing efforts to support repatriation via genetic assignment, future efforts should consider the benefits of complimentary stable isotope analyses, which have proven potentially useful for determining whether wood turtles were wild or captive-born (Hopkins et al. 2022).

Data Sensitivity

Public Disclosure and Spatial Representation of Population Locations.—Providing spatially-explicit location information about populations — particularly within technical documents and publications — increases the likelihood that those populations will be targeted for illegal collection. Therefore, we recommend that spatial information is shared sparingly and only for conservation purposes. State agencies and other data-holding entities (e.g., atlas projects) should carefully consider conservation value of sharing data as well as long-term risks (e.g., what happens to the data after a project is complete?).

Social Media and Citizen Science.— Location information posted to social media platforms and citizen science websites (that do not protect the data) can be used by poachers to identify collection sites. We strongly recommend efforts to encourage the general public to refrain from providing specific location information beyond the county and state on social media and make sure data submitted to citizen science projects is obscured or hidden from the general public.

Data-Sharing Agreements and Permits.— We recommend that all state agencies require data-sharing agreements in order to obtain and work with spatial data.

Outreach

Commercial collection, resulting in many individuals collected per population across numerous populations, likely represents the most significant threat to eastern box turtles with respect to illegal collection, but incidental collection by the recreationists at low levels may still contribute to population decline (Garber and Burger 1995). The NEEBT Working Group should continue to develop, distribute, and refine public outreach materials (Fig. 16) to increase awareness of the vulnerability of turtles to collection and how to report suspicious activities.

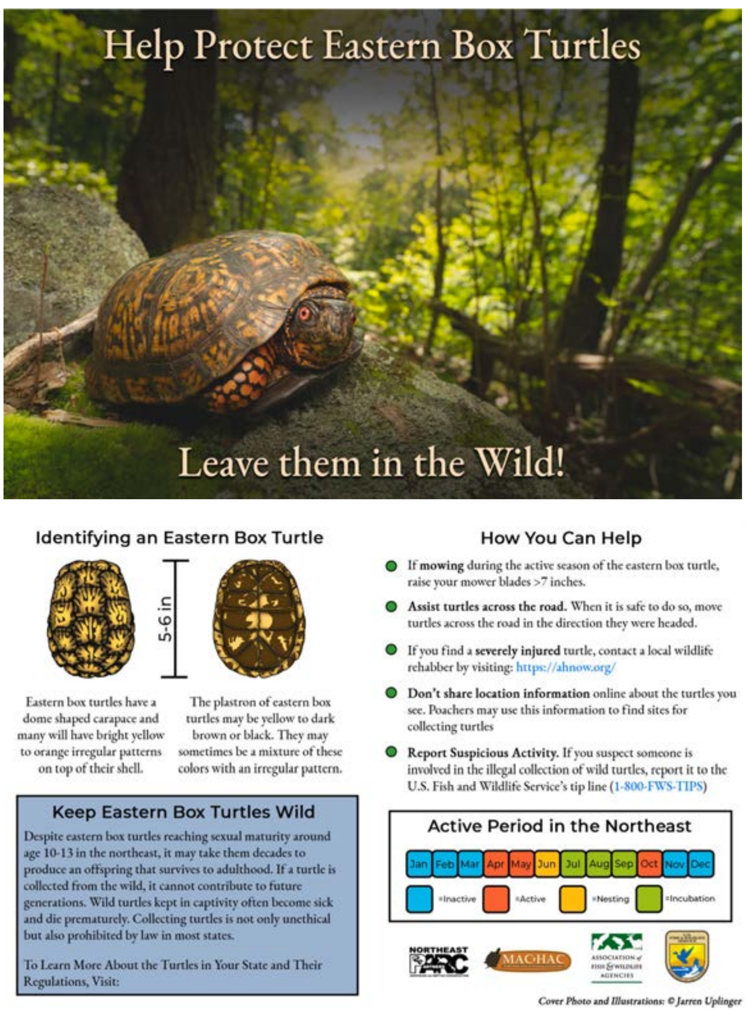

Figure 16. Anti-poaching card developed by the Northeast Eastern Box Turtle Working Group.

Objective 6. Reduce Threats within Focal Core Areas and Focal Landscapes

Initiation timeline: 5+ years (2028–)

Land Protection

Land protection should be prioritized within Focal Core Areas to prevent land conversion and its associated negative effects. While land protection specifically designated for eastern box turtles is uncommon at the state agency level, conservation easements through land trusts and landowners offer promising potential. There is also the possibility for state biologists to facilitate "piggy-backing" conservation whereby land protection for a population is secured through land protection decision-making process for a higher priority co-occurring species. In such cases, the knowledge that a "regionally significant" eastern box turtle population is present may influence the decision-making for a higher-priority species. Similarly, the NEEBT Working Group should consider the possibility of incorporating high-priority eastern box turtle Focal Core Areas into regional and state planning tools that land trusts and others use to prioritize conservation (e.g., Connect the Connecticut, Chesapeake and Delaware Blueprints, New Jersey Conservation Blueprint, BioMap in Massachusetts). The Regional Conservation Partnership Network (https://wildlandsandwoodlands.org/rcpnetwork/about-the-rcp-network-2/overview/) .

Roads

Roads represent a particularly challenging threat to mitigate for eastern box turtles because the terrestrial and generalist nature of this species means that road-crossing hotspots are often not apparent. The most effective method for reducing the threat of road mortality is to prevent further road construction near known activity areas. Seasonal signage during peak movement periods may help to reduce mortality. Where curbs are deemed necessary, public works officials should consider gradient curbs (also called "Cape Cod curbs"), which facilitate box turtle movement off of roads.

Agriculture

The Status Assessment (Erb and Roberts 2023) identified hay and agricultural fields as a potentially significant land-use threat in the Northeast. These cover types are likely associated with mortality resulting from mowing machinery (Erb and Jones 2011). Crop fields may also represent a reproductive sink if females nest in fields when the crop is short, but subsequent crop growth limits solar exposure. Nests may also be crushed or dug up with machinery before hatchlings emerge. Where this threat has been identified as a clear threat to a local population, willing farmers could consider delayed mowing, buffer strips, and shifting to crop varieties more compatible with eastern box turtle ecology (see Best Management Practices, Appendix C, D).

Recreation
Outdoor recreational activity can negatively influence turtle populations through incidental collection (functional mortality), habitat degradation, and direct mortality. Trail relocation, removal, and prevention represents an important strategy for reducing human encounters and lowering the risk of off-road vehicle collisions. In some cases, restricting access to areas via road closures may reduce recreation. Future conservation efforts should also consider the development and dissemination of outreach materials oriented toward recreationists (e.g., hikers and hunters) that discourage collection.

