BOG TURTLE CONSERVATION PLAN FOR THE NORTHERN POPULATION

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i. LIST OF ABBREVIATIONS AND ACRONYMS

Acronym	Definition
AGOL	ArcGIS Online. The Environmental Systems Research Institute (ESRI) online mapping platform using ArcGIS software
AMMs	Avoidance, Minimization, and Mitigation Measures
ATO	American Turtle Observatory
BMP	Best Management Practices
BO	Biological Opinion
DE	Delaware (Recovery Unit)
eDNA	Environmental DNA
EO	Element Occurrence
ESA	Endangered Species Act
GIS	Geographic Information Systems
Herp	Herpetofauna
HH	Hudson/Housatonic (Recovery Unit)
HUC	Hydrologic Unit Code
I Pac	Information, Planning, and Consultation
IS	Intensively Sampled
LiDAR	Light Detection and Ranging
MACHAC	Mid-Atlantic Center for Herpetology and Conservation
MAF/TIGER	Master Address File/Topologically Integrated Geographic Encoding and Referencing
MCP	Minimum Convex Polygon
NEPARC	Northeast Partners in Amphibian and Reptile Conservation
NLCD	National Land Cover Data
NRCS	Natural Resources Conservation Service
OCP	Outer Coastal Plain (Recovery Unit)
PIT	Passive Integrated Transponder (tag)
PPLP	Prairie Peninsula/Lake Plain (Recovery Unit)
RA	Rapid Assessment
RU	Recovery Unit
SCL	Straight Carapace Length
SGCN	Species of Greatest Conservation Need
SP	Susquehanna/Potomac (Recovery Unit)
SSA	Species Status Assessment
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

ii. LIST OF DEFINITIONS

Best Management Practices (BMPs)**:** Structural features or non-structural strategies designed to minimize or mitigate environmental impacts (*e.g.*, those associated with stormwater runoff, including flooding, water pollution, erosion and sedimentation, and reduction in groundwater recharge).

Biological Opinion**:** A Biological Opinion is a document that includes: (1) the opinion of the Service as to whether or not a federal action is likely to jeopardize the continued existence of a listed species or destruction or adverse modification of habitat of a listed species; (2) a summary of the information on which the opinion is based; and (3) a detailed discussion of the effects of the action on a listed species.

Core Habitat**:** An area that meets Bog Turtle suitable habitat requirements where turtles are most frequently found. Multiple core habitat areas may be found within a single delineated wetland but may cross multiple Parcels.

Element Occurrence: Is a record of an observation of a species that is listed as endangered or threatened and these occurrences are tracked by state wildlife agencies.

Extant: A wetland that has had a confirmed Bog Turtle observation in past 30 years.

Extirpated: The wetland has been altered and no appropriate Bog Turtle habitat remains at the site.

Frac-out**:** the inadvertent release to the surface of drilling fluids and mud resulting from directional drilling through fractured bedrock.

Generation Time: Mean age of reproductive individuals.

Headcutting: A stream erosion feature and that appears as a vertical drop in the streambed and the drop will continue to move upstream over time.

Headstart: Turtles collected from the wild as eggs or hatchlings and raised for some period of time in captivity before being released back into the wild.

Herpetofauna: Amphibians and reptiles.

Historical Population: Populations lacking confirmed observations in the past 30+ years.

Important Corridor: Habitat connections between priority populations (see definition below), identified through habitat modeling for the Conservation Plan.

LiDAR: a detection system that is much like a radar system, but uses light from a laser, as opposed to sound.

Limiting Factor(s): A factor that reduces a species' ability to recover. This includes environmental factor(s) that limit the abundance, distribution and/or growth of one or more populations.

Metapopulation**:** Populations with genetic exchange feasible through occasional dispersal events. Populations are close enough to each other to allow occasional movements within one

generation time (10–40 years) of an individual: < 3 km of contiguous wetland, < 2 km of intermediate or mosaic upland-wetland habitat, or < 1.5 km undeveloped upland habitat.

Mucky soil**:** Soft, saturated organic or mineral soil or peat. With regard to Bog Turtles, this term does not refer to a technical soil type. Bog Turtle habitat is characterized by permanently saturated muck at least 3 to 5 inches deep in at least part of the wetland.

No Effect (NE)**:** As defined by the ESA Consultation Handbook, NE is the appropriate conclusion when the federal action agency determines its proposed action will not affect a listed species.

Not Likely to Adversely Affect (NLAA): As defined by the ESA Consultation Handbook, NLAA is the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

Phase 1 Bog Turtle Survey**:** An assessment of a wetland's soils, hydrology and vegetation to determine whether or not the area is suitable habitat for Bog Turtles (*i.e.*, potential Bog Turtle habitat). These surveys can be performed by a Recognized, Qualified Bog Turtle Surveyor. Guidelines for conducting Phase 1 Bog Turtle surveys are available at https://www.fws.gov/northeast/nyfo/es/REVISED%20Phase%201%20and%202%20Protocols_10.26.18_FINAL.pdf.

Phase 2 Bog Turtle Survey**:** A visual survey of suitable Bog Turtle habitat (*i.e.,* wetland with a positive Phase 1 survey) to determine presence or likely absence of Bog Turtles. These surveys can be performed only by a Recognized, Qualified Bog Turtle Surveyor with appropriate permits. Phase 2 surveys should be coordinated with the Service in advance. Guidelines for conducting Phase 2 Bog Turtle surveys are available at https://www.fws.gov/northeast/nyfo/es/REVISED%20Phase%201%20and%202%20Protocols_10.26.18_FINAL.pdf

Phase 3 Bog Turtle Survey**:** A trapping effort conducted in suitable Bog Turtle habitat (*i.e.,* wetland with a positive Phase 1 survey) to determine presence or likely absence of Bog Turtles. This survey is conducted to supplement Phase 2 Bog Turtle survey efforts where vegetation cover is too thick to effectively survey using Phase 2 survey techniques alone (*e.g.,* dominated by Multiflora Rose, Reed Canarygrass, *Phragmites*), or when Phase 2 survey results are negative but the quality and quantity of habitat are good, and the site is located in a watershed of known occurrence. This survey can be performed only by a Recognized, Qualified Bog Turtle Surveyor with appropriate permits and a Service-approved trapping plan. Guidelines for conducting Phase 3 Bog Turtle surveys can be obtained from USFWS upon request.

Population**:** A functionally reproductive group of individuals *(e.g*. at least one individual from each sex or evidence of reproduction such as presence of a hatchling or juvenile) using one or

more core habitat areas, which are within 300 m of each other with no major barriers between them. Movement between core habitat patches likely occurs every 1–10 years.

Population Management: This activity includes headstarting, translocation, repatriation and/or captive breeding of Bog Turtles for the purpose of increasing or starting a population.

Potential Habitat: Wetland that appears to be appropriate for Bog Turtles with respect to vegetation, hydrology and soil conditions, but where there are no known observations of Bog Turtles.

Priority Populations: Populations identified to be of regional significance, through a population ranking assessment. This assessment was performed as part of the Conservation Plan.

Propagation: Breeding adults in captivity to produce young.

Qualified Bog Turtle Surveyor: An individual experienced in field herpetology that the USFWS and one or more state wildlife agencies currently recognize as qualified to identify Bog Turtle habitat and visually survey for the presence of Bog Turtles. Current list of Recognized, Qualified Bog Turtle Surveyors can be found online for each state within the Northern range of this species.

Recovery: Under the ESA, recovery means improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the ESA [50 CFR § 402.02].

Recovery Unit: As defined by the ESA Consultation Handbook, recovery units are management subsets of a listed species that are created to establish recovery goals or carry out management actions.

Repatriate: When turtles are captured from one population (or of unknown origin – in captivity) and released at a historical, but currently unoccupied, Bog Turtle wetland.

Right-of-Way**:** The land, property, or interest therein acquired for or devoted to utility company product (e.g., electricity, natural gas).

Self-Sustaining: A population able to persist for 28 or more years, with very little or no adult mortalities and documented recruitment.

Suitable Bog Turtle Habitat: Wetlands with shallow water levels that are groundwater/spring-fed or soils with perennial saturation. These wetlands typically have saturated, mucky, mineral or organic soils. Plant communities can include wet meadows, fens, shrub swamps, and drainage swales. A more detailed description of suitable Bog Turtle Habitat can be found at: https://www.fws.gov/northeast/nyfo/es/REVISED%20Phase%201%20and%202%20Protocols_10.26.18_FINAL.pdf

SGCN Species: Species of Greatest Conservation Need as identified by each state within their State Wildlife Action Plan.

Take**:** Under the ESA, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a listed wildlife species, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.

Translocate: Eggs, young or adults collected from one population and released into a different population.

Unknown Occupancy: A wetland where it is unknown if Bog Turtles occur and where a full USFWS Phase 2 survey has not been completed (examples below). This could include historical observations or road records where no surveys occurred and habitat exists within 30 m. It may also include recent observations (last 30 years) resulting from environmental review project, survey stopped as soon as a turtle was observed, no further surveys were performed, and habitat exists.

Viable Population: Is defined here as a population likely to persist over time.

I. EXECUTIVE SUMMARY

The Bog Turtle (*Glyptemys muhlenbergii*) is a federally listed species (listed as Threatened in 1997) in need of recovery effort. This Conservation Plan outlines the conservation strategies or actions needed to achieve the recovery criteria established in the 2001 Bog Turtle Northern Population Recovery Plan developed for the USFWS. Provided within this Conservation Plan for each of the five Northern population recovery units is an overview of the population status, descriptions and specific actions needed for all conservation strategies identified to date, and implementation tables regarding conservation actions.

This Conservation Plan reports the results of a population assessment for the Northern Bog Turtle population. The most prominent threats to the Bog Turtle throughout the Northern population range are the direct and indirect effects of development, ecological succession of nesting habitat, incursion of invasive plants, altered hydrology, and impacts associated with roads. It was estimated that the historical range of the Bog Turtle Northern population has contracted by 39% since the time of the species listing. Bog Turtle population and habitat parameters were ranked into groupings of three categories (good, fair, poor) indicating the degree of the potential for the population to persist over time (population viability). These rankings were used to evaluate the health of extant (turtle observation since 1987) Northern Bog Turtle populations. Only 16% (78 of 500) extant populations were ranked as "good" population viability.

Conservation Strategies were identified and described by regional Bog Turtle experts. Experts from the Delaware, Hudson-Housatonic, and Susquehanna-Potomac Recovery Units ranked conservation strategies in terms of their effectiveness to achieve recovery for this species. Average scores from the expert surveys were used to set priority levels for each strategy within each recovery unit. Conservation strategies included broad-scale actions such as ranking populations for viability, habitat protection and habitat management measures, research needs, laws and regulations, population management actions, threat abatement techniques, and recommended best management practices. Conservation partners should use this document to identify priority actions based on the strategies and their priority level within each recovery unit.

Equally important to the main document are the Recovery Unit Action Plans in Appendices A–E. These action plans contain local information regarding the population status, top ranking threats/limiting factors related to recovery, and outlines regarding recent recovery progress. This information can be used by partners to determine local actions of greatest need within a specific recovery unit. Each plan identifies populations in which specific actions are most needed, provides a timeline for completing each strategy, and identifies potential partners related to the implementation of each conservation strategy.

II. INTRODUCTION

The Bog Turtle is one of the most imperiled turtle species in the Continental U.S. and globally (USFWS 2001, IUCN 2011). It is the smallest turtle occurring in North America and primarily inhabits wet meadows and fen-type habitats (USFWS 2001). Prominent threats to the Bog Turtle include development, ecological succession, invasive plants, human alteration of wetlands, and the effects of roads. The Bog Turtle (*Clemmys muhlenbergii*) Northern Population Recovery Plan (here after: Northern Population Recovery Plan) was developed for USFWS in 2001 and outlines Recovery Criteria for the Northern population. This Conservation Plan was drafted to complement the Northern Population Recovery Plan by providing further guidance on specific actions needed to address the Recovery Criteria. State and federal partners can use this document to guide their conservation efforts over the next 10 years. This Conservation Plan summarizes the most prominent threats and limiting factors to the Northern population of the Bog Turtle, the status of populations, and identifies and prioritizes specific strategies needed for recovery of the species. Recovery Unit Action Plans were also developed (Appendix A–E), which identify specific recovery unit priorities which should be used in conjunction with this Conservation Plan. This living document should periodically be re-evaluated and updated.

III. POPULATION ASSESSMENT

This section identifies major threats affecting the status and recovery of the Bog Turtle, compares the historical and current species range, and summarizes key results from a population viability ranking project. Additional information on the status of the species can be found in the Competitive State Wildlife Grant final report and in the Species Status Assessment (SSA) that is currently under development by the USFWS in collaboration with the state wildlife agencies. This SSA report is estimated to be completed by the end of 2020.

3.1. CURRENT THREATS AND STATUS SUMMARY

A list of threats was developed for the Northern Population Recovery Plan and expanded during a species recovery meeting in 2011. In 2017–2018, experts in each of the recovery units participated in ranking these threats based on the risk level or degree of negative influence each has on Bog Turtle populations in the northeast. Mean scores were calculated and used in a relative comparison. In addition, we evaluated the species historical and current range to estimate the amount of habitat that has been lost within the past 30 years.

Threats

Current threats were identified and ranked by experts in the Delaware, Hudson-Housatonic, and Susquehanna-Potomac Recovery Units. Recovery unit expert surveys were subjective but relied on surveyors' experience to collectively summarize past, present and future condition of threats. Among the highest-ranking threats were development (direct and indirect effects), ecological succession, proliferation of invasive plants, altered hydrology, and roads (Fig. 1). A high degree of uncertainty was associated with disease, predation, and salt/contaminants. It should be noted that poaching was not included in this survey; however, it is still considered a major threat. For more details, see the Species Status Assessment (currently in development).

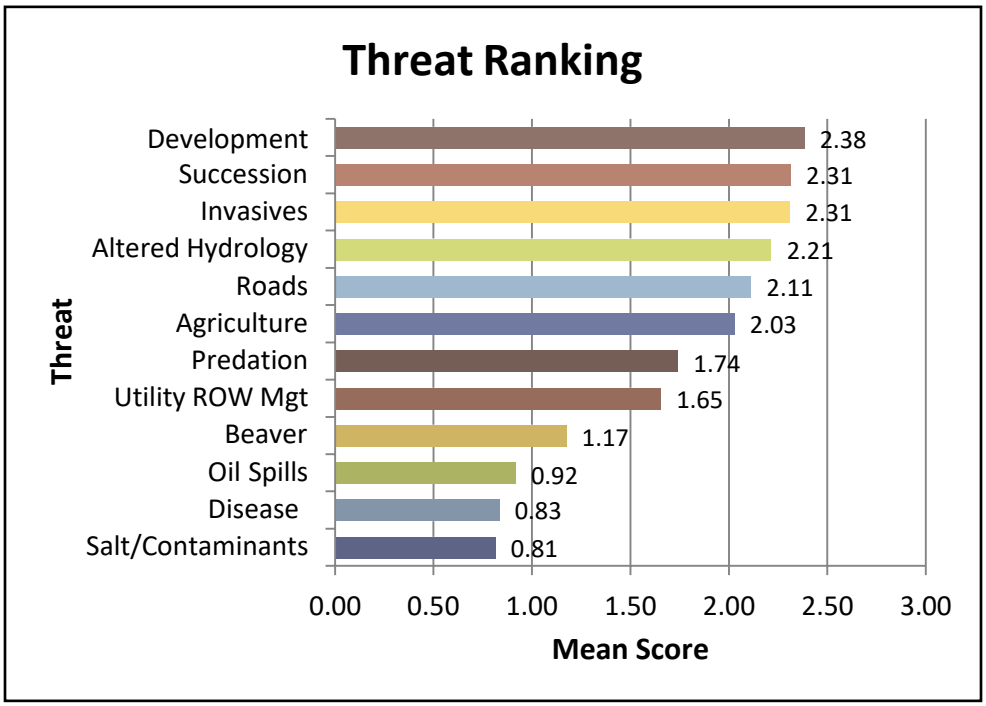


Figure 1. Combined threat ranking for the Delaware, Hudson-Housatonic, and Susquehanna-Potomac Recovery Units, based on expert surveys.

Range contraction

Based on a recent analysis, the species' range has contracted by 39% in the Northern population, resulting in a loss of 7,946,219 acres. Not all of these acres would be considered suitable habitat, but includes upland acres and connective corridors used by bog turtles. Historical and extant (1987–2018) Bog Turtle observational data were used to create historical and current range maps (Fig. 2). The historical range map was delineated by creating a 10 km buffer around all HUC12 sub-watersheds containing historically and/or current turtle observations. A current range map was similarly created using only the HUC12 sub-watersheds with current observations. The historical range includes all observations of the Bog Turtle (historical, extirpated, extant, and unknown) whereas the current range only includes the range for extant populations. The estimated historical range is likely overestimated for the Northern end of the Hudson-Housatonic Recovery Unit, the western half of the Lake Plain Recovery Unit, and the southern portion of Outer Coastal Plain Recovery Unit, where populations have patchy distributions.

The number of acres lost differs slightly from the amount reported in the Northern Population Recovery Plan. The range contraction estimate reported in the recovery plan was based on early mapping efforts that were more inclusive based on old (and unconfirmed) records. Additionally, the recovery plan was generated with a perspective of protecting the species with generalities regarding its estimated range. Also of note is that the maps presented here are not as detailed as predictive models now available (e.g., Howard and Schlesinger 2012). Even within the center of the species' range, populations or colonies are patchy in distribution. Many records represent isolated colonies or populations not associated with a true metapopulation in which turtles occasionally move from one wetland to another.