Succession
Across much of the northeastern United States, natural disturbance processes that historically generated important early-successional, open conditions for eastern box turtles are no longer present or as influential as they once were. Carefully implemented management should be considered at populations with minimal early-successional cover in order to increase structural complexity for thermoregulation and create potential nesting sites (see Best Management Practices, Appendix C, D). In some cases, regular, incremental, low-intensity management of a site can be sufficient to generate early-successional conditions without needing to utilize heavy machinery.

Land Management
Land management practices, particularly those that involve heavy machinery and/or prescribed fire have the potential to cause mass mortality events if implemented during the active period within high-activity areas. In addition to the threat that timber harvesting can pose to eastern box turtles via direct mortality (i.e. crushing) from tractors, skidders, and other heavy equipment, complete (or near-complete) canopy removal within small, isolated forest fragments may negatively affect populations by eliminating suitable overwintering and summer habitat, thus leading to mortality or triggering population-wide dispersal responses. Managers developing management plans within occupied eastern box turtle habitat should consult the Eastern Box Turtle Best Management Practices (Appendix C, D). Generally, management should proceed with some awareness of the relative regional or statewide significance of the population.

Tracking Database
We recommend the development of Focal Core Area site-level management action tracking tables after the next update of the Conservation Plan when data-deficiencies related to population sampling are at least partially addressed. Similar to the Northeast Wood Turtle Conservation Plan, important aspatial and geospatial information (e.g., important threats, nesting habitat availability, habitat change) should be tracked and reevaluated periodically. Population and resource-related information should be recorded, including estimated population size, age structure, sex ratio, extent and quality of nesting habitat, and proportion of site protected.

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Appendix A. Habitat Suitability Modeling

Occurrence Records

We collected eastern box turtle records from state agency natural heritage program, nonprofit, and personal datasets throughout the northeastern United States from Maine to Virginia. In total, we collated 15,859 records from 17 entities across 12 states and the District of Columbia. Known observation dates ranged from 1935–2020. Due to data quality screening protocols in place for most agencies, we assumed that all records within state agency datasets had an accuracy of $<$ 250 m, unless otherwise noted.

For records that contained supporting descriptive locality information and cross-referenced the coordinates and descriptions to verify agreement. Because of the large number of records, we selected a subset for cross-referencing. We projected all records over aerial imagery to identify distributional outliers or likely errors.

We excluded all records prior to 1990 and/or with $>$ 250-m radius accuracy. This distance was chosen because it encompasses the majority of eastern box turtle movements (Willey 2010). We excluded all records from Maine because there is apparent uncertainty about whether these records represent native individuals or released pets (pers. comm.). Once we completed the screening process, we randomly selected as many occurrence records as possible while maintaining a minimum distance of 2000 m between all records using ArcGIS 10.5 (Environmental Systems Research Institute, Inc., Redlands, CA). The final data set used for analyses contained 4,801 records.

Pseudo-Absences

We used ArcGIS to generate pseudo-absences by randomly distributing points with a 10:1 ratio of pseudo-absences to presence locations. Because the database of known presence locations was biased by distance to roads, we generated pseudo-absences proportionally to the relative distance of records from roads within three broad portions of the Northeast: New England (ME, NH, VT, MA, RI, CT), Mid-Atlantic (NY, NJ, PA), South (DE, MD, WV, VA). All pseudo-absences were restricted to within 100 km of an eastern box turtle record or the boundary of the study area, whichever was closer.

Environmental Variables

We identified a collection of land cover, climate, topographic, and soil variables that we expected may influence the distribution and habitat suitability of eastern box turtles (Table 1). Due to computational restrictions, we used 90-m pixel size for all environmental datalayers. We considered variables at six different scales: the individual cell, 90 m, 180 m, 360 m, 720 m, and 1440 m. Models that allow for spatial scale to vary among predictor variables are generally more robust than single-scale models (Johnson et al. 2004, Wheatley and Johnson 2009, Zeller et al. 2014).

Topographic variables included mean elevation (National Digital Elevation Model), mean topographic roughness, mean Topographic Position Index (TPI), mean Terrain Ruggedness Index (TRI), and distance to shore. We calculated roughness, TPI, and TRI using the "raster" package (Hijmans and van Etten 2012) in R (R Core Team 2016), which follows metric definitions described by Wilson et al. (2007). Roughness represents the largest difference between the value of a cell and one of its eight surrounding cells. TRI represents the mean of the absolute differences between the value of a cell and the values of its eight surrounding cells. TPI is the difference between the value of a cell and the mean value of its 8 surrounding cells.

Land cover variables included percent canopy cover, distance to forest, percent imperviousness, percent developed land, road density, percent cultivated crops, percent hay/pasture, percent agriculture (cultivated and hay/pasture combined), and percent forested wetland. We derived percent canopy cover from the NLCD 2016 Tree Canopy dataset (Coulston et al. 2016). We derived percent forested wetland from from the National Land Cover Database (Yang et al. 2018).

Climate variables included mean July temperature, mean minimum January temperature, mean April precipitation, mean annual precipitation, mean July precipitation, mean accumulated growing-degree-days, and mean maximum vapor pressure deficit. Accumulated growing degree days was obtained from USA National Phenology Network (usanpn.org). We obtained the remaining climate data, which represents 30-year normals (1981–2010), from the PRISM climate group (PRISM Climate Group 2010a,b).

Soil variables included saturated soil water content, residual soil water content, hydraulic conductivity, available water content, pH, percent sand, percent silt, percent clay, and percent organic matter. Each soil variable was considered for depths of 0–5 cm. We obtained all soil variables from the POLARIS (Chaney et al. 2016) database (Table 1).

Table 1. Suite of variables considered for inclusion in distribution and habitat suitability models.