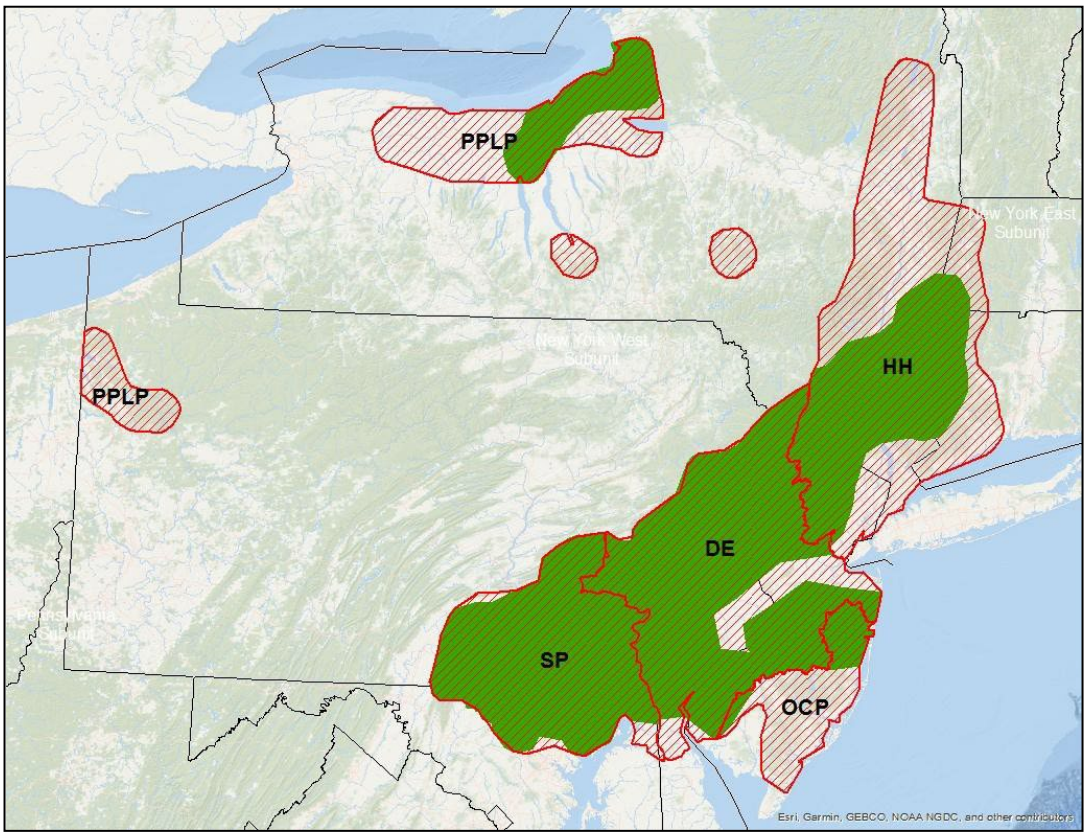


Figure 2. Historical (red hatch) and current (green) Bog Turtle Northern population range including the Delaware (DE), Hudson-Housatonic (HH), Outer Coastal Plain (OCP), Prairie Peninsula-Lake Plain (PPLP), and Susquehanna-Potomac (SP) Recovery Units.

Population Viability Ranking

Bog Turtle experts from across the Northern range developed a population-ranking methodology to categorize populations in terms of their potential for long-term viability. Populations were ranked using 3 population quality parameters and 6 habitat quality parameters. Population quality parameters included: 1) number of individuals known to be present at the site, 2) types of reproduction observed, and 3) the degree of connectivity to other populations. Habitat quality parameters included: 1) the amount of habitat, 2) amount of succession, 3) degree and types of disturbance to hydrology, 4) presence of development pressure (based on two components – state leads expert opinion and GIS spatial data), 5) amount of habitat protection, and 6) degree of road mortality risk (based on two components – road density and proximity of roads to core habitat). Experts determined a weighted average for each parameter, which was used to produce an overall population score (including both the population and habitat quality parameters). Populations were grouped into 3 categories: Good, Fair, and Poor. Experts ranked 78 populations as Good for viability potential, 134 as Fair, and 288 as Poor. One recovery criterion of the Northern Population Recovery Plan is to secure long-term protection for at least 185 viable populations among the 5 recovery units. These population assessment results suggest this goal is achievable; however, substantial work is required to improve and secure the majority of extant populations. A full table of the results was sent to the state wildlife agency leads on Bog Turtle conservation (state leads) and the USFWS

federal coordinator for the Bog Turtle. For further details on the ranking methodology and results, see section 4.2.2 below. Additional information on population estimates and population status will be provided in the SSA (in development).

IV. CONSERVATION STRATEGIES

This section outlines and describes specific conservation strategies that are recommended for implementation to address recovery criteria and recover the Northern population of the Bog Turtle. Conservation strategies were prioritized, methodologies were described and, where appropriate, results are reported of work completed to date.

4.1. CONSERVATION STRATEGIES AND THEIR ASSOCIATION WITH RECOVERY CRITERIA

Experts across the Northern population range identified an exhaustive list of conservation strategies needed for recovery of the Bog Turtle. Bog Turtle experts from the Susquehanna-Potomac (SP), Delaware (DE), and Hudson-Housatonic (HH) Recovery Units ranked strategies in terms of their effectiveness to achieve recovery for this species and calculated average scores for these strategies (Table 1). The relationship between these conservation strategies and the recovery criteria are shown in Table 1. Recovery criteria were identified in the Northern Population Recovery Plan (USFWS 2001) and are listed below. This list can be used to prioritize rangewide conservation efforts, indicating which strategies should be implemented first and to justify funding for related regional projects. Regional Bog Turtle experts were also polled to rank the top threats and limiting factors to recovery in their respective recovery units. The relationship between the top 25 ranked conservation strategies and the top-ranked threats and limiting factors are shown in Appendix H.

Recovery Criteria:

1. Long-range protection is secured for at least 185 viable populations distributed among five recovery units.
2. Monitoring at five-year intervals over a 25-year period shows that these 185 populations are stable or increasing.
3. Illicit collection and trade no longer constitute a threat to the survival of this species.
4. Long-term habitat dynamics, at all relevant scales, are sufficiently understood to monitor and manage threats to both habitats and turtles, including succession, invasive wetland plants, hydrology, and predation.

Table 1. Conservation strategies for the Northern population of the Bog Turtle. Strategies are listed in order of their expected benefit across the Northern population range to the recovery of the Bog Turtle based on expert survey scores. The conservation strategies are grouped in general categories from section 4.2 below to the end of chapter IV. Categories include broad-scale conservation (BC), habitat protection (HP), habitat management (HM), research needs (RN), laws and regulations (LR), population management strategies (PM), best management practices (BMP), and predator, beaver, and collection threat management (PBCTM).

					Recovery Criteria			
Section in the Plan	***Strategy Category***	***Conservation Strategy***	***Mean Score***	***Priority Level***	***1***	***2***	***3***	***4***
4.2.1	*BC*	*Obtain Funding*	5.00	1	X	X	X	X
4.4.1	*HM*	*Conduct Succession/Invasive Plant Management*	4.61	1	X			
4.2.2	*BC*	*Rank Populations for Viability*	4.53	1	X			
4.5.1	*RN*	*Research the Effectiveness of Habitat Management*	4.53	1				X
4.2.5, 4.2.6	*BC*	*Implement Population and Habitat Monitoring*	4.44	1		X		
4.2.3	*BC*	*Prioritize Populations for Habitat Protection and Management*	4.43	1	X			
4.6.1	*LR*	*Seek Max Penalties on Violations of the ESA*	4.41	1	X		X	X
4.4.2	*HM*	*Restore Hydrology*	4.39	1	X			
4.3.1	*HP*	*Connect Fragmented Habitat*	4.35	1	X			
4.2.4	*BC*	*Map Important Habitat Corridors*	4.34	1	X			
4.2.8	*BC*	*Develop a Communication Strategy*	4.33	1	X			
4.5.2	*RN*	*Conduct Inventory/Gap Surveys*	4.31	1	X			
4.3.2	*HP*	*Engage in Landowner Outreach for Habitat Protection*	4.28	1	X			
4.5.3	*RN*	*Research the Effects of Agriculture, Pesticides, and Herbicides*	4.28	1	X			X
4.6.3	*LR*	*Require Surveyor Qualifications*	4.20	1	X			
4.5.4	*RN*	*Research Hydrology & Water Chemistry*	4.18	1	X			X
4.2.9	*BC*	*Monitor Progress of Conservation Actions*	4.15	1	X		X	X
4.4.3	*HM*	*Engage in Landowner Outreach for Habitat Management*	4.14	1	X			
4.7.1	*PM*	*Identify Best Population Management Techniques*	4.08	1	X			
4.6.2	*LR*	*Revise the Northern Population Recovery Plan and Re-evaluate the Recovery Criteria*	4.07	1	X	X	X	X
4.5.5	*RN*	*Research the Effects of Development*	4.05	1	X		X	X

					Recovery Criteria			
Section in the Plan	**Strategy Category**	**Conservation Strategy**	**Mean Score**	**Priority Level**	**1**	**2**	**3**	**4**
4.9.1, App. F	BMP	Draft BMPs to Improve Road Passageways	4.05	1	X			X
4.8.1	PBC	Protect Nests and Perform Predator Control	3.97	2				X
4.5.6	RN	Research Macro and Microhabitat Use	3.95	2	X			X
4.6.4	LR	Implement Regional Survey Guidelines for Consultants	3.90	2	X			
4.9.3	BMP	Draft BMPs to Reduce Impacts from Development Projects	3.84	2	X			
4.3.3	HP	Engage in Mitigation Banking to Protect Habitat	3.83	2	X			
4.5.7	RN	Develop and Evaluate eDNA Techniques	3.83	2	X			
4.6.5	LR	Draft Guidelines to Reduce Adverse Effects	3.80	2	X			
4.3.4	HP	Develop a Stewardship Program(s)	3.78	2	X	X	X	X
4.9.4, App. I	BMP	Draft BMPs to Reduce Impacts from Stream Restoration, Culvert, and Bridge Projects	3.76	2	X			
4.7.3	PM	Draft Guidelines for Population Management	3.76	2	X			
4.5.8	RN	Research the Effects of Roads	3.74	2	X			X
4.7.2	PM	Draft a Population Management Decision Tree	3.73	2	X			
4.6.6	LR	Revise Regulations to Improve Protection	3.73	2	X			
4.4.4	HM	Restore Relic Fens	3.73	2	X			
4.8.5	PBCTM	Train Law Enforcement	3.67	2	X		X	
4.5.9	RN	Conduct Health Assessments	3.67	2	X			X
4.3.5	HP	Conduct Staff Trainings	3.66	2	X			
4.9.2	BMP	Draft BMPs to Reduce Impacts from Roadside Mowing Practices	3.63	2	X			
4.2.7	BC	Create a Standardized Regional Database	3.62	2	X	X	X	X
4.9.5	BMP	Draft BMPs to Reduce Impacts from Pipeline Projects	3.59	2	X			X
4.5.10	RN	Research the Effects of Depredation	3.46	3	X			X
4.9.6	BMP	Draft BMPs for Radio-telemetry Research	3.44	3	X	X		X
4.5.11	RN	Evaluate PIT tagging Techniques	3.42	3	X	X	X	
4.5.12	RN	Research the Effects of Beaver	3.38	3	X			X
4.5.13	RN	Evaluate Population Genetics and Develop a Genetic Library	3.37	3	X			

					Recovery Criteria			
Section in the Plan	*Strategy Category*	*Conservation Strategy*	*Mean Score*	*Priority Level*	*1*	*2*	*3*	*4*
4.9.7	*BMP*	*Draft BMPs for Controlling Predators*	3.35	3	X			X
4.2.10	*BC*	*Develop a Climate Change Strategy*	3.29	3	X			X
4.2.11	*BC*	*Compile a Bibliography of Bog Turtle Literature*	3.24	3	X	X	X	X
4.5.14	*RN*	*Research Life History Traits*	3.19	3	X			X
4.8.4	PBCTM	*Develop an Anti-poaching/Collection Strategy*	3.17	3	X		X	
4.6.7	*LR*	*Improve Environmental Review Tools*	3.15	3	X			
4.7.4	*PM*	*Perform Population Management*	3.10	3	X			
4.9.8	*BMP*	*Draft BMPs for Beaver Management*	3.10	3	X			X
4.8.2	PBCTM	*Perform Beaver Control*	NA	NA	X			X

4.2. BROAD SCALE CONSERVATION STRATEGIES

These are broad brush strategies that are needed throughout the Northern population range of the Bog Turtle. For example, obtaining funding will be of importance at all levels. Additionally, ranking and prioritizing populations for specific actions must be done at a broad scale in order to be able to make standardized comparisons among populations in different states.

4.2.1. OBTAIN FUNDING

Funding is critical to accomplish the conservation strategies listed in this document and, therefore, to the recovery of the Bog Turtle. For instance, obtaining funding to support staff time, travel, and/or equipment and supplies is extremely important to accomplish these objectives. Experts from across the Northern population range produced the following list of potential funding sources. Many of these sources have already been successfully used to support Bog Turtle conservation initiatives.

- USFWS Competitive State Wildlife Grant (C-SWG) – Grant for research, population and habitat monitoring, conservation planning, and habitat and population management.
- USFWS/States Regional Conservation Needs (RCN) – Grant to address critical landscape-scale wildlife conservation needs.
- USFWS Recovery Challenge Grant (RCG) – Grant to enhance partnerships to implement high priority recovery actions for the species.
- Recovering America's Wildlife Act (RAWA) – For state-led wildlife conservation efforts to restore habitat, control invasive species, reintroduction programs, and monitor emerging diseases. This act has only been proposed to date.

- National Fish and Wildlife Foundation (NFWF) – Funding to protect or manage habitat, mitigating threats in buffers, and incentives for local livestock agriculture.
- USFWS Combating Wildlife Trafficking Grant (CWT) – Grant to reduce the threat of collection or poaching.
- USDA National Resource Conservation Service (NRCS) – Funding for habitat management and agriculture-related research.
- State Land Protection Grants – Grants to protect habitat.
- USFWS Section 6 Recovery Land Acquisition Funds – Funding to protect habitat.
- Higher Education Officer and College Laboratory Technician Series (HEO-CLT) – Professional Development Fund for small grants (< $3,000) for CUNY research projects. Landscape Conservation Cooperatives (LCC) – Funds to evaluate the potential effects of climate change on Bog Turtles and their habitat.
- USGS Quick Response Program (QRP) and Science Support Partnership (SSP) – Grants for endangered species recovery (e.g., climate change or hydrology research), ecosystem-based management, and National Wildlife Refuge System management.
- Ducks Unlimited, National Wild Turkey Federation, or Trout Unlimited – Funding for local conservation projects such as land protection and management.
- North American Wetlands Conservation Act (NAWCA) – Grants for land protection and management of private lands.
- NGOs or family foundations – These entities may donate small amounts of funding towards turtle conservation actions. A few example organizations are listed below:
    - The Turtle Survival Alliance
    - The Turtle Conservancy
    - The Orianne Society
    - American Turtle Observatory
- Army Compatible Use Buffer Program – Funding to protect habitat near Army installations.
- Non-profit Land Trusts – Funding to protect and manage habitat.
- Mitigation Banks – Pooling mitigation funding from environmental review projects to use for habitat protection and management.
- In Lieu Fee Programs – Funds for short-term habitat protection.

4.2.2. RANK POPULATIONS FOR VIABILITY

Introduction

A metric ranking system has been developed to evaluate the potential viability of extant populations throughout the Northern range of the Bog Turtle. Ranking metrics were organized into two general groups that evaluate population quality, and habitat quality. Each population (of 500 total extant populations) was given a score for each of the metrics outlined below and those metric scores were summed for an overall population score. An expert group ranked the importance of each metric within the two groupings. Results from the survey were used to determine the weight of each metric in the overall population score.

Methods

Population Quality Evaluation

(Past 28 years; see Section ii for definition of population and metapopulation)

Population Size – Sites were categorized based on the number of individual Bog Turtles observed, known, or estimated at a given site over the past 28 years (1990–2018).

1. Up to 5 individuals (based on ≥ full Regional Phase 2 survey effort)
2. Unknown (hasn't been surveyed well)
3. 6–15 individuals
4. 16–29 individuals
5. 30 or more individuals

Reproduction/Recruitment – Observations of recruitment over the past 28 years (1990–2018).

1. None (based on ≥ full Regional Phase 2 survey effort)
2. Unknown (hasn't been surveyed well)
3. Gravid female(s), egg(s) or nest(s) observed
4. Hatchlings, yearlings (1 yr) or juveniles (2–5 yrs) observed
5. Subadults* (6–9 yrs) and/or multiple age classes observed

*10 years was selected because Bog Turtles reach sexual maturity at ~10 years of age in the more southern parts of the population range. Age at maturity at the Northern edge of the range is not as well known and likely occurs at an older age (Whitlock 2002, Rosenbaum et al. 2018) due to a shorter growing season that leads to slower growth in turtles.

Interconnectedness – Interconnectedness/proximity to other Bog Turtle sites. See Section ii for a description of population and metapopulation.

1. Isolated population (not part of a metapopulation)
3. Part of a metapopulation with one other small-sized population (15 or fewer individuals)
5. Part of a metapopulation with a large population (>15 individuals) or more than one other small population

Habitat Quality Evaluation

Population Habitat Size – Combined size of all the extant core habitat within the population.

1. 0–2 acre(s)
2. 2–4 acres
3. 4–6 acres
4. 6–8 acres
5. >8 acres

Succession in the Core Habitat – Data used were from the regional database. These values were known for some sites and estimated (using GIS, site photos, or surveyor memory) for other sites. If unknown or if left blank, this metric was excluded from the ranking.

1. 41–60% coverage OR >60% coverage
2. 26–40% coverage and unknown
3. 11–25% coverage.
4. <10% coverage
5. 0

Altered Hydrology in the Core Habitat – Includes: beaver activity, ditching, fill material, pipeline, roads/culverts, man-made ponding, and multiple disturbance types, etc. If unknown this metric was excluded in the ranking.