Variable	Source	Year	Citation
Climate			
Mean Annual Precipitation	PRISM Climate Data	1981–2010	PRISM Climate Group 2010b
Mean April precipitation	PRISM Climate Data	1981–2010	PRISM Climate Group 2010b
Mean July Precipitation	PRISM Climate Data	1981–2010	PRISM Climate Group 2010b
Accumulated Growing-degree-days	USA National Phenology Network		USA National Phenology Network
Minimum January Temperature	PRISM Climate Data	1981–2010	PRISM Climate Group 2010a
Mean July Temperature	PRISM Climate Data	1981–2010	PRISM Climate Group 2010a
Maximum Vapor Pressure deficit	PRISM Climate Data	1981–2010	PRISM Climate Group 2010a

Topography			
Elevation	National Elevation Dataset	2009?	USGS 2009
Slope	Derived from National Elevation Dataset	2009	USGS 2009
Roughness	Derived from National Elevation Dataset	2009	USGS 2009
Topographic Position Index	Derived from National Elevation Dataset	2009	USGS 2009
Topographic Ruggedness Index	Derived from National Elevation Dataset	2009	USGS 2009
Distance to Shore	Derived using ArcGIS		
Topographic wetness	NALCC		
Soil			
Saturated soil water content	POLARIS	2016	Chaney et al. 2016
Residual soil water content	POLARIS	2016	Chaney et al. 2016
Percent sand	POLARIS	2016	Chaney et al. 2016
Percent silt	POLARIS	2016	Chaney et al. 2016
Percent clay	POLARIS	2016	Chaney et al. 2016
Ph	POLARIS	2016	Chaney et al. 2016
Percent organic matter	POLARIS	2016	Chaney et al. 2016
Hydraulic conductivity	POLARIS	2016	Chaney et al. 2016
Available water content	POLARIS	2016	Chaney et al. 2016
Land Cover		2018	McGarigal et al. 2018
% Canopy	NLCD- Tree Canopy	2016	Coulston et al. 2012
% Forested wetland	National Wetland Inventory	2014	USFWS 2014
% Agriculture	NLCD - Land Cover	2016	Yang et al. 2018
% Cultivated Crops	NLCD - Land Cover	2016	Yang et al. 2018
% Hay/Pasture	NLCD - Land Cover	2016	Yang et al. 2018
% Impervious	NLCD - Imperviousness	2016	Yang et al. 2018
% Developed	NLCD - Land Cover	2016	Yang et al. 2018
% Road	NLCD - Land Cover	2016	Yang et al. 2018

Model Building

Using presence and pseudo-absence locations, we performed a single-variable logistic regression for each environmental variable and scale, where both linear term or a quadratic terms were included in separate models. We chose the scale for each variable with the lowest AIC value. We assessed Spearman's rank correlations between all variables and removed the variable with the larger AIC value for pairs of variables with $r > 0.6$.

We used ensemble models to estimate habitat suitability. Ensemble models have been shown to outperform single species distribution models and may be ideal for pseudo-absence-based models (Grenouillet et al. 2011). Models contributing to the ensemble included generalized linear models, multiple adaptive regression splines, random forests, and boosted regression trees. We used the "biomod2" package (Thuiller et al. 2016) in R to create all models. Final models for each modeling methodology were selected automatically within the "biomod2" package. We conducted 4-fold cross validation to assess the predictive ability of each model. For each of the four validation datasets held out, we calculated the area under the receiver operating curve as a measure of relative performance (ROC; Hanley & McNeil 1982).

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Appendix B. Expert Opinion Survey Respondents

First Name	Last Name	State	Affiliation	Title	Experience
Julian	Avery	PA	Penn State	Assoc Research Prof Wildlife Conservation	4
Scott	Buchanan	RI	RIDEM Fish & Wildlife	Herpetologist	10
Russell	Burke	NY	Hofstra University	Professor	15
Phillip	deMaynadier	ME	Maine DIFW	Reptile, Amphibian & Invertebrate Program Leader	20
Ken	Dodd	FL	FLMNH, University of Florida	Courtesy Associate Curator of Herpetology	30
Lori	Erb	MD	MACHAC	Turtle Conservation Specialist	20
Katharine	Gipe	PA	PA Fish and Boat Commission	herpetologist	9
Lori	Johnson	MA	SWCA Environmental Consultants	GIS Specialist / Ecologist	16
Michael	Jones	MA	MassWildlife	State Herpetologist	15
Nancy	Karraker	RI	University of Rhode Island	Associate Professor	12
John	Kleopfer	VA	Department of Wildlife Resources	State Herpetologist	
Josh	Megyesy	NH	NHFG	Wildlife biologist	7
Nate	Nazdrowicz	DE	Division of Fish and Wildlife	Herpetologist	10
Kevin	Oxenrider	WV	West Virginia Division of Natural Resources	Amphibian and Reptile Program Leader	6
Mike	Ravesi	CT	CT DEEP Wildlife Division	Wildlife Biologist	3
Andy	Royle	MD	USGS	Senior Scientist	4
Brandon	Ruhe	PA	The Mid-Atlantic Center for Herpetology and Conservation	President	24
Richard	Seigel	MD	Towson University	Professor Emeritus	30
Scott	Smith	MD	MD DNR-Natural Heritage Program	Wildlife Diversity Ecologist	15
Christopher	Swarth	MD	retired animal ecologist and educator	retired	17
Jason	Tesauro	NJ	Jason Tesauro Consulting, LLC	biologist	25
Liz	Willey	MA	Antioch University / American Turtle Observatory	Faculty	16
Derek	Yorks	ME	Maine Department of Inland Fisheries and Wildlife	Wildlife Resource Biologist	10

Appendix C. Best Management Practices

BEST MANAGEMENT PRACTICES FOR EASTERN BOX TURTLE IN THE NORTHEASTERN U.S.

Summary

The eastern box turtle (*Terrepene carolina carolina*) is an at-risk subspecies that is experiencing population declines throughout its range and in the Northeast. They inhabit forests, fields, ecotones, and early successional habitats, occasionally using ephemeral and shallow wetlands. In the Northeast, eastern box turtles spend the winter underground in forested habitat where they overwinter in deciduous or mixed forests, with an abundance of leaf litter. In the spring they emerge from their hibernacula and move toward ecotones where they thermoregulate and are active throughout the day. Nesting occurs in the late spring through the early summer and takes place in open canopy, upland areas with well-drained, loose soils. Once the nesting season is complete, turtles typically move to closed-canopy forests or wetland edges where they spend the rest of the summer. This species remains active until late fall and early winter when it begins to overwinter, thus restarting the annual activity cycle.

This species is threatened by numerous anthropogenic and natural pressures, which decrease the survivability of individuals and populations. Prescribed fires are known to cause mortality in eastern box turtle populations. Therefore, we recommend that prescribed fires occur during the eastern box turtles' inactive season from November 1 through March 31. Closed-canopy forests are important habitats for eastern box turtles and timber harvesting can cause direct mortality by crushing individuals. The mortality of eastern box turtles can be reduced during timber harvests by minimizing the frequency of motor vehicle use, minimizing the vehicle impact area, and only using vehicles during the inactive season when the ground is frozen. This species depends on early successional habitats such as fallow fields which can be improved by mowing, herbicide treatment, and/or grazing. Mower blades and vehicles can kill and injure turtles; therefore, we suggest that mowing takes place during the inactive season. Degraded nesting habitat may limit the reproductive output of this species and creating or enhancing nesting habitats may increase recruitment. Enhancing, creating, or managing the vegetation at a nest site should occur during the inactive season and nesting studies prior to management is recommended. The collection of individuals for the pet trade is a persistent threat to eastern box turtle populations. We recommend not sharing the location of eastern box turtle populations online or in publication and reporting suspicious behavior to state and federal wildlife agencies. Below we provide additional recommendations and details for minimizing the risk of injury and mortality to eastern box turtles during management activities. Sites

may support other rare or vulnerable species with unique needs. Site managers will need to develop a management plan that considers the impacts to all species to avoid negative impacts.