1. Full disturbance (throughout most of the site)
2. Partial disturbance including: ditching, fill material, multiple types
3. Partial disturbance including: man-made ponding, roads/culverts, other
4. Partial disturbance including: beaver activity, pipeline, sedimentation
5. None

Development

- Development pressure within 91 m (or 300-ft, to align with the Zone 2 described in the Bog Turtle Recovery Plan)

    1. In Both (core habitat and buffer) and in Wetland only (all development types)
    2. In Zone 2 (300-ft buffer) – roads, residential, agricultural, and multiple types
    3. None OR Zone 2 – manicured lawns or barns

- Percent of medium and high-intensity development within each USGS HUC-12 sub-watershed, using the 2011 National Land Cover Data (NLCD).

    1. 10.0 %
    2. 5.0–9.99 %
    3. 3.0–4.99 %
    4. 1.0–2.99 %
    5. <1.0 %

Habitat Protection for Bog Turtle – Land protection of core and buffer habitat.

1. No protection in Core or Buffer OR no protection in core habitat and partial protection in the buffer
2. Partial protection in the core habitat and no protection in the buffer
3. Partial protection in both the core habitat and buffer OR full protection in the core and none in the buffer
4. Full protection in core habitat and partial in the buffer
5. Full protection in core habitat and buffer

    +1 point for sites with specific language/conservation measures for Bog Turtles

Road Mortality Risk– GIS assessment using national roads data layer and hand editing where necessary.

- Number of road meters for all roads within 91 m (or 300-ft/Zone 2) of the core habitat.
    1. >400 m
    2. 300–400 m
    3. 200–300 m
    4. 100–200 m
    5. 0–100 m
- Distance to nearest road within 91 m (300-ft/Zone 2).
    1. 0–10 m
    2. 10–30 m
    3. 30–50 m
    4. 50–91 m
    5. >91 m (> 300-ft)

Population Viability Ranking

Parameter Weight (Percent) of Overall Score for Extant Populations – An expert survey was used to identify the importance of the contribution of each metric to both population quality and habitat quality scores. Table 2 and 3 show the assigned percentages of the total population or habitat quality score for each metric based on the results of the expert survey.

Table 2. Population quality metrics used to rank populations.

	Percent of Population Quality Score
Population Size	46
Reproduction	35
Interconnectedness	19

Table 3. Habitat quality metrics used to rank population.

	Percent of Habitat Quality Score
Habitat Protection for Bog Turtle	23
Altered Hydrology in the Core	21
Population Habitat Size	20
Succession in the Core	15
Development *(Pressure and Impervious Surface)*	13
Road Mortality Risk *(Road Density and Proximity)*	8

Population Quality and Habitat Quality Categories

Ranking Categories for Population Quality: Good ≥3.5; Fair = 2.50–3.49; Poor <2.50
Range of Population Quality Scores for all Populations (Fig. 3) = 1.01–5.5

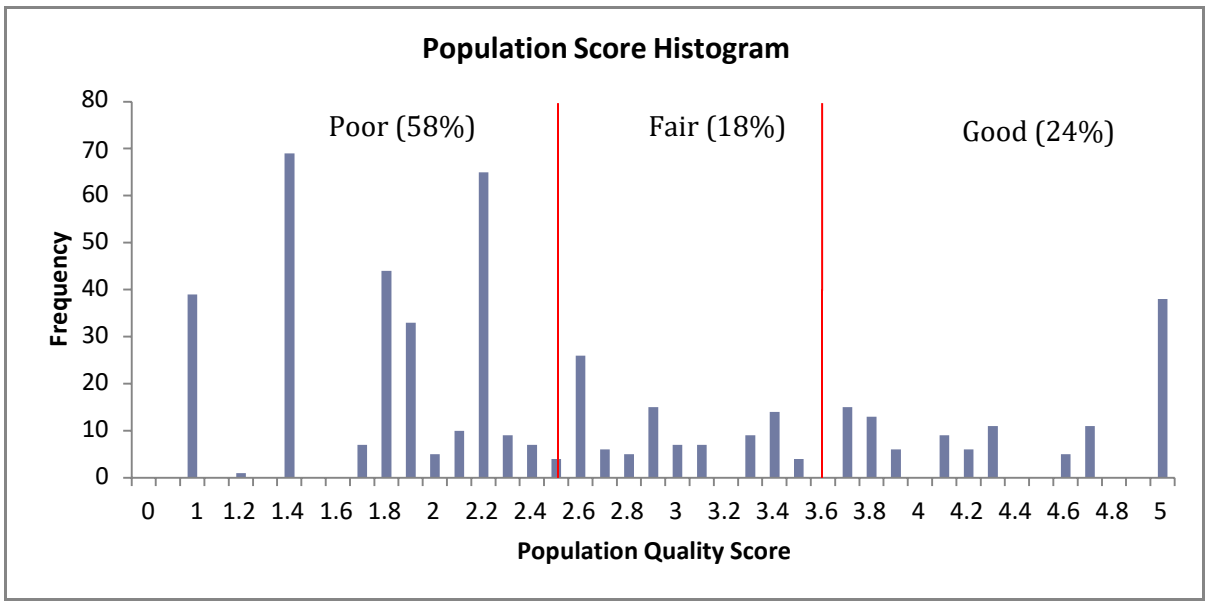


Figure 3. A histogram of the population quality scores for all extant populations and the break points (red vertical lines) among ranking categories for population quality.

Ranking Categories for Habitat Quality: Good ≥3.5; Fair = 2.50–3.49; Poor <2.50
Range of Habitat Quality Scores for all Populations (Fig. 4) = 0.86–4.72

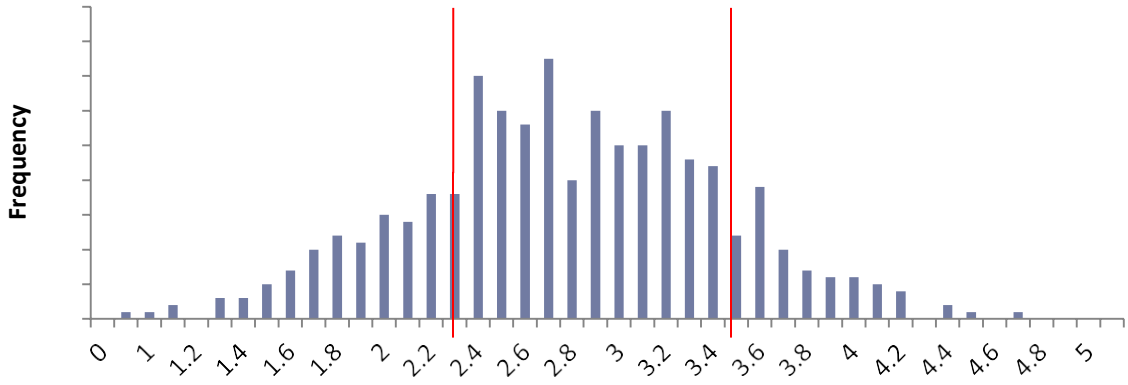


Figure 4. A histogram of the habitat quality scores for all extant populations and the break points (red vertical lines) among ranking categories for habitat quality.

Overall Population Viability Categories

After each population was ranked for both population quality and habitat quality, an overall population viability ranking was determined (Table 4).

Table 4. Overall population viability rank based on the population and habitat quality ranking.

Population Quality Rank		*Habitat Quality Rank*		*Overall Population Viability Rank*
Good	+	Good	=	Good
Good	+	Fair	=	Good or Fair*
Good	+	Poor	=	Fair
Fair	+	Good	=	Good or Fair*
Fair	+	Fair	=	Fair
Fair	+	Poor	=	Fair or Poor*
Poor	+	Good	=	Fair
Poor	+	Fair	=	Poor
Poor	+	Poor	=	Poor

*These required a decision by the state leads.

HUC12 Ranking

USGS HUC12 GIS data layers were ranked using the population ranking data results. All HUC12 sub-watersheds where Bog Turtles had occurred or currently occur were selected and each was ranked as Good, Fair, Poor, Historical, or Unranked. HUC12 rankings of Good, Fair and Poor were determined using the mean of the combined value of population quality scores and habitat quality scores for all populations within each HUC12.

Ranking categories for HUC12 sub-watersheds: Good ≥6.50; Fair = 4.50–6.49; Poor <4.50
Range of HUC12 Scores (Fig. 5) = 2.66–8.42

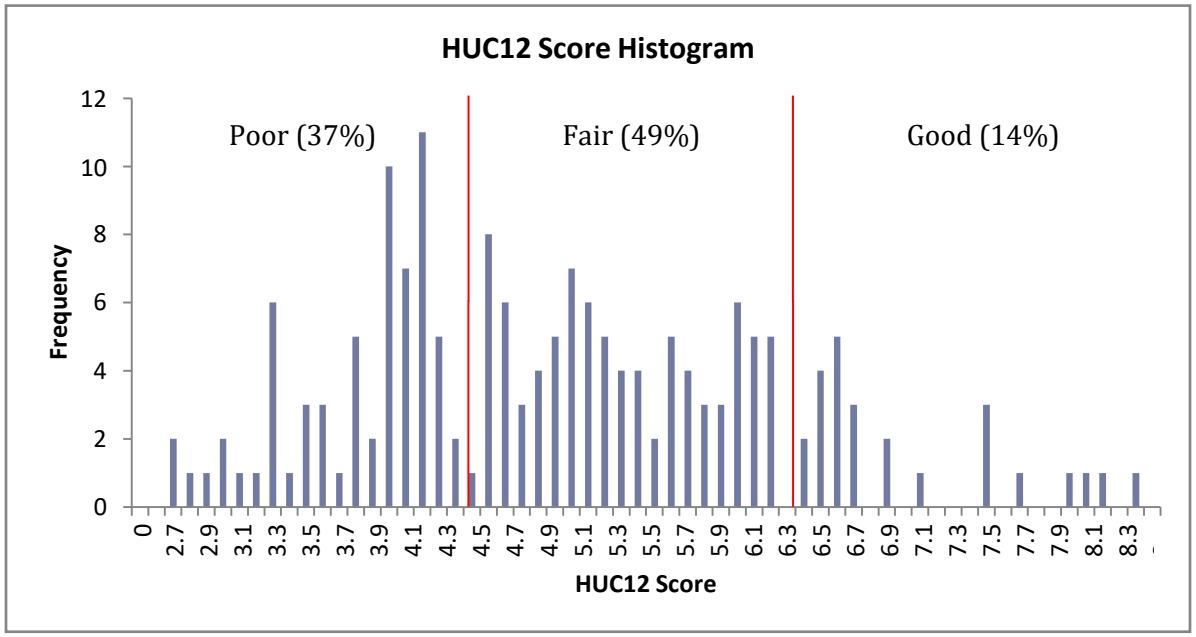


Figure 5. Histogram of the HUC12 scores and breaking points (red vertical lines) indicating separations among ranking categories.

Future Periodic Assessments

Populations should be ranked every 5–10 years using these or similar methodologies to evaluate progress towards recovery, as well as to identify population and habitat trends over time. It is recommended that this ranking be done prior to USFWS 5-year reviews (for more information visit https://www.fws.gov/endangered/what-we-do/pdf/5-yr_review_factsheet.pdf).

Results and Discussion

A total of 882 populations were identified, with 500 of these consisting of extant populations (Fig. 6). Of extant populations, 78 were considered to have "Good" potential of being viable, whereas 137 were ranked as "Fair," and 288 ranked as "Poor" for viability (Fig. 7). A breakdown of the result by recovery unit is also presented in Table 5. Results for the individual metrics can be found in Appendix I.

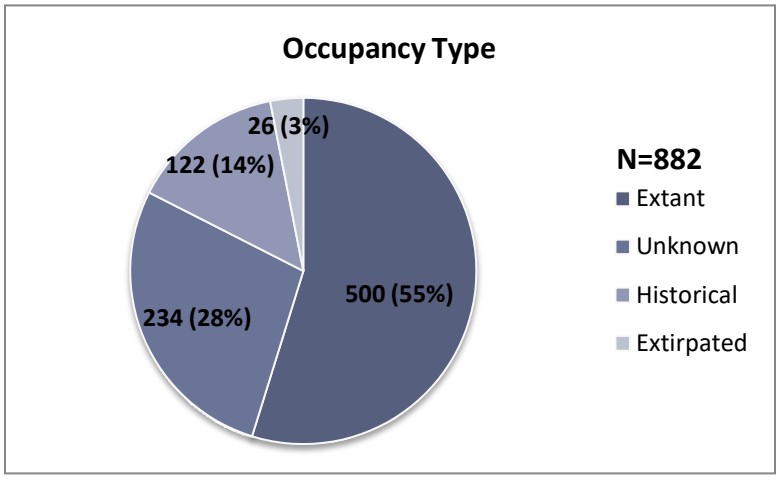


Figure 6. Occupancy type for all Bog Turtle populations identified during this analysis.

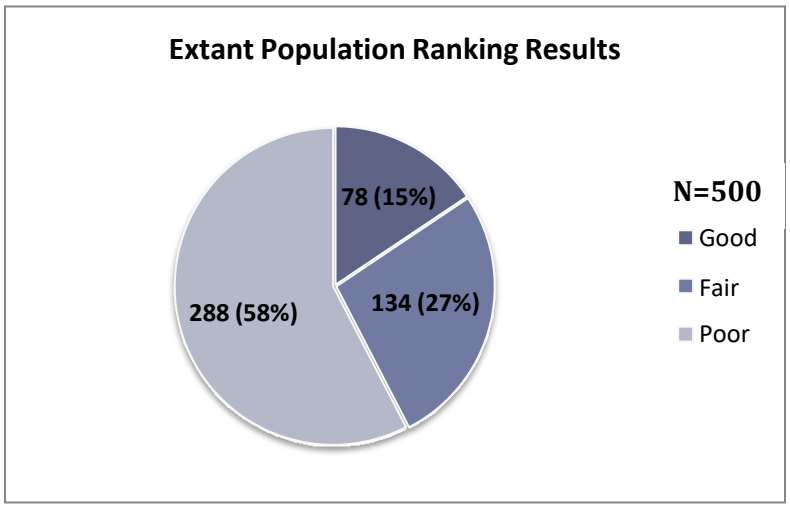


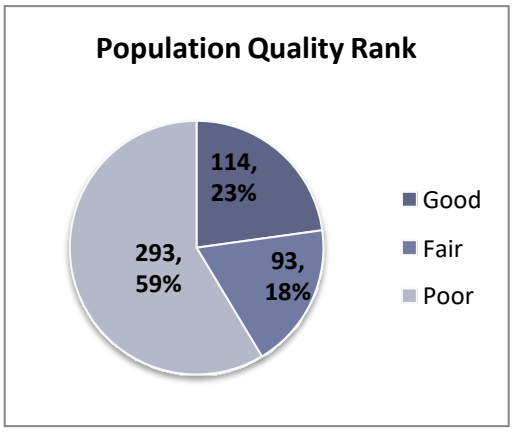
Figure 7. Percentages for each ranking category for population viability potential for all extant Bog Turtle populations.

Table 5. Number of extant populations by viability ranking category for each of the five Bog Turtle recovery units including the Delaware (DE), Hudson-Housatonic (HH), Prairie Peninsula-Lake Plain (PPLP), Outer Coastal Plain (OCP), and Susquehanna-Potomac (SP) units.

	Good	*Fair*	*Poor*
DE	21	48	150
HH	30	30	67
PPLP	3	2	0
OCP	0	1	3
SP	24	53	68
Total	78	134	288

Habitat condition appears to be a relatively greater issue than population quality (Fig. 8), although work is typically needed on both in many Bog Turtle populations and these are not mutually exclusive. For instance, improving nesting habitat will also improve recruitment and, therefore, population quality at many locations.

(a)



(b)

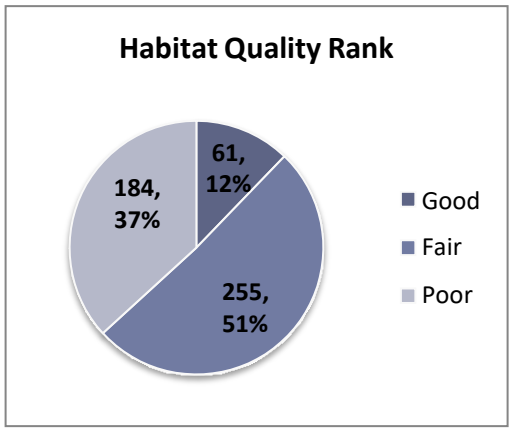


Figure 8. Number of extant populations (N=500) and percentages by ranking category for (a) population quality and (b) habitat quality.

4.2.3. PRIORITIZE POPULATIONS FOR HABITAT PROTECTION AND MANAGEMENT

Guidelines were developed to prioritize populations for both habitat protection and habitat management practices. Habitat protection here refers to either fee simple purchases of land or conservation easements. Habitat management includes all types of management such as grazing, mechanical removal of vegetation, herbicide application, etc. A list of populations that fit these criteria can be found in each of the Recovery Unit Action Plans. These priority lists should be re-evaluated and updated periodically (e.g., every 5–10 yrs) along with other components of this Conservation Plan.