Background

The eastern box turtle (*Terrapene carolina*) in the northeast, also known as the woodland box turtle (*T. c. carolina*), is an at-risk subspecies that is experiencing population declines throughout most of its range (Fig. 1, Kiester and Willey 2015). They are a Species of Greatest Conservation Need (SGCN) in all the northeastern states and the District of Columbia, included in CITES Appendix II, and state-listed as Endangered, Threatened, or a Species of Special Concern in Connecticut, Maine, Massachusetts, New Hampshire, and New York. They face many threats, including habitat alteration and fragmentation from development, roadway traffic and ATV use in natural areas, agricultural activities, incidental and illegal collection, habitat management activities (e.g., mowing, prescribed fires), inflated level of predation, disease, climate change and natural disturbances (e.g., floods and fires). Populations are particularly vulnerable to adult mortality and very slow to recover (potentially many decades) from decline due to low reproductive output and juvenile survival. The purpose of this document is to provide guidelines aimed at sustaining and promoting healthy populations by reducing the potential for management activities to lead to mortalities or injuries.

Figure 1. Eastern Box Turtle Carapace (Left). Eastern Box Turtle Plastron (Right)

Seasonal habitat use and habitat requirements

In the Northeast, eastern box turtles are typically an upland species that use a variety of habitat types seasonally (e.g., Madden 1975; Nazdrowicz et al. 2008; Quinn 2008; Willey 2010; Frederickson 2014). They use a variety of habitat types such as forests, fields, and to a lesser degree, ephemeral wetlands, and shallow wetland edges of larger water bodies (Kaye et al. 2001; Donaldson and Echternacht 2005; Fredericksen 2014; Henriquez et al. 2017). Although they are considered a habitat generalist, they have specific requirements for nesting, overwintering, and thermoregulation (Dodd 2001; Ernst and Lovich 2009).

Winter

Generally, eastern box turtles in the northeast spend the winter underground in forested habitats (Table 1; Fig. 2 and 4). They typically overwinter in deciduous or mixed forests, with ample leaf litter duff, which provides insulation and supports the retention of moisture (e.g., Nazdrowicz et al. 2008; Savva et al. 2010; Willey 2010). In late fall and early winter, they have been found just below the soil surface, but may burrow deeper as temperatures drop later in the season (Savva et al. 2010; Woodley 2013; Boucher et al. 2017). Activity usually ceases by the first frost of the season (Ernst and Lovich 2009; Boucher et al. 2017), but they may resurface during warm periods, particularly in early winter and early spring.

Figure 2. Eastern box turtle in partial form in preparation for brumation (left). Overwintering forest habitat example (right)

Spring/Nesting

In spring (late March through early May) they emerge from their hibernacula and move toward ecotone habitats such as forest-field edges where they can move in and out of the sun throughout the day to thermoregulate (Adams et al. 1989; Iglay et al. 2007; Fredericksen 2014). They utilize ecotones and early successional habitats through the late spring when females nest (Wilson and Ernst 2005; Willey and Sievert 2012; Nicholson et al. 2020). For nesting, female eastern box turtles in the Northeast mainly use open canopy, upland areas with well-drained, loose soils (Fig. 3 and 4, Quinn 2008; Willey 2010). Substrate materials vary and may consist of sand, loam, gravel or mulch. Nesting sites in the Northeast require sun exposure throughout the day, such as open canopy sites with a south-facing aspect, to incubate the eggs in time for hatching before winter arrives (Congello 1978; Willey 2010). Nest sites also need to be above the floodplain to avoid being periodically submerged in water, which will kill the eggs (Duchak and Burke 2022). Sparsely vegetated sites are preferred since plant roots can destroy eggs, infiltrating and absorbing the egg's nutrients (Steggman et al. 1988; Willey and Sievert 2012).

Figure 3. Eastern box turtle female actively nesting in sand.

Summer

After the nesting season, most turtles move to closed-canopy forests or wetland edges where they spend the rest of the summer (Ernst and Lovich 2009; Fredericksen 2014). However, a smaller proportion of any population may stay within, or regularly use, early-successional (i.e. herbaceous or shrubby) communities during the summer (Dod 2001; Nazdrowicz et al. 2008). Individuals may use field-forest ecotones or open-canopy areas in the fall before heading deeper into the forest to overwinter again (Walden and Karraker 2018).

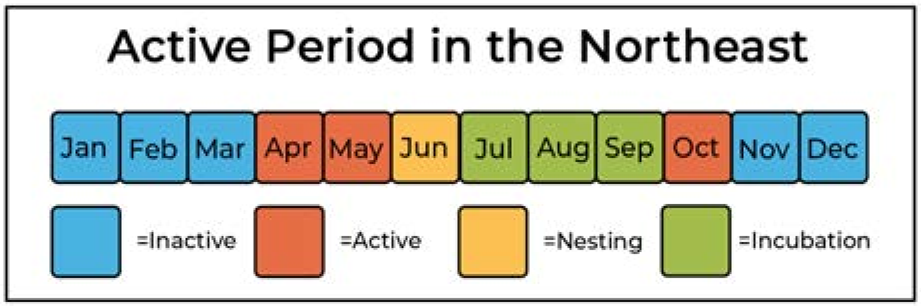

Figure 4. Active Period of Eastern Box Turtles in the Northeastern United States.

Table 1. Eastern box turtle brumation period with periods when most turtles are underground in dark gray and periods when only part of the population is underground.

	Oct		**Nov**		**Dec**		**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Source**
Massachusetts			dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray				Willey 2010; Kaye et al 2001; Erb 2011
Connecticut		light gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray	light gray			Quinn, D. 2008
New York (LI)*		light gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray	light gray	light gray	light gray		Walden and Karraker 2018
Delaware			dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray	light gray			Nazdrowicz et al 2008
Washington DC			dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray	light gray			Allard 1935
Maryland		light gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray	light gray			Quinlan, M. 2019 pers. comm.
Virginia		light gray	light gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	dark gray	light gray	light gray			Fredericksen 2014

West Virginia																	Oxenrider 2022

*LI = Long Island

Managing Threats

The following guidelines are specific to eastern box turtles in the northeast, however many of these actions will benefit other herpetofauna (e.g., snakes and wood turtles) as well as other species and/or taxonomic groups (e.g., ground nesting birds, bats that brumate in leaf litter). Recommendations are grouped by management activity with a few general recommendations up front. By using as many of these recommendations as possible you will reduce the risk of injury and mortality to eastern box turtles.