The criteria used to assign priority numbers to each Bog Turtle population are indicated below:

Priority 1:

- Populations ranked as having "Good" potential for viability over the long-term OR
- Populations ranked as having "Good" population quality and "Good" or "Fair" habitat quality

AND

- For habitat protection – populations with a habitat protection score of 2–4
- For habitat management – populations with a habitat protection score of 3–5

Priority 2:

- Populations ranked as having "Good" potential for viability over the long-term OR
- Populations ranked as having "Good" population quality score and "Fair" or "Poor" habitat quality OR
- Populations ranked as having "Fair" population quality score and "Good" or "Fair" habitat quality score

Priority 3:

- Good or Fair population quality rank and Poor habitat quality rank

Priority 4:

- Opportunistic – as resources become available for other populations not occurring within locations with Priority 1–3 rankings

Priority 1 populations should be secured first whenever possible. Priority 2 populations should be secured after all Priority 1 populations have been protected and managed (where possible). Priority 3 populations should be secured after all Priority 2 populations have been secured (where possible). Priority 4 populations should be protected and managed opportunistically as resources become available and the landowner is willing to protect and/or manage the habitat or after all conservation needs have been met/achieved at Priority 1, 2, and 3 populations. A landowner's unwillingness to assist with recovery actions may be an impediment to working on or protecting higher priority sites.

4.2.4. MAP IMPORTANT HABITAT CORRIDORS

Important habitat corridors were identified and mapped for the purpose of improving or maintaining metapopulation dynamics for all extant metapopulations. Extant core habitats that are considered to be part of a metapopulation were identified using ArcGIS and each was buffered by 200 m. These buffered core habitats were used to create Minimum Convex Polygons (MCPs) that contain all core habitats within the same population. This same process was used to create MCPs for all populations within the same metapopulation. Historical and extirpated populations were also included if they were part of the extant metapopulation, if habitat still exists, and if no major barriers were present (e.g., 4-lane highway or multiple high traffic 2-lane roads). Resulting spatial data for these important corridors within each state were distributed to the appropriate state leads. The spatial data and rankings should be used in combination with other habitat mapping tools (e.g.,

potential Bog Turtle habitat models, state-specific habitat corridor models, etc.) to identify habitat linkages for protection, and management actions towards locations that will be most beneficial for maintaining and improving connectivity among populations within a single metapopulation. Specific sections of existing roads should be identified at target areas within these important habitat corridors for improvement of turtle passageways. Partners should work with their state's Department of Transportation to improve connectivity at these locations as opportunities arise.

The criteria used to assign priority numbers to each important corridor are indicated below:

Priority 1:

> Habitat between all extant populations within a single metapopulation and with ≥1 population that ranked as "Good" for viability. These locations are the highest priority for habitat protection and management actions. These are also important sites for locating and surveying other potential wetland habitats for the presence of suitable Bog Turtle habitat and Bog Turtles.

Priority 2:

> Habitat between all extant populations (and core habitats within each population) within a single metapopulation and with ≥1 population that ranked as "Fair" for viability.

Priority 3:

> Habitat between all extant populations (and core habitats within each population) within a single metapopulation and with only populations that ranked as "Poor" for viability.

Priority 4:

> Linkages between two or more populations that ranked as "Good" for viability and are not currently part of the same metapopulation (based on the mapping guidelines), are within 2 km of each other, and are not separated by a 4 lane highway or multiple high traffic state roads.

Priority 1 important corridors should be secured first whenever possible. Priority 2 important corridors should be secured after all Priority 1 corridors have been protected and managed (where possible). Priority 3 important corridors should be secured after all Priority 2 corridors have been secured (where possible). Priority 4 corridors should be secured opportunistically as funding and resources become available for work in these areas and the landowners are amenable. Similarly to assigning priority numbers to populations above, at times, opportunities may not exist for managing/protecting corridors due to unwilling landowners. Therefore, the priority rankings for corridors outlined above provide a starting place should there be opportunities at the higher priority sites.

One hundred Important Corridors were identified and delineated in early 2019 using these methods. Resulting geospatial data were provided to the state agency leads to the seven states within the Northern range. One of these corridors extends across the state boundary between two states. No important habitat corridors were identified during this exercise for the OCP or PPLP Recovery Units. See Table 6 for more details on the location and distribution of these corridors.

Table 6. A breakdown of the number of important habitat corridors by recovery unit and state for priority level 1 (a), 2 (b), 3 (c), and 4 (d).

(a)

	CT	DE	MA	MD	NJ	NY	PA	Total
DE		2			6		4	12
HH	1*				4	7*		12
SP				11			2	13
Total	1	2	0	11	10	7	6	37

*CT and NY have one shared metapopulation.

(b)

	CT	DE	MA	MD	NJ	NY	PA	Total
DE					5		9	14
HH			1		1	7		9
SP				9			3	12
Total	0	0	1	9	6	7	12	35

(c)

	CT	DE	MA	MD	NJ	NY	PA	Total
DE					6		5	11
HH					2	2		4
SP				8			1	9
Total	0	0	0	8	8	2	6	24

(d)

	CT	DE	MA	MD	NJ	NY	PA	Total
DE					1			1
HH								0
SP				4				4
Total	0	0	0	4	1	0	0	5

4.2.5. IMPLEMENT POPULATION MONITORING

Introduction

A population monitoring program has been developed and has been in use since 2014. Standardized population monitoring is critical for tracking population trends and was identified as recovery criterion #2 in the Northern Population Recovery Plan. Data obtained through monitoring surveys will help guide future conservation and management decisions regarding the recovery of the Bog Turtle across the Northern population range.

Monitoring Goals:

Establish a regional, standardized, and robust sampling framework to assess the population status and long-term population trends of the Bog Turtle in the northeastern US.

Use the monitoring information to evaluate the population status and progress towards the Northern Population Recovery Plan recovery goals.

Sampling Objectives:

- Quantify and track trends in regional estimates for detection, occupancy, and abundance of Bog Turtle populations throughout the northeast every 5–10 years.
- Quantify and track trends in site-specific population size and structure at a subset of sites in each of the three major recovery units (Hudson-Housatonic [HH], Delaware [DE], and Susquehanna-Potomac [SP] Recovery Units) every 5–10 years, as a minimum. Tracking site-specific trends in the Outter Coastal Plain (OCP) and Prairie Penninsula-Lake Plain Recovery Units is also desired for any remaining large populations.
- Evaluate the effects of population management actions.

Methods

Survey Season

Recovery Unit	*Visual/Tactile Surveys*	*Trapping Surveys*	*Nesting Surveys*	*Radio Telemetry*
DE, HH, OCP, and SP	15 April–15 June	1 May – 15 June 1 Sept – 15 Oct	1 June – 15 June	Year round
PPLP	25 April–25 June	15 May–15 Sept	5 June–20 June	Year round

Sampling Design

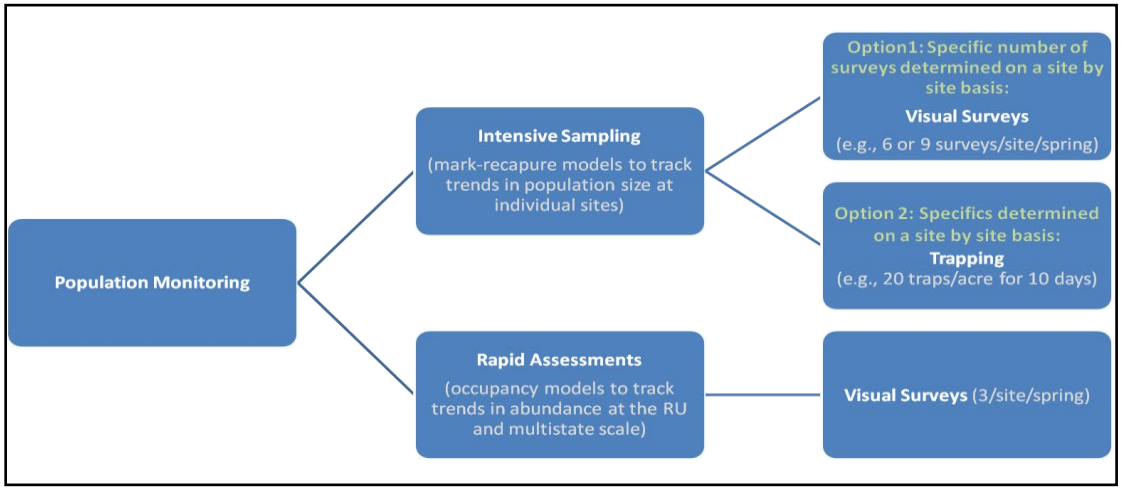


Figure 9. Two-tiered population monitoring design with intensive sampling to evaluate population demographics and rapid assessment to track changes in the abundance of Northern populations. Intensive sampling can be accomplished with multiple visual surveys or trapping.

Monitoring Site Selection

- Survey locations will be centered on core habitat.
- Areas with appropriate vegetation, hydrology and soils for Bog Turtles.
- Monitoring sites will be separated by ≥3 km (or one per metapopulation).
- Sites selected should be diverse and span the types of habitat and landscape conditions that are present.
- ≥20 Rapid Assessment (RA) sites will be selected in each of the three major RUs (DE, HH, and SP) and at least one in the PPLP RU.
- ≥2 Intensively Sampled (IS) sites will be selected in each of the RUs (a subset of the RA sites).
- Sites will be stratified by the level of habitat management.
    - 1/3 sites with no management
    - 1/3 sites with light management (1/2 or less of the site impacted)
    - 1/3 sites with heavy management (most of the site impacted)
- Sites selected should have recent turtle observations, within the past 30 yrs.
- Sampling areas will range in size from 0.25 –7.5 acres.

Rapid Assessments (RA)

<u>Survey Timing and Schedule</u>

- Each site will be surveyed every 5–10 years.
- 3 visual/tactile surveys will be completed within a single season.
- Sites should not be re-sampled within a 7 day period, when possible.
- Survey time of day will be between 8 AM and 8 PM.
- Survey weather conditions constraints include: temperature should be between 65°–85° F and surveys should not occur during heavy rains if surveyor visibility is otherwise hindered.

<u>Basic Protocol and Pre-season Planning</u>

- State leads will determine surveyors qualified to lead monitoring surveys.
- When possible, alternate surveyors for the 3 surveys at an individual site to minimize a surveyor bias at a given site.
- One or more lead surveyors will be present to supervise during all surveys.

<u>Field Methods</u>

- Perform visual/tactile surveys, spending approximately 2-person hrs/acre actively searching for turtles.
- Calculate search time based on survey area and number of surveyors (refer to the effort hour chart in Appendix A).
- Search the entire survey area during the allotted time; however, the lead surveyor should use best professional judgment in directing assistant surveyors to spend more time in areas with the best habitat (e.g., open canopy, mucky soils).
- Briskly walk throughout the survey area looking for turtles that are on the surface. After the entire area has been traversed, surveyors can use tactile/probing methods to search the

best habitat until the predetermined survey time is completed. Surveyors should search under dead vegetation, in puddles, mud, and tunnels particularly near tussock sedge and around the roots of shrubs.

- Keep track of each surveyor's time spent actively looking for turtles (sometimes surveyors stop once an animal is found). Record the survey start and end times. Each time a survey is stopped for any reason (e.g., to process turtles or speak to someone), record the stop time and then record the time when the survey is resumed. The number of minutes NOT spent actively searching will need to be calculated in order to estimate effort hours.

Intensive Sampling (IS)

- Intensive Sampling will occur at a minimum of 2 sites in each RU.
- Intensive Sampling will be performed at a subset of the RA sites so that the IS survey data can help to inform the RA results.
- Intensive Sampling may include visual/tactile surveys or trapping and may be supplemented with nest surveys or radio-telemetry.

<u>Visual/tactile surveys</u>

- The survey window and methodology are the same as RA surveys but with additional replication.
    - The number of surveys required will be assessed on a site by site basis, but will typically be 6–9 surveys occurring within 2-years in each 5-year round of sampling. If in question, perform 9 of the RA surveys.

<u>Trapping</u>

A trapping protocol is needed. The guidelines below provide a starting point. Previously collected trapping data should be used to inform the develop of a protocol.

- The Survey Window is *1 May – 15 June* and *1 Sept – 15 Oct*.
    - Except for the PPLP area which is *15 May–15 Sept.*
        - Distribute traps relatively evenly throughout the sampling area (the same area in which visual/tactile surveys were performed).
- Use Fahey or eel pot-type trap designs with wings. Traps should be ≥4" in height.
- Use 3 drift fences set up perpendicular to the flow of water, where possible.
- Follow the Regional Phase 3 survey protocol for detailed instructions on trap labeling.

<u>Nest Surveys</u>

- The Survey Window is *1 June – 15 June* .
    - Except for the PP/LP area which is *5 June to 20 June.*
- Search along transects spaced 8 m apart in a grid pattern across the open canopy core habitat.
- Detailed methodology is yet to be developed.

Telemetry

- Obtain locations on radio-tagged turtles at least twice weekly throughout the active season and once every 4–6 weeks throughout the inactive season.
- Ideally, ≥10% of the population would be tracked with an equal ratio of males to females. At a minimum 10 individuals (5 males and 5 females) should be tracked
- Consider more intensive effort during the nesting season.
    - Obtain locations on female turtles every 1–2 days.
    - Use thread spool to track fine-scale movements.
- Consider evaluating home ranges before and after habitat management.
- Consider using Mark-resight models to estimate population size.

SGCN Species Assessment

This protocol is designed to provide guidance in assessing potentially co-occurring Species of Greatest Conservation Need (SGCN) at Bog Turtle sites, particularly during population or habitat monitoring surveys.

An SGCN species list has been created for each state where Bog Turtles occur within the Northern population range. Prior to the survey season, each state lead (or lead surveyors) should print their state's list to keep with their other survey forms. Immediately before surveys (population or habitat), the lead surveyor should review the SGCN species list with all assistant surveyors, requesting them to be on the lookout for these species. Immediately following the population or habitat monitoring survey, surveyors should spend 10–15 minutes searching and listening for SGCN species. Surveyors should search accessible areas adjacent to the Bog Turtle core habitat, particularly along stream corridors and upland edges and listen for vocalizations of SGCN species. All SGCN species observed during the site visit should be noted on the Bog Turtle survey form.

Suggested data to collect on SGCN species and distribution of the data are as follows:

Turtle SGCN Species

> At a minimum, a GPS location and photograph should be taken for all turtle SGCN species. If time allows, consider fully processing turtles. Permits and coordination with the state's herpetologist will be required for marking turtles. If your state has a herp atlas project, report species observations to the atlas database.

Other Herp SGCN Species

> At a minimum photograph at least one individual of each Herp SGCN species observed and preferably one of each age class and sex. If time allows, collect GPS locations. If your state has a herp atlas project, report species observations to the atlas database.

Non-Herp SGCN Species

> At a minimum, photograph or collect an audio recording (if appropriate) for at least one individual of each SGCN species. If time allows collect GPS locations on each observation.

Each state lead should determine where this data will be distributed beyond the Bog Turtle regional database.

In addition, enter all SGCN species observations into the Bog Turtle regional database using the following format: One digit Class code – two-digit genus and two-digit species code (e.g., Green Heron (*Butorides virescens*) might be B-BUVI where B is for the class Birds and BUVI is the species code).

Survey Results

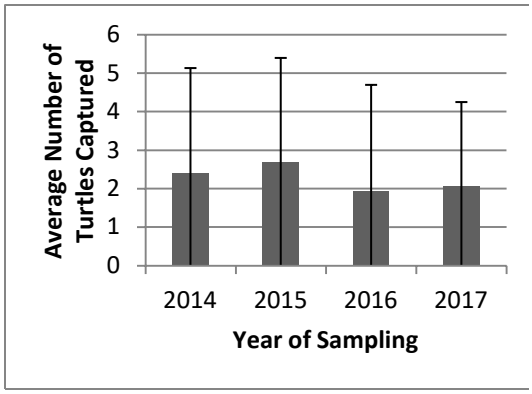
Using the protocols outlined above, baseline data were collected from 2014 to 2018 (Table 7). This concluded the first round of sampling at the population monitoring sites. Each sampling period is to occur over a 5-year time frame. At the end of each 5-year sampling period it is recommended that the data be evaluated and comparisons assessed between sampling periods. It should be noted, that the 2018 data presented here are incomplete; not all of the 2018 data were compiled and entered electronically at the time of writing this Conservation Plan. Surveys had a naïve occupancy (average number of surveys that resulted in turtle captures) of 0.86.

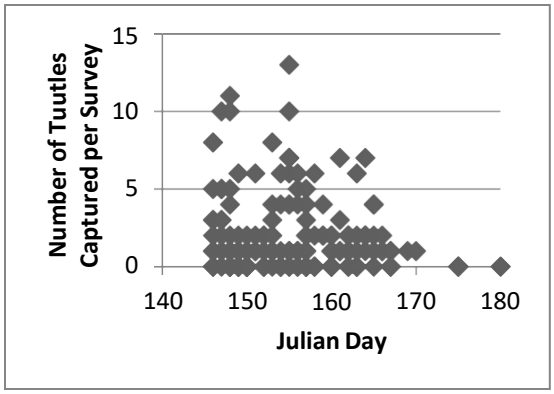
Table 7. Number of rapid assessment, intensively sampled sites, and average number of Bog Turtles captured per survey within each recovery unit during the 2014–2018 survey period.

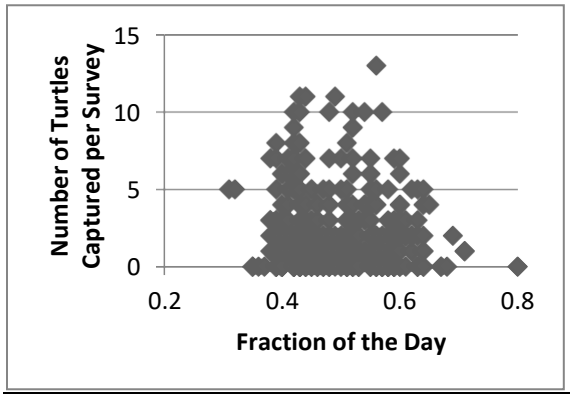
Recovery Unit	Rapid Assessment	Intensive Sampling	Average Number of Bog Turtles/Survey
DE	32	5	2.09
HH	28	4	2.09
OCP	0	0	-
PPLP	2	2	1.50
SP	27	8	2.41

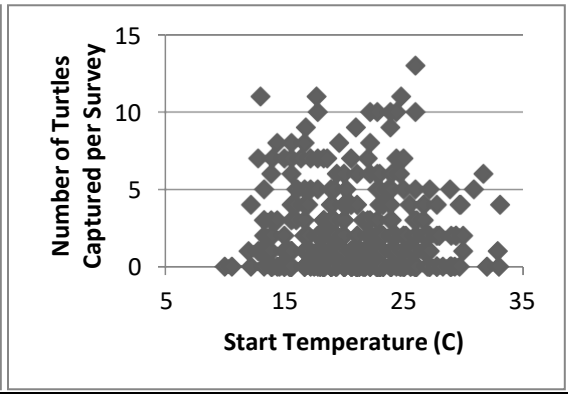
Rapid Assessment Results

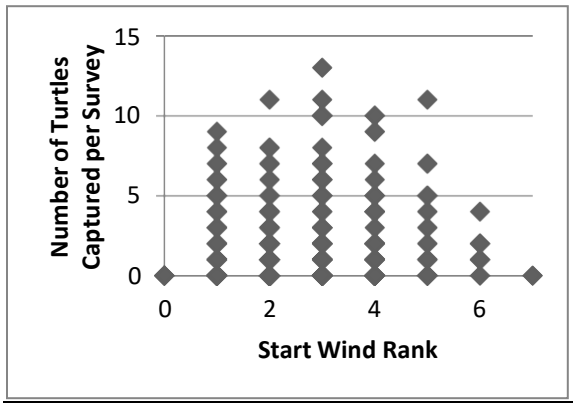
From 2014–2018, there were 805 captures of Bog Turtles (including recaptures). This included 372 surveys at 115 locations (most sites were surveyed 3 times). Twenty-two of these sites were sampled in more than one year (i.e., more than one round of 3 surveys), to evaluate annual variation in captures. The number of turtles captured during the last survey of the season was slightly lower (222) than the first two surveys (286 and 297, respectively). Sampling was dispersed across the Northern range with 32 sampling sites in the DE Recovery Unit, 28 in the HH, 2 in the PPLP, and 27 in the SP Recovery Units. No sites were sampled in the OCP Recovery Unit. Sampling covariates were evaluated to determine if any may have an influence on survey results. These data suggest that the sampling restrictions outlined in the protocol have minimized any influence of other variables (e.g., weather conditions, time of year, etc.; Fig. 10). The majority of captures were of adult females, followed by adult males (Fig. 11). Of several occupancy models evaluated the Royle-Nichols model (Royle and Nichols 2003) was the best fit model (Table 8).

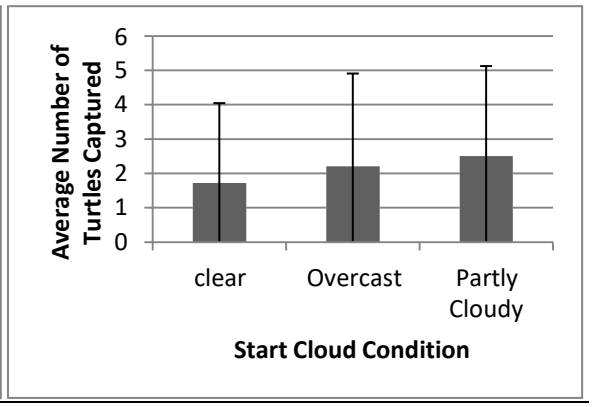

Average Number of Turtles Captured
6
5
4
3
2
1
0
2014
2015
2016
2017
Year of Sampling

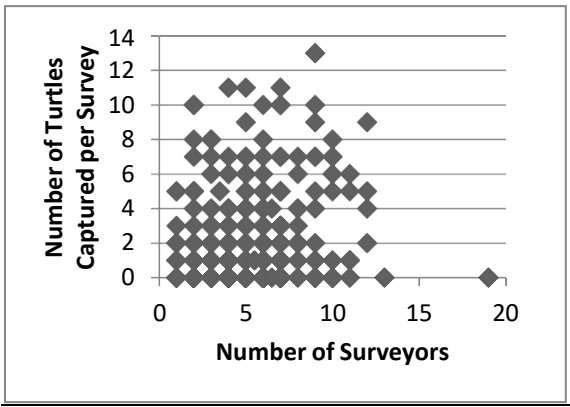

Number of Tuutles Captured per Survey
15
10
5
0
140
150
160
170
180
Julian Day

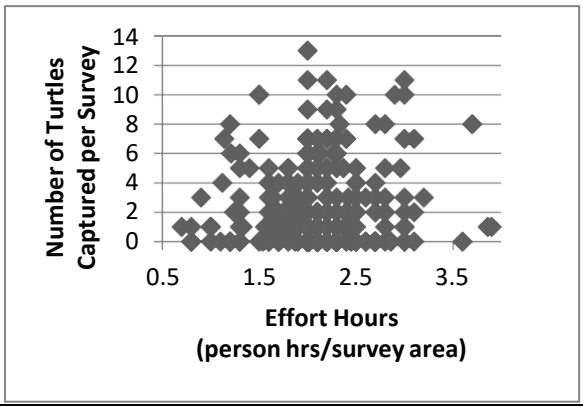

Number of Turtles Captured per Survey
15
10
5
0
0.2
0.4
0.6
0.8
Fraction of the Day


Number of Turtles Captured per Survey
15
10
5
0
5
15
25
35
Start Temperature (C)


Number of Turtles Captured per Survey
15
10
5
0
0
2
4
6
Start Wind Rank


Average Number of Turtles Captured
6
5
4
3
2
1
0
clear
Overcast
Partly Cloudy
Start Cloud Condition


Number of Turtles Captured per Survey
14
12
10
8
6
4
2
0
0
5
10
15
20
Number of Surveyors


Number of Turtles Captured per Survey
14
12
10
8
6
4
2
0
0.5
1.5
2.5
3.5
Effort Hours
(person hrs/survey area)

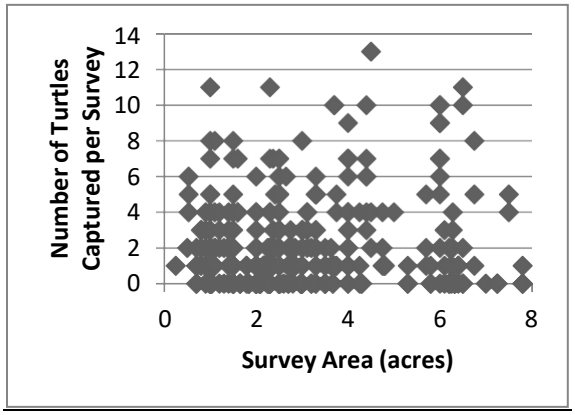


Figure 10. The number of turtle captures for Bog Turtle population monitoring across the Northern range from 2014–2018 by sampling variables, including year, date (Julian day), time of day of survey (fraction of the day), temperature (°C), wind rank, cloud condition, number of surveyors, efforts hours, and area.

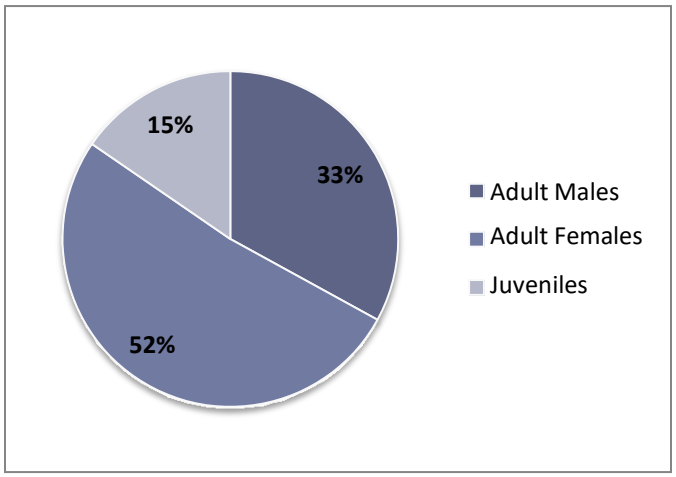


Figure 11. Proportion of individuals captured (N=794) that were adult males, adult females, and juveniles.

Table 8. Model fit comparison for five occupancy model types, including Akaike information criterion (AIC), change in AIC, AIC weight and the number of parameter in the model.

Model	AIC	deltaAIC	AIC weight	No. Parameters
Lambda(.),c(.)	434.09	0.00	0.9839	2
Psi(.),p(.)	443.85	9.76	0.0076	2
1 group, Constant P	443.85	9.76	0.0076	2
1 group, Survey-specific P	447.59	13.50	0.0012	4
Lambda(.),r(.)	2668.63	2234.54	0.0000	2

Intensive Sampling Results

Results of intensive sampling surveys will be evaluated and included in the SSA (in development).

SGCN Species Observations Results

During the population monitoring surveys, we also collected data on other SGCN species observed at sampling sites. Below is a list of SGCN species and count data for observations by state (Table 9). These data are for the population monitoring survey only.

Table 9. List of Species of Greatest Conservation Need (SGCN) that have overlapping habitat use with Bog Turtle in the northeast. Count data represent the number of Bog Turtle surveys in which an SGCN species was observed for each state.

Scientific Name	Common Name	Code	Connecticu :	Delaware	Maryland	Massachusetts	New Jersey	New York	Pennsylvania
AMPHIBIANS AND REPTILES									
Ambystoma laterale	Blue-spotted Salamander	AMLA	0			0*	0	0	0
Notophthalmus viridescens viridescens	Red-spotted Newt	NOVI	0	0*					
Hemidactylium scutatum	Four-toed Salamander	HESC	0	0		0*	0**	0	8*
Anaxyrus fowleri	Fowler's Toad	ANFO		0*			0	0**	0
Ambystoma jeffersonianum	Jefferson Salamander	AMJE			0**	0*	0	0	0
Eurycea longicauda longicauda	Eastern Long-tailed salamander	EULO		0			0	0**	
Lithobates pipiens	Northern Leopard Frog	LIPI	0			0*			0**
Pseudotriton ruber ruber	Northern Red Salamander	PSRU		0*	16		0	0*	
Gyrinophilus porphyriticus porphyriticus	Northern Spring Salamander	GYPO	0		0**		0**		
Ambystoma maculatum	Spotted Salamander	AMMA	0	0*			0**		
Lithobates sylvaticus	Wood Frog	LISY	0	0*					
Terrapene carolina carolina	Woodland Box Turtle	TECA	0	0	9	0*	6	1	25
Coluber constrictor constrictor	North American Racer	COCO	0			0*	4**	0**	
Thamnophis sauritus sauritus	Common Ribbonsnake	THSA	0	0	1	0	2	9	4
Agkistrodon controtrix mokasen	Northern Copperhead	AGCO		0*		0*	0**	0**	0
Regina septemvittata	Queen Snake	RESE		0			0**	0**	6
Storeria occipitomaculata occipitomaculata	Northern Red-bellied Snake	STOC	0	0*					
Opheodrys vernalis	Smooth Greensnake	OPVE	0		0**	0*	0**	0	
Chelydra serpentina	Snapping Turtle	CHSE						4	
Clemmys guttata	Spotted Turtle	CLGU	0	0	10	2	3	26	16
Crotalus horridus	Timber Rattlesnake	CRHO			0**	0*	0**	0**	0
Glyptemys insculpta	Wood Turtle	GLIN	0		0**	0	4**	1	12
BIRDS									
Botaurus lentiginosus	American Bittern	B-BOLE	0	0	0**	0	0	0	1

Scolopax minor	American Woodcock	B-SCMI	0	0	0	0	0	0	0
Icterus galbula	Baltimore Oriole	B-ICGA	0	0*			0**		
Coccyzus erythropthalmus	Black-billed Cuckoo	B-COER		0*		0*	0	0	
Nycticorax nycticorax	Black-crowned Night Heron	B-NYNY		0*	0**	0*	0**	0**	1
Setophaga caerulescens	Black-throated Blue Warbler	B-SECA		0*	0**		0	0**	0
Setophaga virens	Black-throated Green Warbler	B-SEVI		0*	0**		0		0
Vermivora cyanoptera	Blue-winged Warbler	B-VECY		0*	0**	0	0	2**	0
Vermivora chrysoptera	Golden-winged Warbler	B-VECH	0	0*	0**	0*	0**	0	0
Dumetella carolinensis	Gray Catbird	B-DUCA					0		0
Butorides virescens	Green Heron	B-BUTO	0*			0*			
Passerina cyanea	Indigo Bunting	B-PACY					0*		
Ixobrychus exilis	Least Bittern	B-IXEX	0	0	0**	0	0	0	0
Cistothorus palustris	Marsh Wren	B-CIPA	0	0	0**		0		0
Parkesia noveboracensis	Northern Waterthrush	B-PANO			0**				0
Cistothorus platensis	Sedge Wren	B-CIPL	0	0	0**	0	0	0	0
Catharus fuscescens	Veery	B-CAFU		0	0		0		
Rallus limicola	Virginia Rail	B-RALI	0	0*			0		0
Empidonax traillii	Willow Flycatcher	B-EMTR		0*	1	0*	0	0*	0
Gallinago delicata	Wilson's Snipe	B-GADE	0	0*		0*	0*		0
Coccyzus americanus	Yellow-billed Cuckoo	B-COAM					0		
Nyctanassa violacea	Yellow-crowned Night Heron	B-NYCI		0*	0**		0**	0**	0
Setophaga dominica	Yellow-throated Warbler	B-SEDO		0	0**		0*		
MAMMALS									
Sylvilagus transitionalis	New England Cottontail	M-SYTR	0			0*		0	
Sorex palustris	American Water Shrew	M-SOPA	0			0*	0**		0
Lasiurus borealis	Eastern Red Bat	M-LABO		0*	0	0*	0**	0**	
Sorex hoyi winnemana	Southern Pygmy Shrew	M-SOHO			0				
INSECTS									
Cordulegaster obliqua	Arrowhead Spiketail	I-COOB			0		0**	0**	0*
Euphydryas phaeton	Baltimore Checkerspot	I-EUPH	0	0	0		0**		
Sympetrum semicinctum	Band-winged Meadowhawk	I-SYSE	0	0*					0*
Bembidion pseudocautum		I-DEPS	0						
Euphyes conspicua	Black Dash	I-EUCO	0	0*	0**				0*
Hemileuca spp	Bog Buckmoth	I-SESP						0*	
Cordulegaster bilineata	Brown Spiketail	I-COBI		0*	0				0*
Euphyes dion	Dion Skipper/Sedge Skipper	I-EUDI	0	0*	0**	0	0**		0*
Nannothemis bella	Elfin Skimmer	I-NABE		0*	0**		0**	0*	0*
Carmenta bassiformis	Eupatorium Borer Moth	I-CABA	0	0*					
Satyrodes eurydice	Eyed Brown	I-SAEU	0	0*			0**		0*

Tachopteryx thoreyi	Grey Petaltail	I-THAT			0	0**	0**	0*
Chlosyne harrisii	Harris Checkerspot	I-CHHA	0		0**	0		0*
Spialia galba	Indian Skipper	I-SPGA		0*	0			0*
Polites mystic	Long Dash	I-POMY			0	0**		0*
Merycomyia whitneyi		I-MEWH	0					
Poanes massasoit	Mulberry Wing	I-POMA		0	0**			0*
Sargus fasciatus		I-SAFA	0*					
Nehalennia irene	Sedge Sprite	I-NEIR		0*	0*			
Argia bipunctulata	Seepage Dancer	I-ARBI		0*	0			0*
Boloria selene	Silver-bordered Fritillary	I-BOSE	0	0*	0**	0**		0*
Nehalenia gracilis	Sphagnum Sprite	I-NEGR		0*	0			
Cordulegaster erronea	Tiger Spiketail	I-COER		0*	0	0**	0**	0*
Siphlonisca aerodromia	Tomah Mayfly	I-SIAE	0				0**	
Euphyes bimacula	Two-spotted Skipper	I-EUBI	0		0**	0**		0*
Libellula flavida	Yellow-sided Skimmer	I-LIFL		0*	0			0*

*Species that were removed from the SGCN list since 2014.
**Species that were added to the SGCN list since 2014.

4.2.6. IMPLEMENT HABITAT MONITORING

Introduction

This monitoring program is designed to evaluate the impact of habitat management activities and guide future conservation and management decisions within an adaptive management framework. Habitat monitoring data can be used to track changes in habitat conditions and initiate habitat management actions for the recovery of the Bog Turtle across the Northern population range.

Monitoring Goal:

Track the effect of, and help to inform, adaptive habitat management activities in core habitat.

Sampling Objectives *(Fig. 12)****:***

- Quantify and track changes in coarse-level habitat metrics indicating vegetation structure in core habitat throughout the northeast.
- Quantify and track changes in site-specific plant community distribution (at least for a subset of sites).
- Evaluate the effect of habitat management actions on Bog Turtle populations.