General Recommendations for all management activities

- **Coordinate interagency planning**
  - Develop strong coordination between agencies (i.e., the state's Forest Service and Natural Heritage Program) to identify areas containing populations of box turtles that are of conservation significance and/or at high risk of being impacted by a prescribed fire.
- **Understand habitat use**
  - Use visual surveys and/or radio-telemetry to understand seasonal habitat use and areas of high-density occupancy at managed sites. This will provide information needed to make informed decisions about the best timing of burns to avoid conflicts with box turtles and areas to avoid or where special considerations would be most useful.
- **Review NEPARC habitat management guidelines**
  - Review the Habitat Management Guidelines for Amphibians and Reptiles of the Northeastern U.S., developed by the Partners in Northeast Amphibian and Reptile Conservation (NEPARC). These guidelines provide recommendations to generally reduce the risk to herpetofauna while creating a diversity of habitats. The document can be downloaded from the NEPARC website (http://northeastparc.org/habitat-management-guidelines/)

Prescribed Fire

Prescribed fires are known to cause high mortality in eastern box turtle populations (Bigham et al. 1965; Frese 2003; Platt et al. 2010; Harris et al. 2020; Buchanan et al. 2021). Other studies indicate that fires can also result in long-term injuries and poor body condition (Howey and Roosenburg 2013; Harris et al. 2020). Fire can also be beneficial to eastern box turtles in some circumstances due to habitat changes resulting from fire (Markle et al. 2020). Those changes may create or improve existing nesting habitat and increase the diversity of vegetation density locally to provide a gradient of thermal conditions for thermoregulation and foraging (Robertson et al. 2022). However, given the importance of adult survivorship for population stability and the slow rate of recovery after decline, the habitat-related benefits of fire are quickly overshadowed if adult mortality results. Turtles that survive may also suffer scute loss (Fig. 5) and internal injuries that make them more susceptible to disease, cold, heat, and drought (Dodd 2001; Albery et al. 2021.) Land managers should use as many of the following practices as feasible to help reduce eastern box turtle mortality while using prescribed fire to achieve habitat management goals. These recommendations are ordered by their likelihood to reduce eastern box turtle mortality with the most effective measures listed first.

Figure 5. Active burn in overwintering forest habitat with example photos of burn scars and scute deformities on eastern box turtle carapaces from prescribed fires.

Recommendations

- **Prescribed burns should be restricted to November 1 through March 31[1]**
  - November 1 through March 31 is the eastern box turtle's inactive season.
  - Choosing a cooler (below 13 °C), overcast day[2] is best particularly during November and March to assure most individuals are underground.
  - When these dates will not work, the second-best burn window is April[3]. Turtles are usually active and above ground but less sluggish than when they first emerge from their hibernacula.

- **Use single front fires**[5]
    - Single front fires (instead of ring fires that burn inward) allow turtles to escape to fire breaks and other refuge. This is generally good for all wildlife.
- **Burn in smaller rotational units**[6]
    - This provides shorter distances for turtles to get to fire breaks. Leaving unburned units interspersed within the larger burn area, until adjacent areas recover, will also provide a refuge for turtles during the burn and in later months.
    - Pollinators, rare invertebrates and snakes will also benefit from burning smaller rotational units no more than every 3 years.
- **Use slow-moving low intensity and severity fire**[4]
    - Increased fire intensity and severity increases the risk to turtles in the burn area.
- **Maintain refugia with woody debris, undergrowth, and leaf litter**
    - Areas characterized by cool, moist microhabitats provide microrefugia for turtles, as well as snakes and amphibians, both during and after burns[7] .
    - Avoid performing burn clean ups. When reducing some woody debris and undergrowth is necessary, prior to burning consider the following[7]:
        - Use hand tools to clear undergrowth or, if using heavy equipment, use machinery during the inactive season to avoid crushing turtles.
        - Use grazers (i.e., goats) to reduce undergrowth prior to burns.
    - Leave some woody debris and other refuge for turtles to hide under during a fire, such as downed tree limbs and tree stumps.
        - Avoid going back to burn/reignite areas that were missed in the original burn.
- **Exclude a 30m (~100 ft) forest-field edge from fire**[8]
    - This is particularly important for forests adjacent to known nesting sites. Egg-laying snakes will also benefit.
- **Perform turtle sweeps prior to a prescribed burn**
    - Coordinate with your state's natural heritage program and/or wildlife agency to conduct visual surveys, for eastern box turtles, of the burn area within 24 hrs of ignition to remove as many turtles as possible until the fire is extinguished.

Justification

1. Eastern box turtle mortality, during fire events, is lower during the turtle inactive season (Table 1), when turtles are still underground for the winter (e.g., Frese 2003; Harris et al. 2020; Buchanan et al. 2021). Being underground helps to protect turtles from being exposed to extreme temperatures. Roe and Bayles (2021) found that subsurface temperatures during fire events did not exceed 23° C, while ground temperatures were 350-600° C.
2. During the eastern box turtle's inactive season, individual turtles and other herpetofauna may become active on warm days (Bigham et al. 1965; Frese, 2003) and are less likely to be above

ground during cooler/overcast days. This is more likely to occur during late fall (November) and early spring (March-April).