Methods

Survey Season

RU	*Habitat Surveys*
DE, OCP, and SP	13 June–3 July
HH and PPLP	27 June–17 July

Sampling Design

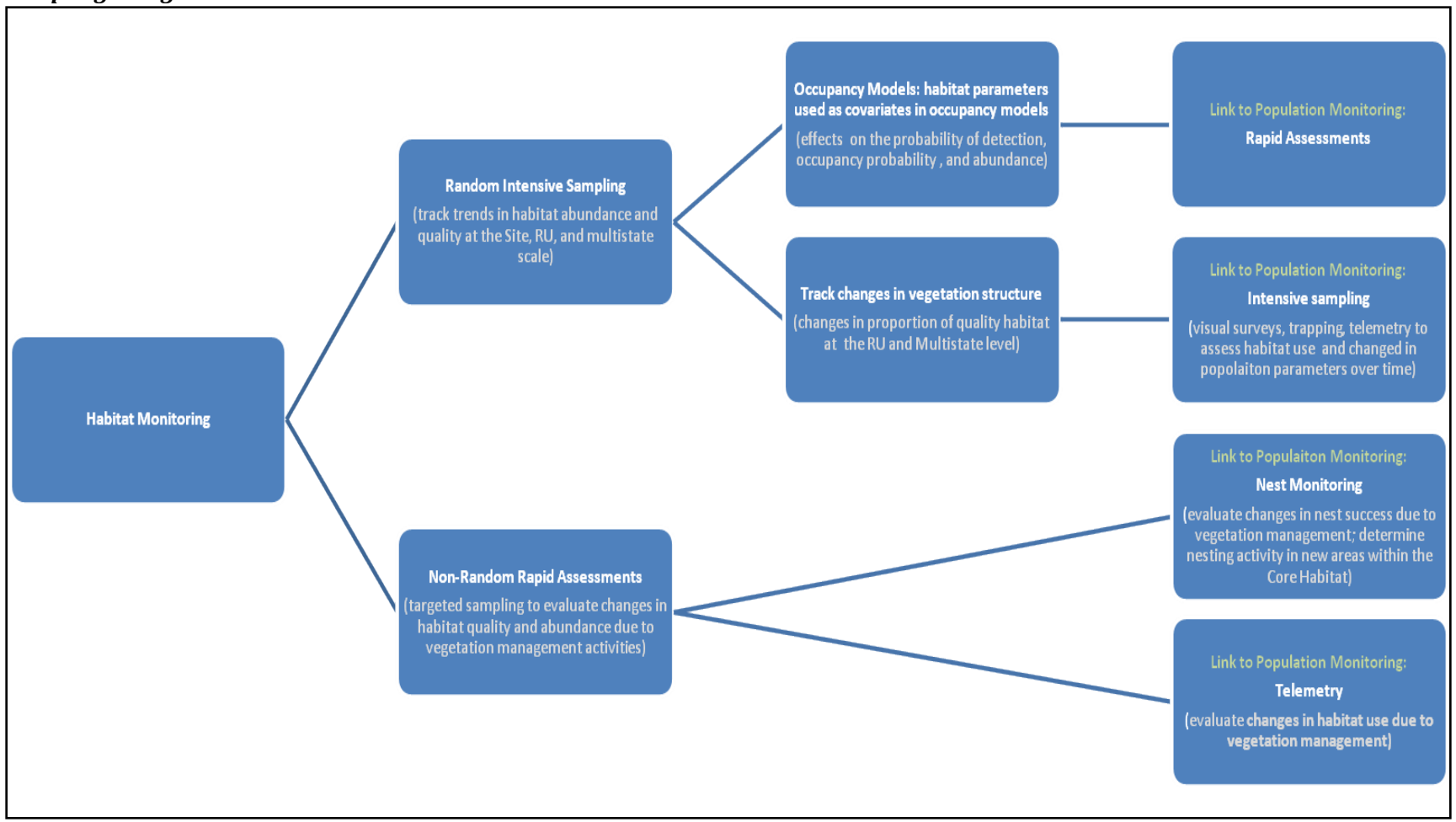


Figure 12. A two-tiered habitat monitoring sampling design was developed, with random intensive sampling used to evaluate and track trends in habitat structure throughout the selected core habitat, and a non-random rapid assessment (or targeted sampling) for tracking changes due to specific habitat management action in part of a core habitat.

Monitoring Site Selection:

- Habitat monitoring will occur at a subset of population monitoring sites (core habitats) and locations where pre- and post-habitat management monitoring is of interest.
- Survey locations will be centered within core habitat and contain appropriate vegetation, hydrology, and soils for Bog Turtles.
- Sites selected should be diverse, spanning the types of habitat and landscape conditions that exist across the northeast region.
- We will select ≥10 Random Assessment (RA) sites in each of the three major RUs (DE, HH, and SP) and at least one in the PPLP RU.
- We will select ≥2 Intensively Sampled (IS) sites in each of the three major RUs.
- Sites will be stratified by the level of habitat management.
    - 1/3 sites with no management
    - 1/3 sites with light management (≤1/2 of the site impacted)
    - 1/3 sites with heavy management (most of the site impacted)
- Sampling areas will range in size from 0.25 –7.5 acres.

Determining Plot Locations:

- Habitat monitoring stations will be established at 1–22 random locations throughout the core habitat; approximately 3 plots/acre of core habitat (includes appropriate open canopy and forested habitat; see List of Definitions). Table 10 to determine the number of plots for each monitoring site (core habitat).
- The state lead and/or regional coordinator will map core habitat using GIS.
- Evenly spaced points will be generated in GIS throughout the core habitat polygon. These will be used as potential monitoring locations (see Fig 13 for example). The point spacing will vary by size of the core habitat, with approximately 100 points generated within each core habitat. These 100 points are your pool of possibilities, of which 1–22 will be selected randomly as the center point of your sampling plots.
- Points will be randomly chosen as monitoring stations (for methods see Appendix K); however, no two monitoring points selected should be adjacent to one another. For practical reasons, monitoring locations may be shifted slightly (< 4 m) prior to the initial setup of the monitoring station (e.g., if the location is inaccessible for sampling), but should not be shifted due to perceived poor habitat. Several backup locations should also be chosen as substitutes to replace locations that do not contain core habitat (e.g., point at the edge of the habitat) or due to a major obstruction such as a cattle feeding station.

Table 10. The number of habitat plots to evaluate by size of the monitoring site/core habitat.

Core Habitat Area (acres)	*Number of Habitat Plots*	*Core Habitat Area (acres)*	*Number of Habitat Plots*
≤0.33	1	**4.00–4.33**	12
0.34–0.66	1	**4.34–4.66**	13

Core Habitat Area (acres)	*Number of Habitat Plots*	*Core Habitat Area (acres)*	*Number of Habitat Plots*
0.67–1	2	**4.67–5**	14
1.00–1.33	3	**5.00–5.33**	15
1.34–1.66	4	**5.34–5.66**	16
1.67–2	5	**5.67–6**	17
2.00–2.33	6	**6.00–6.33**	18
2.34–2.66	7	**6.34–6.66**	19
2.67–3	8	**6.67–7**	20
3.00–3.33	9	**7.00–7.39**	21
3.34–3.66	10	**7.34–7.50**	22

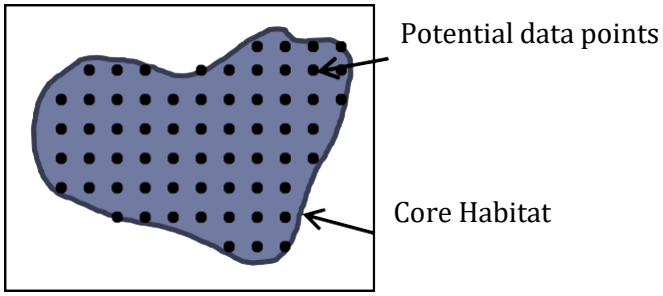


Figure 13. Example of evenly spaced points placed throughout a core habitat.

Basic Protocol and Pre-Season Planning

- Each site will be surveyed every 5–10 years.
- Habitat assessments will be performed at population monitoring sites within a year after turtle surveys are completed. At non-random sites where habitat management is planned, habitat assessments should take place before habitat management activities commence and then several years after management activities have been completed.
- Each state lead should set up a habitat surveyor's exam designed to train and provide consistency in percentage calculations among surveyors. The training can consist of an indoor exercise using quadrats and pieces of paper of known area. The project lead could set up several quadrats with these pieces of paper covering parts of the area within each quadrat. Habitat surveyors will be asked to independently estimate the percent of cover. A comparison can then be made between the estimated values and the real values to help surveyors understand whether they tend to under or overestimate percentages, and make corrections accordingly.
- State leads will determine surveyors qualified to perform the habitat assessments.

Field Methods

- Set up markers and boundaries of the habitat monitoring plots.
- Evaluate dominant species and stem density within a 0.5 m x 0.5 m quadrat placed 0.5 m north of the southwestern monitoring station marker.
- Evaluate canopy cover, species composition, hydrology and soils within a 4 m x 4 m square plot.

- Evaluate habitat disturbance and land use within the entire core habitat area.

For details on the metrics measured, see Appendix K.

Results

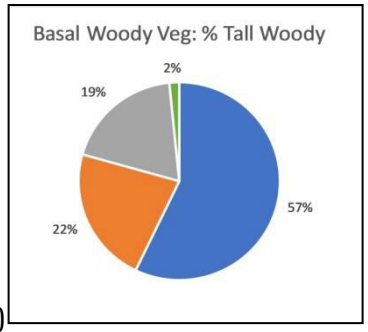
The habitat protocols outlined above were used to collect baseline data from 2014 to 2018 (Table 14). This concluded the first round of sampling at these monitoring sites. A sampling period is to occur every five years. At the end of each 5-year sampling period, it is recommended that the data be evaluated and comparisons assessed between sampling periods and then compared to the population monitoring data. It should be noted that the 2018 data presented here are incomplete; not all of the 2018 data were compiled and entered electronically at the time of writing this Conservation Plan.

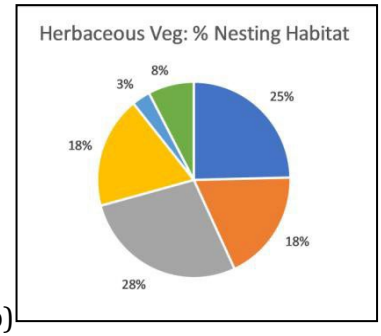
Table 11. Number of Bog Turtle habitat monitoring locations where Random Sampling and Targeted Sampling occurred from 2014–2018.

Recovery Unit	Random Sampling	Targeted Sampling
DE	13	5
HH	27	2
OCP	0	0
PPLP	1	0
SP	9	12
Total	50	19

<u>Random Sampling</u>

Presented below are habitat monitoring results for random sampling conducted from 2014–2018 (Fig. 14 – Fig 17). These are baseline data collected during the first sampling round. Most data represent estimates from randomly located plots within the Bog Turtle core habitat, however, some data represent an evaluation of the entire core habitat.

(a) 

(b) 

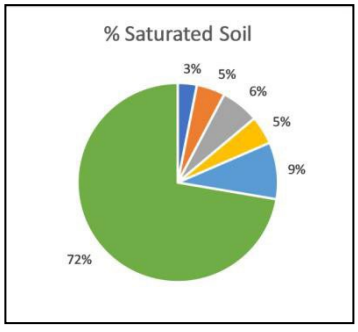
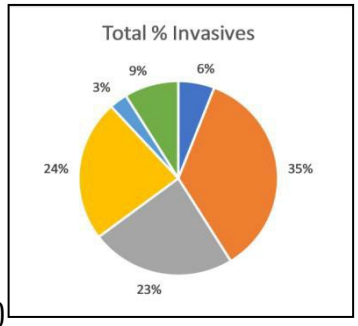
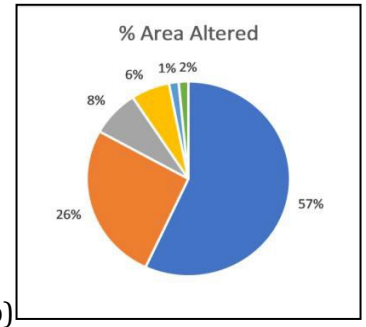
(c) 

Figure 14. Mean percent of tall woody plant basal area (a), herbaceous vegetation basal area (nesting habitat) (b), and saturated soil (c) coverage estimated within randomly placed 4m x 4 m plots across 50 sites. Percentage categories are 0 (dark blue), ≤10 (orange), 11–25 (gray), 26–40 (yellow), 41–60 (light blue), and >60 (green).

(a) 

(b) 

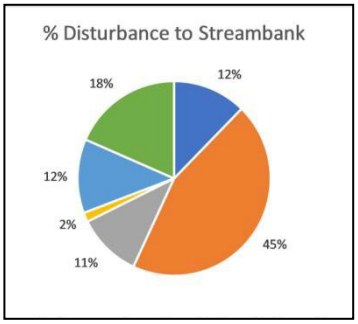
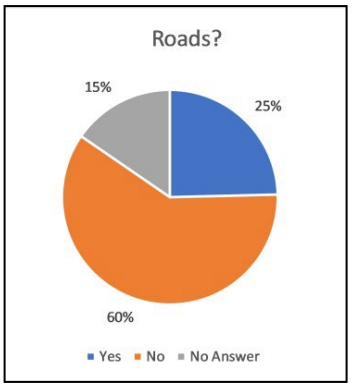
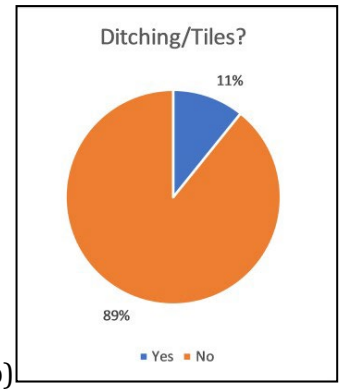
(c) 

Figure 15. Mean percent of invasive plant coverage (a), altered hydrology (b), and disturbance to the streambank (c) estimated within the entire core habitat across 50 sites. Percentage categories for (a) and (b) are 0 (dark blue), ≤10 (orange), 11–25 (gray), 26–40 (yellow), 41–60 (light blue), and >60 (green). Percentage categories for (c) are no stream (dark blue), 0 (orange), ≤40 (gray), 41–60 (yellow), 61–80 (light blue), and >80 (green).

(a) 

(b) 

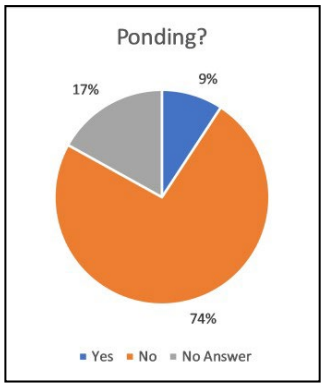
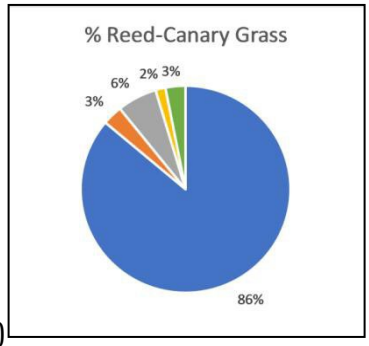
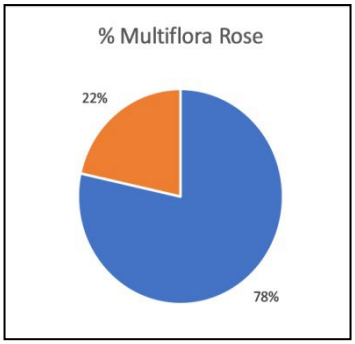
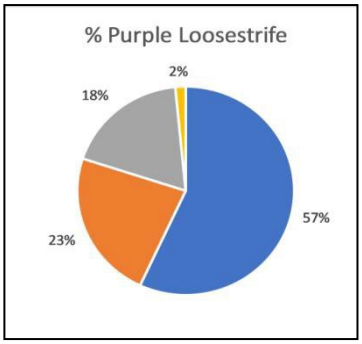
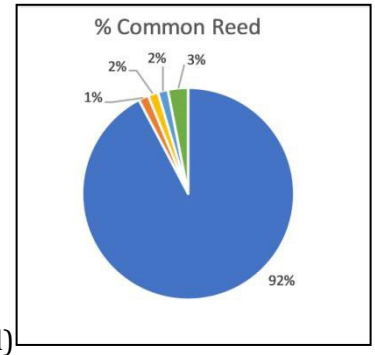
(c) 

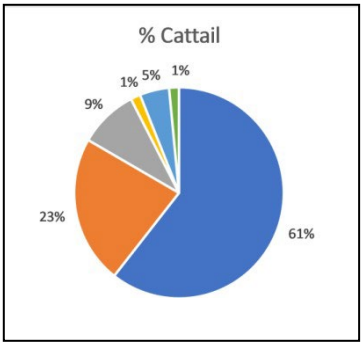
Figure 16. Mean percent of sites with disturbance due to roads (a), ditching/drain tiles (b), and ponding (c) estimated within the entire core habitat across 50 sites.

(a) 

(b) 

(c) 

(d) 

(e) 

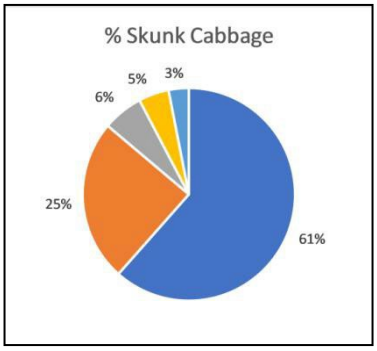
(f) 

Figure 17. Mean percent of Reed Canarygrass (*Phalaris arundinacea*) (a), Multiflora Rose (*Rosa multiflora*) (b), Purple Loosestrife (*Lythrum salicaria*) (c), Common Reed (*Phragmites*)(d), Cattail (*Typha*) (e) and Skunk Cabbage (*Symplocarpu foetidus*) (f) estimated within randomly placed 4m x 4 m plots across 50 sites. Percentage categories are 0 (dark blue), ≤10 (orange), 11–25 (gray), 26–40 (yellow), 41–60 (light blue), and >60 (green).

Most of the plant coverage estimated in Fig. 17 are of non-native invasive plants. Cattail (*Typha spp.*) and Skunk Cabbage (*Symplocarpu foetidus*) are thought to be invasive native plants at some Bog Turtle sites. This is likely due to alterations to water and sediment chemistry from development, agriculture and other anthropogenic stressors on the habitat.

Targeted Sampling

There are too few sites with pre- and post-habitat management surveys to be able to evaluate the data at this point. More time and additional sampling events as well as additional sampling sites are needed.

4.2.7. CREATE A STANDARDIZED REGIONAL DATABASE

Introduction

A regional approach to data management is needed to better evaluate the status of the species during USFWS 5-year reviews. Such an approach includes standardization of terminology, database fields, and database attributes among all 7 states where the Bog Turtle is present in the Northern range. Definitions for core habitat, population and metapopulation can be found in the list of definitions at the beginning of this document (Section ii). Utilizing a standardized approach and compiling data within a centralized database will be an extremely powerful tool for future research objectives, such as determining the most effective habitat management techniques and a Bog Turtle age at maturation for different geographic regions.

Goal:

To create and populate a standardized multi-state database to assist with current and future status assessments of Bog Turtle Populations throughout the Northern range and for regional consistency in data collection.

Core Habitat Mapping

Each state used the following mapping guidelines to delineate core habitat polygons in ArcGIS for known Bog Turtle locations in their respective state.

Linking Distance:

- Combine all contiguous suitable wetland habitats where turtle observations occur, stopping at any major barriers to movement.
- For turtle observations not within 30 m of suitable habitat (e.g., roadside observation) the observation should not be mapped, unless it is known where the turtle originated from or was destined.
- Potential habitat would be mapped the same way as core habitat, but given a separate designation (i.e., potential core habitat) in the database.

Habitat to Include:

- Areas known to be important to and used by the population (based on turtle data).
- Wet meadows, fens, shallow emergent marshes, and bogs. Also include adjacent wetlands such as shrub wetland and/or wooded wetlands (e.g., red maple swamps) up to 30 m from these open canopy wetland types and beyond for areas known (or thought) to be used based on field data and best professional judgment.
- Adjacent upland habitat* known or thought to be used based on field data.
- Areas of light agriculture (i.e., pastures, hayfields) that are wet may be included if the area is known to be used or may be used by turtles.
- Residential lawns if wet and known to be used or may be used by turtles.
- While roads are not considered habitat they should be included in the core habitat polygons unless they are considered a barrier (described below) or on the edge of the polygon.

*Upland habitat is defined here as non-wetland habitat.

Habitat to exclude:

- Residential, commercial and industrial development.
- Large open water bodies unless known to be used.
- Upland habitat more than 30 m from suitable habitat unless known to be used by turtles.
- Agricultural lands that are heavily used for row crops and not known to be used and/or wet.
- Major Barriers (described below).

Major Barriers:

- A frequently used 2-lane road is considered a major barrier separating core habitats within a population. Also, if two or more 2-lane state roads are present between core habitat patches combined they are considered a barrier.
- Any 4 lane roadway designated as a state highway or interstate highway is considered a barrier, unless turtles are known to use a box culvert or a bridge between the core habitat

patches. The MAF/TIGER GIS roads data (Interstate Highways=S1100, State and US Highways=S1200) or equivalent state GIS data can be used as a guide.
- Railways with intact rails (active or inactive) are considered a barrier.
- Man-made dams or impoundments are considered a barrier.
- Un-traversable terrain (e.g., steep cliff).

Population (EO) Mapping

Each state used the following mapping guidelines to identify which core habitats should be grouped together as a single population for known Bog Turtle locations in their respective state.

Linking Distance:

- Connect core habitat patches within 300 m of each other with no major barriers between.

Major Barriers:

- High-density residential, commercial, or industrial development areas lacking wetland for more than 30 meters.
- Any 4 lane roadway designated as a state highway or interstate highway without a box culvert or a bridge between the core habitat patches is considered a barrier.
- A 2-lane road (including local roads) is not considered a major barrier. However, if two or more 2-lane state roads are present between core habitat patches combined they are considered a barrier.
- Railways with intact rails (active or inactive) are considered a barrier.
- Man-made dams or impoundments and large open water bodies (> 5 ha), but not the undeveloped and low density developed wetland edges.
- Un-traversable terrain (e.g., steep cliff).

Metapopulation (EO) Mapping

Each state used the following guidelines to determine which populations are to be grouped together as a single metapopulation.

Linking Distance:

- Combine observations/sites within 3 km across continuous or nearly continuous wetland.
- Combine observations/sites within 2 km across a mixed upland/wetland matrix.
- Combine observations/sites within 1.5 km across continuous or nearly continuous upland.

Major Barriers:

- High-density residential, commercial, or industrial development areas lacking wetland for more than 30 meters.
- Any 4 lane roadway designated as a state highway or interstate highway without a box culvert or a bridge between the core habitat patches is considered a barrier.
- A 2-lane road (including local roads) is not considered a major barrier. However, if two or more 2-lane state roads are present between core habitat patches combined they are considered a barrier.

- Railways with intact rails (active or inactive) are considered a barrier.
- Streams with white water (rapids or fast moving) for more than 0.25 km stretch of stream between sites are considered a barrier (includes patchy or sporadic rapids).
- Un-traversable terrain (e.g., steep cliff).

Database Design, Fields, and Domains

A geospatial database was developed by Herb Bergquist and Blake Massey of USFWS in collaboration with the state leads, the USFWS regional coordinator, and with assistance from the Mid-Atlantic Center for Herpetology and Conservation (MACHAC). The database schema that was developed over a series of initial meetings among the Partnership members was aimed at generating a set of data fields that would allow for inclusion of important historical data, current data, and any future research and management needs.

The final database structure consists of 16 feature classes with 50 domains (allowable values for a field), and a set of underlying spatial and attribute-based relationships among features (Fig. 18). 'Administration and Biological Boundaries' feature classes are used across states, but all other feature classes are duplicated for each state. We used ArcGIS Diagrammer to produce an XML schema of the database feature classes and relationships, the program R to replicate the structure for each state, and Python to load the entire schema into an ESRI ArcServer Geodatabase. Partner states entered their existing data into Excel worksheets and worked with the USFWS team to match tabular records with geospatial data. We used the program R to modify and update the legacy data to conform with the schema and Python to convert the final data into an ArcGIS format.

Each state's legacy data was uploaded to ArcGIS Online (AGOL) in state-specific, user-access controlled sites. This platform allows for a secure, centralized database with interfaces including online maps, customized applications, and synchronization with desktop ArcGIS programs. This system assures consistent information within and among states.

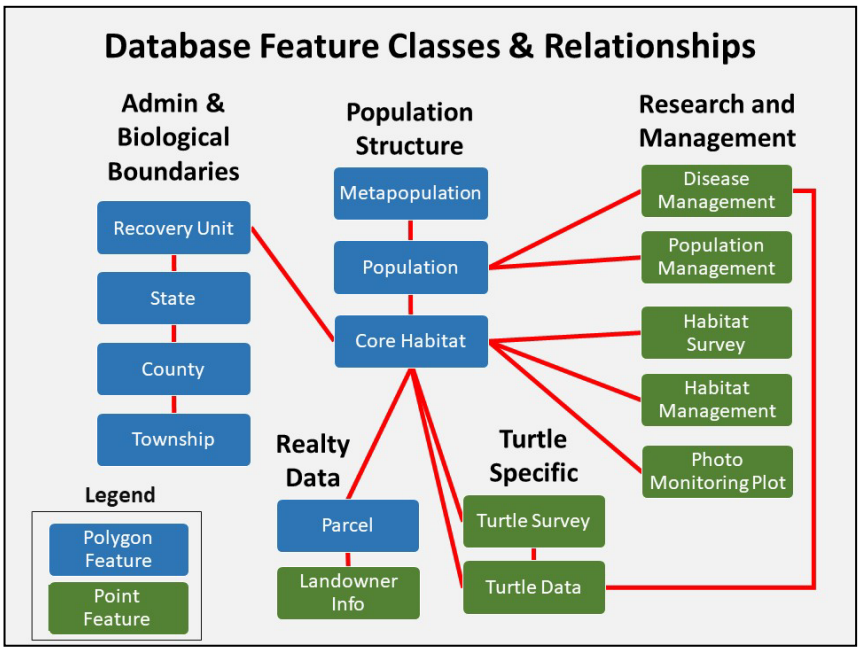


Figure 18. The general database structure of the Regional Bog Turtle database showing the general categories of the feature classes and their relationships (red lines). The relationships indicated that data from one feature class can be queried based on a related attribute field in another feature class (e.g., populations have multiple related core habitats, a 1-to-many relationship). All features are spatially-explicit points or polygons.

Data Entry

Biologists have two options for appending research and management field data to the database: customized Excel worksheets or ESRI Survey123 forms (Fig. 19). Each state's Survey123 forms allow users to collect data in the field on a mobile device (or a desktop computer) via electronic forms that automatically validate input data, calculate survey times, and record GPS locations. Data entered in the Excel worksheets or Survey123 is transferred to a state's main data layers using a custom Python toolbox. This workflow allows records to be joined to pre-existing spatial data, such as core habitat centroids, or as new point locations. AGOL data layers can be viewed and edited online in custom maps or downloaded for local editing in ArcGIS Desktop or Pro. Data in maps can also be viewed and edited on mobile devices using the ESRI Collector app.

Roles and Data Use

Roles

USFWS – Created the database platform, worked with the state leads to identify the fields and domains to be contained with the database, and set up access to a list of individuals permitted to view and modify the data. The USFWS will continue to manage access to the database, create backups, and modify (as needed) the database schema. They will identify how biologist's research and management needs may be addressed through AGOL applications and mapping tools as they become available. They will also assist with training state leads to use the database and with the development of research or status assessment queries.

State Leads – Determine who is permitted to access their state's data. Reviews the legacy data initially imported in the database to determine everything is correct and fixes any errors they find. They are to be in charge of importing any new data collected as of January 2019 and determining specific workflow plans for entering their state's data.

Data Use

USFWS – May use data in the regional database to perform periodic assessments of the species' status. Other uses of the data will require permission by the appropriate state leads.

State Leads – The states retain data ownership and may use their state's data as needed.

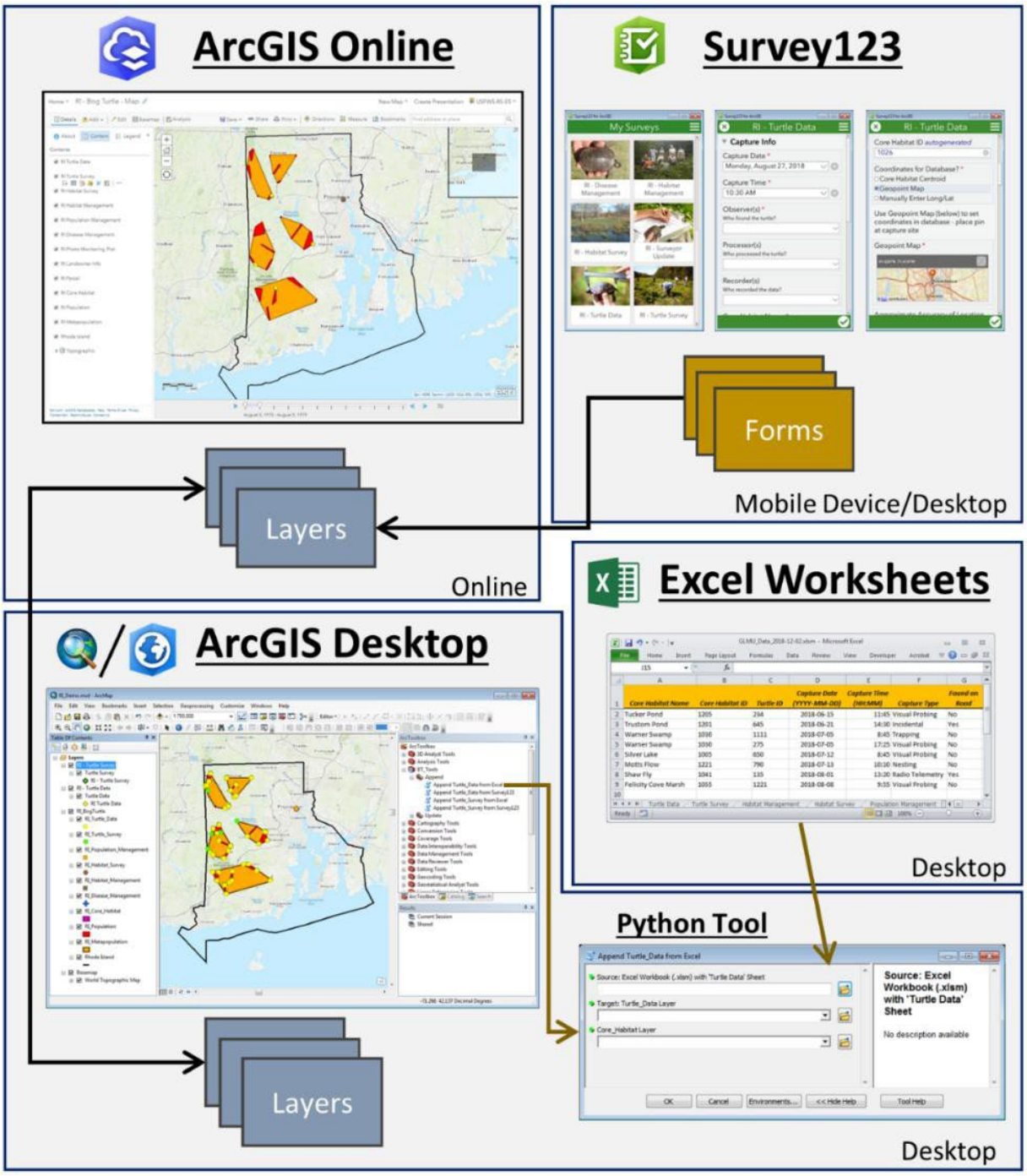


Figure 19. This shows the general interface of the database using data randomly generated for Rhode Island (as a proxy state) for demonstration purposes. Data can be uploaded by use of an Excel Worksheet file or using Survey123 in the field or on a desktop machine. All geospatial and tabular data is stored in a secure location using ArcGIS Online.

4.2.8. DEVELOP A COMMUNICATION STRATEGY

Introduction

This communication strategy was developed by the Mid-Atlantic Center for Herpetology and Conservation (MACHAC) with input from state leads and the USFWS regional Bog Turtle recovery coordinator. The purpose of this communication strategy is to provide talking points and approaches for connecting with particular audiences about the federally-threatened Bog Turtle.

Target Audiences

The Press/General Audience

Key Messages

The Bog Turtle is the rarest turtle in the United States and requires open, grassy wetland habitats, such as fens or wet meadows. Many of these wetlands have been destroyed or degraded by humans. Bog Turtles need these open wetlands to incubate their eggs, which they lay in sedge and grass clumps. Luckily, in some cases, it is possible to improve the habitat conditions with management, which we hope can eventually recover the species.

- The Bog Turtle is one of the most endangered freshwater turtle in the U.S.
- Bog Turtles are habitat specialists, requiring open-canopy fen or wet meadow habitats for reproduction and a healthy population.
- Habitat loss due to succession (when open, sunny wetlands transition to forested wetlands over time) and development are the species' greatest threats.
- Habitat management can improve many Bog Turtle wetlands and increase native populations.
- Bog Turtles are important because the species has a natural role in the ecosystem, like all other wild animals.
- Bog Turtles are important to humans because the habitats they live in are also headwater wetlands. Headwater wetlands are places where groundwater emerges in the form of springs**,** which flow to streams and rivers. These springs tend to be clean, clear, cold, and full of oxygen and minerals**,** which are all important for human welfare as well (e.g. clean drinking water and healthy fish populations).
- Protecting wetland, in general, helps to abate the effects of flooding.
- Extinction is forever.

Continued management of Bog Turtle wetlands is needed due to man-made disturbances (anthropogenic influences), e.g., increased levels of nitrogen in the water and/or soil from agriculture that degrade these stable wetland systems and stimulate ecological succession by providing an unnatural nutrient load, allowing trees and shrubs to grow quickly.

- Fen habitat was historically very stable open-canopy habitat until shortly after the industrial age when woody and invasive plants began to take over these unique habitats, turning them into scrub-shrub or forested wetlands. In part these wetlands were historically maintained by large ungulates that grazed in these habitats. In addition, normal fire regimes have been suppressed.

- Ecological succession of open-canopy habitats to forest lowers the water table due to increased water intake of the woody plants, and decreases sun exposure of nesting areas, thereby decreasing hatching success.
- Woody and invasive plants can be controlled by mechanical removal of woody plants, herbicide treatments, prescribed fire and/or grazing by livestock such as goats and cattle.

Strategies and Tactics

- Increase awareness of the Bog Turtle through press releases and education/outreach programs. Education should be for both children and adults. Children are a very effective audience, as they often bring knowledge and concern home to share with parents. Confiscated Bog Turtles could be used to engage the audience.
- Develop a curriculum for elementary and middle schools.
- Develop and foster positive working relationships with all potential partners and audiences.
- Highlight success stories of partnerships between various audiences. Speak generally about successes involving financial transactions with landowners. Don't mention easement payment amounts or fee-simple amounts in print as this may incite individuals that do not share favorable views of conservation. Simple statements like "financial assistance or financial compensation is available to eligible landowners" should suffice. Additionally, caution should be used when identifying landowners, as poachers may use that information for the illegal collection of Bog Turtles.
- Use social media to build support (e.g., create a Facebook page).
- Creation and distribution of general information on the Bog Turtle, conservation partnerships, and programs available to assist partners.
- Compile existing Bog Turtle educational materials (north and south) into one location and have templates that allow for some modification to make the document(s) more locally relevant.
- When possible encourage media representatives to go into the field with researchers. There is a sense of excitement when seeing rare animals for the first time, particularly one that has so much secrecy surrounding it. Prepare them to get muddy and wet beforehand and to bring a change of clothes. MAKE SURE THAT THE REPORTER KNOWS TO KEEP SITES CONFIDENTIAL DUE TO POACHING THREATS.

Residential and Agricultural Landowners

Key Messages

Farmers/livestock producers and private landowners are critically important partners and play an essential role in the recovery efforts for the Bog Turtle.

- The majority of extant Bog Turtle populations are on privately owned lands.
- Habitat improvement can benefit other wildlife species such as trout, woodcock, and deer.
- Unlike many endangered or rare species in the news, certain farming activities like livestock grazing or conservation haying can actually be helpful to the Bog Turtle.