3. When burning during the active season, April is likely the best timeframe. Buchanan et al. (2021) found that the risk of injury or mortality increased May through June.
4. Fire intensity increases the risk of mortality of eastern box turtles during natural and prescribed fires (Buchanan et al. 2021; Harris et al. 2020; Jones et al. 2021). In some cases increased frequency of prescribed burns may help lower fire intensity by reducing debris/fuel load present, but also increases exposure to fire risk to turtles (Howey and Roosenburg 2013; Harris 2019). Slower moving fires allow time for turtles to escape (Cross et al. 2021; Harris et al. 2020; Platt et al. 2010).
5. The use of single front fires allows turtles to move in the opposite direction to escape or find refuge (Harris et al. 2020), although Harris et al. (2020) observed that not all turtles will move out of the fire's path. Multiple fire fronts within a burn unit (i.e., fire rings) are sometimes used to complete burns faster, but this can entrap eastern box turtles and other wildlife and prevent them from reaching fire breaks and other refuge (Melvin 2017; Harris 2019).
6. Smaller rotational units provide refuge areas (burn breaks and unburned units) for box turtles to access during a fire and provide unburned areas nearby for use after the fire (Robertson et al. 2022; Roe and Bayles 2021). Refuges are important to increase survivorship by providing areas to escape the fire and habitat to use after fire events to support individuals and the population (Robinson et al. 2013). In addition, leaf litter is a very important habitat feature for eastern box turtles (e.g., Dodd 2001; Gibson 2009; Weiss 2009; Willey 2010). It provides cover on hot dry summer days and is preferred at sites selected for overwintering (e.g., Luensmann 2006; Willey 2010).
7. Removal of some shrubs and woody debris before fires could reduce fuel loads and thereby fire intensity (Jones at al. 2021). However, it is important to both minimize potential mortality due to heavy equipment and leave some woody debris for turtles to use as refuge during a fire (Roe et al. 2019; Harris et al. 2020; Buchanan et al. 2021; Roe and Bayles 2021).
8. Excluding forest-field edge habitat from prescribed fire plans will reduce eastern box turtle mortality, because box turtles heavily use these habitats (Laarman et al. 2018).
9. Burning less frequently can decrease the possibility of fire-related turtle mortalities and maintain greater leaf litter (Melvin 2017; Laarman et al. 2018; Platt et al. 2010). Longer fire-return intervals allow woody debris to collect between fire events, thus providing refuge structures for turtles to use during subsequent fire events (Roe and Bayles 2021).

Timber Harvesting

Closed-canopy deciduous and mixed forests are critically important for the eastern box turtle in the northeastern U.S. The turtles rely heavily on forest habitat for overwintering and summer refuge from the heat (e.g., Quinn 2008; Willey 2010). Heavy equipment used in timber harvesting can cause direct mortality of eastern box turtles by crushing during any time of the year (Fig. 6). Timber harvesting can also positively or negatively change thermal conditions on the ground. Thinning and small canopy openings can create gradients in thermal conditions that provide thermoregulatory opportunities as well as habitat for juveniles and basking areas for adults in spring and fall (Felix et al. 2008; Currylow et al. 2012). Conversely, harvesting with intensive removal of woody debris eliminates cooler more humid microhabitats within the harvest area and can result in unfavorable conditions for a box turtle, in some cases affecting growth rates and thereby the ability of a population to recover (Dodd and Dreslik 2008; Heaton et al. 2022). Large-scale clearcuts (>5 ha) will result in more extreme thermal conditions (hotter in the summer and colder in the winter; Currylow et al. 2012), reducing available habitat during these times of the year, as well as increasing their vulnerability to predators while moving through these areas due to the lack of vegetative cover. The guidelines that follow are designed to outline measures that can reduce the risk of injury to turtles and increase the likelihood that a harvest will be compatible with box turtle conservation.

Figure 6. Image of timber harvesting.

Recommendations

- **Reduce the effect of motorized vehicles**
    - Minimize the frequency[10] that motorized vehicles are used. This is also generally good for all ground nesting or dwelling animals.
    - Minimize the vehicle impact area[10] to < 25% of the total area.
    - Clearly mark vehicle use areas (skid roads, wood roads, and staging areas and

landings) to minimize the impact area.
    - Only use motorized vehicles November 1 through March 31 and preferably when the ground is frozen[11].
    - Use rubber-tracked vehicles[11] to distribute the weight of the equipment weight over a larger surface area and thereby decrease soil compaction.
    - Discontinue use of logging roads once the harvest is completed.
    - Conduct soil scarification by hand to reduce the risk of turtle-vehicle interactions and avoid soil compaction.
    - Create designated vehicle use areas that reach as many trees as possible within the management area.
- **Leave microhabitat refugia**
    - Leave fallen logs, tops of trees, snags, and leaf litter[12]. This is also good for snakes, amphibians, and forest birds.
    - Retain small patches of uncut trees around snags to reduce possible safety concerns for workers related to falling snags[12].
- **Maintain vegetated wetland buffers**
    - Clearly mark boundaries of filter strips surrounding vernal pools, streams, ponds, and other water bodies to maintain unaltered wetland buffers[13].
- **Only use landings for wood chip piles**
    - Avoid creating and leaving wood chip piles anywhere outside the landing area[14]. Wood chip piles attract many other species which will also benefit from this action.
- **Avoid clear cuts if the forest patch is <1 ha**
    - Forest habitat is critically important for overwintering success for the eastern box turtle in the northeast[1]. This will benefit any forest species occupying the sites.
- **Limit clear cuts to 0.5-5.0 ha in large intact forests**[15]
- **Plan longer intervals between cuts**
    - Heavier cuts with longer intervals between cuts are favored over lighter, more frequent cuts, provided sufficient forest habitat remains[10].
- **Install turtle exclusion fencing around log piles**
    - If log piles are necessary and will be manipulated during the active season, use silt fencing to exclude turtles from using the log pile as a site of refuge.

Justification

10. Reducing the frequency of use and area of impact will reduce the likelihood of turtle-vehicle interactions.
11. Working in winter when the turtles are inactive and underground, the ground is frozen, and using a rubber-tracked vehicle will increase the chance that a turtle could survive a turtle-vehicle interaction (e.g., Nazdrowicz et al. 2008; Currylow et al. 2012).

12. Woody debris, leaf litter, and small patches of uncut trees provide microhabitat refuges for turtles (MacNeil et al. 2013). They provide overwintering sites and cool, moist microhabitat important for thermoregulation throughout the turtles' active season.
13. Leaving wetland buffers provides turtle refuge areas and reduces impacts to wetlands, which are important to box turtles and other species (MacNeil et al. 2013).
14. Large wood chip piles alter the microhabitat and if not removed potentially entrap turtles underneath.
15. Clear cuts of this size will allow most box turtles with a home range that includes the harvest area to move to intact forest within their home range or within a reasonable movement distance. It's important to maintain at least 1 ha of intact forest habitat to provide overwintering habitat for the eastern box turtle. South and southeastern slopes are particularly important.

Mowing

The eastern box turtle depends on early-successional habitats (Fig. 7) such as fallow fields for thermoregulation, foraging, and nesting (e.g., Dodd 2001; Nazdrowicz et al. 2008). Maintenance of these habitats with use of mowing, herbicide treatment, and/or grazing can be important for long term persistence of the species. However, mower blades and tires can also cause mortality (Nazdrowicz et al. 2008; Tingley et al. 2009; Erb and Jones 2011). The following recommendations are provided to help minimize the risk to eastern box turtles while managing open canopy habitats. These measures are generally ordered with the most effective measures listed first.

Figure 7. Examples of habitats mowed to control woody and invasive species.

Recommendations

- **Restrict mowing to the turtles' inactive season**[16]
    - Mowing is best done November 1 through March 31, the inactive season of the eastern box turtle. Although, keep in mind that dates may vary a bit by state and annually.
    - If mowing must occur during the growing season, mow during mid-July through August, when conditions are hotter and drier. Turtles will be less likely to use field habitats under these conditions.
- **Leave a 5 m (~15 ft) unmowed edge until after 15 October**[17]
- **Provide longer time intervals between mowing events**[18]
    - Mow once every 2-3 years instead of every year. This will also benefit snakes and ground nesting birds.
- **Use other tools to maintain field habitat**
    - Consider management tools such as use of grazing and/or chemical control of woody and invasive plant species.
- **Mow only a portion (25%-50%) of large fields in any given year**[18]
- **Avoid using flail mowers**[19]

- Flail and other mowers with heavy guide bars that roll along the ground increase the surface area where turtles could be crushed.

- **Raise the mower blade height to >18 cm (7 in)[20]**
  - For areas that need to be mowed lower, only mow during the inactive season or mow frequently to discourage turtles from hiding in the grass and so mower operators can see turtles. This will also benefit snakes, amphibians, and ground nesting birds.
- **Mow fields from near the center of the field outward[17]**
  - Leaving the outer edges for last provides time and a route for turtles to escape into the forest edge. This will also benefit snakes.
  - Edges are best left for midday on sunny days, when the field edges are hottest and when turtles are less likely to be using them.
- **Mow at a slower speed[21]**
  - Lower speed may provide time for the driver to see turtles in the mower's path and turtles a chance to escape.

Justification

16. Simply driving a mower through a field has the potential to cause up to 46% mortality of turtles using the field from tractor tires alone (Erb and Jones 2011). In Massachusetts, the peak season for use of early successional habitats was 1 May through 15 September (Willey 2010). Based on the similarity in the active season across the Northeast (Table 1), we expect these dates to work throughout the region. Avoiding mowing field habitats during the time when box turtles are most likely to be using these habitats will greatly reduce the risk to turtles.
17. Eastern box turtles and similar species like the wood turtle are more often found close to the forest-field edge (Tingley et al 2009; Willey 2010), and some individual turtles will try to escape perceived danger (such as mowers), so mowing the edge last and/or leaving an unmowed edge until late in the season will reduce the chance that turtles will be in the area being mowed. In addition, mowing from the center of the field towards the outer edge will allow some turtles to escape.
18. Mowing less frequently and mowing only portions of larger fields reduces the likelihood that a turtle will be hit by a mower blade or crushed by mower tires.
19. Some mower styles pose a higher risk of woodland box turtle mortality (Erb and Jones 2011). When comparing flail, rotary, and sickle bar mowers, the flail mower crushed almost everything in its path due to the heavy guide bar that rolls along the ground, whereas the sickle bar mowers had the least likelihood of killing a turtle.
20. Raising the mower blade height to ≥18 cm (7 inches) reduced the likelihood of injury or mortality to eastern box turtles in the mower's path (Erb and Jones 2011). Raising the blade height can also reduce wear on the blade (Rider and Barr 1987) and increase crop yield in subsequent harvests, because the remaining vegetation helps to maintain soil moisture

(Smith 1978; Sharp et al. 1995).Mowing at a slower speed can give turtles an opportunity to escape and the mower operator a greater chance to see a turtle in the mower's path.

Expanding, Improving, and/or Creating Nesting Habitat

Eastern box turtles primarily use open-canopy, upland habitat with well-drained soil for nesting (Fig. 8, Dodd 2001; Ernst and Lovich 2009). Nesting habitat may be lacking in quantity or quality at box turtle sites, limiting the ability for a population to remain sustainable or recover from any perturbations, such as a flood or disease outbreak, that decrease the local population size or abundance. Created and enhanced nesting sites have proven successful in attracting female box turtles and producing successful broods (e.g., Willey 2010).

Figure 8. Sand-loam access road with mounds for nesting (left) Sand dominated powerline access with open canopy for nesting (right).

Recommendations

- **Survey the site**
  - Survey known and/or potential nesting sites to determine what is needed and delineate the work area.
- **Determine nest site location(s)**
  - Within 300m of, or within, forest habitat[23], preferably within 600m of where box turtles have been observed.
  - No roads nearby[24] or between the forest and nesting site.

- Level ground or southern facing slope to provide sun exposure of the nests throughout the day.
- Above the spring/summer floodplain[25].
- Multiple or larger nest sites will reduce the likelihood of depredation[26].
- Away from human activity areas such as picnic areas, boat landings, ball fields, and other recreational areas[27].

- **Obtain appropriate permits**
  - Permits may be required from ACOE, state agencies, the local conservation commission, county, or township, and landowner.
- **Restrict vegetation clearing with heavy machinery (if needed) to November 1 through March 31** , the box turtle's inactive season[28].
- **Expose sand-gravel substrate or create mounds (during inactive period)** of sand-gravel (<5% clay and <25% gravel)
  - If soil is brought in, use washed soil to reduce the risk of introducing invasive plant species.
  - Pile introduced soil to at least 10-12 inches in depth.
- **Retain or provide 5-25% native vegetation cover**[29] such as sedges, grasses, and short shrubs. This is also great for snakes.
- **Monitor vegetation growth**
  - Vegetation removal and management will likely be required every 2-5 years
  - Inspect the habitat every 2-3 years to determine if any management is needed.
  - Remove non-native plants.
  - Reduce woody and herbaceous plants if they cover >50% of the site.
  - Remove shrubs taller than 24" in height.
- **Monitor turtle use of the nesting sites**
  - Consider performing visual surveys or setting up surveillance cameras to evaluate turtle use and predator activity, which can inform management needs.

Justification

21. Female eastern box turtles in the Northeast primarily overwinter in forest habitats and often move to open canopy-forest edge habitat in the spring to bask and nest (e.g., Quinn 2008; Willey 2010).
22. Roads, even if infrequently traveled, are a source of potential mortality.
23. Eggs can drown if the nest is submerged in water for an extended period.
24. Nest depredation can be higher at sites with more concentrated nesting habitat (Marchand and Litvaitis 2004). Creating multiple nest sites or larger ones may reduce depredation of nests.
25. Areas of human recreation often have sources of food waste that can attract and subsidize predator populations. These areas also increase the likelihood of human-turtle interaction, potentially resulting in incidental collection.

26. Doing work during the turtle's inactive season, when they are underground in the forest, will reduce the likelihood of injury to turtles from heavy equipment or even electric hand tools.
27. Sparsely distributed vegetation provides turtles with cover from predators. Females often arrive at the nesting sites early and remain there until they are ready to lay their eggs.

Limiting Incidental Collection and Poaching

Eastern box turtles can live a century or more in intact habitat with few threats. In the Northeast, females reach sexual maturity and lay their first nest by approximately 10-13 years of age depending on the latitude, with shorter time to maturation in more southern climates where the growing season is longer. Nest predation varies considerably but can be as high as 100% in areas with subsidized predator populations. With late age of maturation and high nest predation, many turtles have to reach 30-40 years in age before replacing themselves in the population. Even without other threats, collection of turtles from the wild can quickly result in population decline. Every turtle counts and is important to the local population.

Recommendations

- **Discourage recreational use of known nesting areas**[29]
- **Become informed and spread the word**
  - Collecting wild box turtles is illegal in all of the northeast states with the exception of two states (Delaware and Maryland), which allow the collection of one eastern box turtle[30].
  - Removing or moving even a few individuals can result in local extinction. For more information go to #EveryTurtleCounts.
  - Turtles do not make good pets. Turtles are a long-term commitment with some turtles living for over 50 years, have specialized care and habitat requirements which can be costly, and can be carriers of salmonella.
  - Sharing turtle location information on social media sites can be detrimental. Poachers use these sites to find sites to target for collecting turtles.
  - Releasing pet store turtles into the wild can introduce new diseases into wild turtle populations. Re-homing them is much safer for both the captive and wild turtles.
- **Watch for and report suspicious activities**
  - If you suspect someone is involved in the illegal collection of wild turtles, report it to the U.S. Fish and Wildlife Service's tip line (1/844/FWS-TIPS) or consult https://wildlifecrimestoppers.org/report-a-poacher/ to find your state wildlife agency's law enforcement phone number. Learn more about what to look for and always keep your safety in mind.
  - Poachers may try to gain access to both public or private properties with a good turtle population. Ask questions and be vigilant.

Justification

28. Turtle populations have been found to decline once an area was opened up to human recreation, with two populations crashing within a 10-year period (Garber and Burger 1995). Nesting turtles are the most important in the population, are very vulnerable when nesting, and the nesting season coincides with the start of the peak recreational season.
29. A summary of collection and possession regulations for eastern box turtles for each northeastern state and for all freshwater turtles can be found on the Partners in Amphibian and Reptile Conservation website.

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Appendix D. Eastern Box Turtle Best Management Practices Brochure

Creating Nesting Areas

Eastern Box Turtles in the northeast primarily nest in open-canopy, upland habitat with well drained soil. These conditions occur both naturally and anthropogenically in the form of powerline right-aways, gravel pits, and fields with sparse vegetation.

Recommendations for Managing Nesting Habitat

- Survey and determine active or potential nesting habitat using ground surveys and aerial imagery.
- If vegetation clearing is deemed necessary, this should be restricted to 1 November through 31 March during the box turtles inactive season.
- Monitor vegetation growth and use of nesting sites.

Creating Nesting Habitat

Expose any existing sand-gravel substrate or bring in washed soil to create mounds 10-12 inches in depth. Retain or provide 5-25% native vegetation cover. Remove non-native plants. Remove woody or herbaceous plants if they cover >50% of the site. Remove shrubs taller than 24" in height.


Photo: © Lori Erb


Photo: © Jarren Uplinger

Eastern Box Turtle Habitat

Eastern Box Turtles are an upland species. In early spring, they emerge from subterranean overwintering locations within forests and move toward open canopy habitats to increase body temperatures. During late spring, females use early successional habitat for nesting. After nesting season, most turtles move back to forests or into shallow wetlands. In the fall, most turtles will be seen gathering in areas with open canopies before heading back to the forest to overwinter.

Observe an Eastern Box Turtle?

If you discover an Eastern Box Turtle, take photographs, note the location, and report your sighting to your state wildlife agency. Unless a box turtle is in immediate danger (on a roadway) it is best not to move the individual. If the turtle must be moved, carefully pick it up and move it across the road in the direction it was headed.

Report Suspicious Activity. If you suspect someone is involved in the illegal collection of wild turtles, report it to the U.S. Fish and Wildlife Service's tip line (1-800-FWS-TIPS)

https://www.americanturtles.org/ http://northeastparc.org/

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Management Guidelines for the Eastern Box Turtle

(Terrapene carolina carolina)

Nesting Areas	Prescribed Fires
Timber Harvesting	Mowing


Photo: © Jarren Uplinger

Prescribed Fires

Fire damage on Eastern Box Turtle Carapace

Adult survivorship is crucial to maintaining stable Eastern Box Turtle populations and fire has the potential to negatively affect survivorship. Fire also has the potential to be used as a conservation tool to improve nesting and foraging habitat. The following recommendations will help reduce the risk of turtle mortality during fire events.

Recommendations for prescribed fires

- Utilize visual surveys and radio telemetry to better understand seasonal habitat use.
- Restrict burns to 1 November through 31 March.
- Use single-front fires to allow turtles to escape to fire-breaks or other cover.
- Burn slowly at a low intensity.
- Burn in smaller rotational units.
- Maintain refugia areas with woody debris, undergrowth, and leaf litter.
- Exclude a 30m (~100ft) forest edge from fire.

Timber Harvesting

Deciduous and mixed forests are critical habitat for the Eastern Box Turtle. They are used for overwintering, summer refuge, and foraging grounds. Timber harvesting can lead to death by crushing and interfere with thermal and microhabitat conditions. While there is no perfect time for forest management, these recommendations will help to reduce the risk to turtles during such events.

Recommendations for timber harvesting

- Restrict use of motorized vehicles to 1 November through 31 March.
- Minimize the frequency and total area where vehicles are used.
- Leave microhabitat refugia such as fallen logs, leaf litter, and a vegetated wetland buffer.
- Limit clear-cuts to large forests and restrict clearing to 0.5-5 ha.

Active Period in the Northeast

Mowing

The Eastern Box Turtle depends on various early successional habitats such as fallow fields for foraging and nesting. While it is important to manage this habitat with mowing, mower blades and tires can cause high mortality in Eastern Box Turtles.

Recommendations for mowing

- Restrict mowing to 1 November through 31 March.
- If mowing must be done during the active season, restrict mowing to July and August
- Leave a 5m (~15 ft) unmowed edge until 15 October.
- Mow once every 2-3 years or mow smaller portions of an area each year.
- Avoid using flail mowers or other mowers with heavy guide bars that roll along the ground.
- Raise mower blades to >18cm (7 in). In areas were the blades need to be lowered, do so during the inactive season.
- Mow at a slower pace from the middle of the field outward.