Low-density livestock grazing can be a compatible land-use benefiting Bog Turtles and their habitat.

- Grazing of Bog Turtle wetlands with livestock can be beneficial to Bog Turtle populations, by controlling the growth of woody and invasive plants.
- Improving habitat quality on your property is a great legacy for future generations. In some cases, this involves only minor modification of your current land management practices, or even no changes at all.
- Incentive programs exist to provide financial support to landowners for habitat management such as:
    - USDA Natural Resource Conservation Service programs
    - Partners for Fish and Wildlife
    - National Fish and Wildlife Foundation
    - Your local land trust or conservancy
- Bog Turtle habitat management specialists will assist landowners with development of a habitat management plan and in some cases will actually perform the restoration work.

<u>Strategies and Tactics</u>

- Develop, foster, and maintain positive working relationships with private landowners.
- First impressions are extremely important. When possible, use a male and female team when first approaching landowners. Each landowner will be different and may interact better with a male or female or one personality type than another. Working in teams will increase the possibility of a successful first impression. Please note, that the male/female team dynamic is particularly important in some areas of the Bog Turtle range. Based on past experience, married conservative Anabaptist (Amish and some conservative Mennonite sects) men may be reluctant to let an all-male survey team into wetlands they own if it is near their residence and they will not be home. Additionally, married Anabaptist women have refused access to all-female teams into wetlands they own if it is near their residence. Use of mixed-gender survey teams alleviated these issues. Conservative Anabaptists will also sometimes request modest dress when entering their properties. Of importance, please note that many Anabaptist landowners will not request this modest dress and simply not allow future access when requested in order to avoid conflict. Long-sleeve shirts and pants are strongly suggested, regardless of the genders of the team members. Some of the larger societal issues and advances hashed out in the larger public and media arenas may not be apparent when entering these older order Anabaptist regions. Keep in mind you are a guest and not mandated access to private properties. As long as Bog Turtle conservationists are safe from physical harm and other abuses, keep your personal opinions private. Leave the politics at home and remain culturally-sensitive, regardless of personal beliefs. The bottom line is, if access to a site is lost, the opportunity to help Bog Turtle conservation is lost.
- Collaborate with Natural Resource Conservation Service (NRCS) or land trust staff to approach landowners, particularly ones that already have a good working relationship with the landowner.
    - Update the existing NRCS outreach materials
- Focus on potential benefits to the landowner, particularly economic incentives and benefits for sportsmen and future generations.
- Address the disconnection between government and landowners by use of fact sheets or other general public outreach materials.
- Develop additional approaches to engage landowners.
- Produce talking points to highlight how agriculture practices can benefit the Bog Turtle.

- Develop a landowner advocacy group, as examples of positive working relationships. Find landowners willing to talk with other landowners to share advice and provide insights on their experience. Neighbors are often very helpful for messaging on a local-level as they are often familiar with their neighboring landowners.
- Develop and maintain relationships with agricultural groups such as state agricultural agencies, conservation district associations, and the Farm Bureau. Provide literature or other offer advice to these often over-worked groups. Help them help landowners and the resource.

Commercial, Energy, Transportation, and Industrial Landowners

Key Messages

Management and stewardship of Commercial, Energy and Industrial property can leave a positive impression on the public and thereby benefit businesses.

- Public sentiment affects profits.
- Stewardship is good public relations – it encourages community support for their business or company.
- These types of landowners would set a good example and encourage other businesses to become land stewards.

Proactively protecting and managing habitat for the Bog Turtle may reduce regulatory conflicts in the future.

- Avoiding disturbance and improving habitat in key locations will reduce project conflicts, and potentially avoid delays in project timelines.
- Land protection and support of Bog Turtle conservation can help offset field impacts as a mitigation measure.

Strategies and Tactics

- Build partnerships with Natural Resource biologists within these organizations.
- Provide staff trainings on Bog Turtles and their habitat.

Conservation Advocates and Land Trusts

Key Messages

Protecting and managing habitat for the Bog Turtle can make a difference for the recovery of the species, increase species diversity, protect headwaters, and increase public support.

- Funding sources are available to manage habitat for Bog Turtles.
- Habitat management could provide a learning opportunity to teach the benefits of habitat diversity and topics such as habitat succession.

- Conservation organizations that protect and manage habitat or provide grants for these activities are essential for accomplishing conservation strategies to recover the Bog Turtle.

Strategies and Tactics

- Create and maintain positive working relationships with land protection specialists and Biologists in other organizations.
- Collaborate with the American Fish and Wildlife Association on the continuation and enhancement of conservation practices covered in the Farm Bill.
- Develop a multi-agency partnership with conservation organizations working in Washington D.C.
- Provide presentations and staff trainings to distribute information on the conservation issues Bog Turtles face and ways conservation advocates can help contribute to the recovery of the Bog Turtle.

Natural Resource Professionals

Key Messages

Protecting and managing open-canopy fen or wet meadow habitat will improve conditions necessary for recovery of the Bog Turtle and provide habitat for a greater diversity of wildlife.

- Open-canopy wet meadow habitat is critical for maintaining a healthy Bog Turtle population.
- Bog Turtle eggs require sunlight during the incubation period, throughout the day, for development.
- Creating and maintaining a diversity of habitat types will increase wildlife diversity.
- "Early successional habitat" is an important concept and terminology when discussing Bog Turtle habitats.
- Bog Turtle habitat management experts are available to assist with the development of habitat management plans.
- Funding is available to support habitat management for Bog Turtles (see section 4.2.1) for potential funding sources).

Strategies and Tactics

- Network with Natural Resource biologists in all organizations such as federal and state wildlife agencies (e.g., foresters, park rangers), Department of Transportation, and Department of Defense installations. For example, communicate that riparian tree plantings are not typically beneficial in Bog Turtle habitat.
- Perform staff trainings on the conservation issues and ways to help conserve the Bog Turtle.
- Provide guidance on available resources.
- Identify and promote information on other species that will benefit from habitat protection and management of Bog Turtle wetlands.

Municipalities

Key Messages

Management and stewardship of municipal property can leave a positive impression on the public.

- Public sentiment is imporant.
- Stewardship is good public relations and it encourages community support.
- Stewardship actions would set a good example and encourage other landowners to become land stewards.
- Protecting and managing open-canopy fen or wet meadow habitat will improve conditions necessary for recovery of the Bog Turtle and provide habitat for a greater diversity of wildlife.
- Maintaining connectivity between shallow wetlands (wet meadows/fens) is important for maintaining health Bog Turtle populations.
- Protecting wetlands helps to abate the effects of flooding.

Proactively protecting and managing habitat for the Bog Turtle may reduce regulatory conflicts in the future.

- Avoiding disturbance and improving habitat in key locations will reduce project conflicts, and potentially avoid delays in project timelines.
- Land protection and support of Bog Turtle conservation can help offset field impacts as a mitigation measure.

Strategies and Tactics

- Develop educational materials to describe the habitat needs of Bog Turtles.
- Outreach to train staff on issues related to Bog Turtles.
- Provide presentations and staff trainings on regulatory review and incorporation of Bog Turtle avoidance measures for development projects…or something like this.
- Build partnerships with Natural Resource biologists.
- Provide staff trainings on Bog Turtles and their habitat.

Elected Officials – U.S. Congress

Key Messages

Governmental and non-governmental organizations are working together to conserve and manage habitat for our rarest and smallest turtle in the U.S.

- Our multi-state efforts have built successful and strong partnerships among many organizations, and provide a regional approach to conserving the Bog Turtle.
- Habitat protection and management have great potential to recover the species.
- Protection of Bog Turtles and their habitat also protects drinking water and fish and game habitats (sportsmen's issues are big topics in some congressional districts).

- Highlight the role farmers/livestock producers and rural residents can play in Bog Turtle protection. Bog Turtle conservation can help maintain the strong rural and agricultural heritages of the regions in which they are found.

Strategies and Tactics

- Use success stories to promote regional conservation work and partnerships.
- Advocate for funding to support our conservation strategies.
- Highlight the value of maintaining open-canopy wetland habitat.
- Visit Capitol Hill to promote our work.
- Offer to bring legislators out into the field to see Bog Turtles first hand.

4.2.9. MONITOR PROGRESS OF CONSERVATION ACTIONS

To track progress of recovery actions, a list of performance metrics should be developed and updated yearly by state and federal partners. This list would include such measures as number of populations where management has occurred, number of acres managed, number of populations surveyed for the regional population monitoring program, etc.

4.2.10. DEVELOP A CLIMATE CHANGE STRATEGY

Existing climate models should be evaluated as part of the Species Status Assessment (SSA). Determine what models may already exist (e.g., Schlesinger et al. 2011), and if needed, develop a Bog Turtle fen/wet meadow habitat-specific climate model to predict effects on these habitats and this species. Climate change models for the northeastern U.S. suggest that we will have increased frequency and severity of rain events, particularly during the spring and summer months (e.g., Frumhoff et al. 2007, Hayhoe et al. 2008). This would affect Bog Turtle nesting ecology with increased water levels, that may drown eggs, and cloudier conditions which may increase the time needed for egg development. In addition, an increase in severity of storm events may cause habitat disturbance from increased water levels and water flow velocity through the wetland system, which could change the vegetation community composition and displace mats of shallow-rooted vegetation, respectively.

- It is largely unknown how well Bog Turtles will respond to climate change.
- Bog Turtle populations that are in tidally-influenced areas could experience sea level rise over time.
- Increased precipitation could cause increased water tables and more flash flooding. Some populations may already be affected.
- Longer growing seasons may result which may be beneficial, increasing nest success and general health of the turtles.
- Invasive and woody plants will benefit more from increased carbon in the atmosphere, which could have adverse effects by outcompeting native herbaceous plants and cause succession of wetland.

4.2.11. COMPILE A BIBLIOGRAPHY OF BOG TURTLE LITERATURE

A bibliography of Bog Turtle literature would be useful for researchers and conservation biologists to help uncover information related to the species' biology, habitat needs, habitat management, etc. A draft bibliography can be found in Appendix N.

4.3. HABITAT PROTECTION STRATEGIES

State and federal agencies and their conservation partners have protected or partially protected 176 of 500 extant population (196 core habitats) to date; however, much work is still needed to preserve these populations and additional areas. Only 67 of these populations have full and permanent protection of the core habitat and fewer (49 populations) have full permanent protection of both the core habitat and the 300-ft buffer (which is critical supporting habitat that may include essential habitat for dispersal, aestivation, and hydrological inputs). Funding programs to support habitat protection are of utmost importance and have been key to our current successes. In particular, the Wetlands Reserve Easements (WRE: formerly WRP) of the NRCS and National Fish and Wildlife Foundation (NFWF) grant programs, as well as Section 6 Recovery Land Acquisition Grant from USFWS to protect habitat have been invaluable and the USFWS's Partners for Fish and Wildlife Program that offers 10-yr agreements to landowners for habitat restoration. Some local land trusts have also been actively protecting Bog Turtle Habitat.

Protection of core habitat and important supporting landscape areas is not only vital to protect populations from development, but also critical for allowing access to manage the habitat for the Bog Turtle. Partners should use the Recovery Unit Action Plans to determine priority populations for such habitat protection actions. It is important to note that land trust and agricultural easements are typically geared to separate development rights only and rarely maintain a mechanism for specific management actions that are beneficial for Bog Turtles. In many instances, the documented presence of Bog Turtles in the past on an easement property has not ensured access for more even the most superficial of short-duration investigations, let alone presence/probable absence surveys, population studies, and habitat management actions. Working with land trusts and agricultural conservation programs to update their easement language and plan in concert with Bog Turtle conservation entities should be considered a priority.

4.3.1. CONNECT FRAGMENTED HABITAT

Roads and development were both identified by experts as top threats to Bog Turtle populations. Connecting fragmented habitat was also listed in the top 10 limiting factors to recovery of the Bog Turtle. To address these threats, habitat should be protected and managed within the important habitat corridors described in section 4.2.4. In the future this should be taken a step further to develop a list of barriers (e.g. culverts) to be upgraded to allow passage. Partners should find ways to work with their state's Department of Transportation and local municipalities to improve connectivity in these areas. Road passageway guidelines are also needed to assure work is done with least amount of disturbance to turtles and to provide a turtle passageway. A working group of the Northeast Partners in Amphibian and Reptile Conservation has been working on a turtle passageway guidance document that could be modified to specifically address Bog Turtle

conservation measures. Research is needed to better understand the appropriate size and conditions of passageways for optimal use by turtles. Retrofitting roads for turtle passageways is typically cost-prohibitive as a stand-alone action item with standard construction techniques, so it is essential that planning occur on the front-end of road construction projects, whether that be novel projects or re-construction projects on existing roadways.

4.3.2. ENGAGE IN LANDOWNER OUTREACH FOR HABITAT PROTECTION

The majority of Bog Turtle populations are on private lands, making landowner relations and cooperation extremely important to the recovery of this species. Partners should refer to the Communication Strategy outlined in section 4.2.8 above for talking points and strategies when approaching landowners. For example neighboring partners (i.e., landowners or local land trusts) maybe be able to assist in making connections with landowners. The Recovery Unit Action Plans provide a prioritized list of populations of greatest importance for habitat protection. Working with NRCS, state, and local land agents can be beneficial in providing landowners with guidance and options. In order to ensure smooth working relationships with landowners, repeated contacts by multiple personnel with differing goals should be discouraged and points of contact established by the agencies.

4.3.3. ENGAGE IN MITIGATION BANKING TO PROTECT HABITAT

USFWS is in the process of developing a credit-based system to allow mitigation banking. Mitigation banking could funnel monies towards protection and management of the most robust extant populations, as opposed to protecting declining local populations affected by an environmental review project. Oversight will be important to assure conservation of highest priority sites are benefiting. This would primarily be important when turtle density and habitat restoration potential to recover the species are low in the affected population. It also provides a more streamlined review process for developers. This plan should be created collaboratively and vetted by conservation partners and researchers prior to the final drafting.

4.3.4. DEVELOP A STEWARDSHIP PROGRAM(S)

Stewardship programs may be useful in some states. In such cases, population stewards should help identify ways to protect the habitat, provide oversight for habitat management actions, watch over the site to thwart any illegal activities, and build good working relationships with local landowners. Stewards could take on some of these roles. Stewards must also be vetted carefully by the agencies to avoid potential conflicts of interest. All data collected and information garnered should be provided, in writing, to the state lead on an annual basis. Any habitat management work must be planned out in writing and submitted to state and federal agency leads prior to execution.

4.3.5. CONDUCT STAFF TRAININGS

Staff training for local, state, and federal government agencies, and non-governmental conservation organizations can help raise awareness of and protect Bog Turtles and their habitat. These partners can help discover and report new sites. Bog Turtle experts can provide a description of potential habitat, information about whom to contact if they find potential Bog Turtle habitat or a Bog Turtle, and best management practices for Bog Turtle habitat. These trainings should not be considered a surrogate for the expert opinions of agency and professional Bog Turtle surveyors.

4.4. HABITAT MANAGEMENT STRATEGIES

Specific habitat management techniques of greatest importance to achieve recovery of the Bog Turtle are listed below. Partners should refer to the Recovery Unit Action Plans to identify populations to prioritize for management practices. Conservation partners have managed habitat for a minimum of 56 populations (60 core habitats), in some cases management involved multiple treatments over multiple years. While this is considerable progress, the state's species leads have identified management needs at 261 populations. In some cases this would involve extensive work such as restoration of the hydrology at the sites and may not be practical or realistic. However, in most cases simply treating woody and invasive plants can dramatically improve the habitat conditions and benefit the local population. Agencies are encouraged to create a matrix for prioritization of habitat management sites.

4.4.1. CONDUCT SUCCESSION/INVASIVE PLANT MANAGEMENT

Succession and invasive plants are major threats for the Bog Turtle, second only to development based on an expert survey to rank threats. Maintaining or increasing native plant variability at sites will increase wildlife diversity, an added benefit beyond the importance of habitat management for Bog Turtles. Controlling woody and invasive plants is a tangible action that may have measurable benefits to the species. There was strong agreement among Bog Turtle experts that habitat management practices need to continue. This will require a long-term commitment since multiple applications through multiple years are often needed and periodic re-treatments will often be necessary. The NRCS has been an important partner and funding resource for this work. Unfortunately, NRCS currently only pays for one-time treatments and has had challenges with implementing grazing in some states, though this strategy has recently (2018) been altered to incorporate multiple-year treatments in Pennsylvania. Partners should work with NRCS to address these gaps, to achieve greater success in our habitat management efforts. There also seems to be a need for additional licensed herbicide applicators to do this work. Partners should refer to the Recovery Unit Action Plans to identify priority populations for succession/invasive plant management.

Herbicide and grazing are important tools for controlling succession and invasive plans. Chemically treating the leaves or stems of woody plants (after mechanically cutting them) is the only way to prevent re-sprouting of these woody plants in some cases, and may be the most practical way to control other species like Reed Canarygrass. Grazing may be an efficient and effective long-term strategy to control woody and invasive plants. However, additional research is needed to document

the effects of grazers on Bog Turtle habitat and populations (see Section 4.5.1). If this research provides evidence of a positive influence on Bog Turtle habitat, we hope that funding agencies will continue to fund these projects and/or recognize it as a compatible and important management tool for the recovery of the Bog Turtle. Grazing may not be an appropriate tool for all sites. For example, some wetlands are too small to accommodate grazing animals and placing grazers on public lands could pose logistical challenges.

4.4.2. RESTORE HYDROLOGY

Hydrology is one of the key characteristics of Bog Turtle Habitat and has been altered to some degree for 237 populations (268 core habitats). Perennially saturated mucky soils with small pools of water and rivulets are important habitat features needed to sustain a Bog Turtle population (Fega 2013, Roos and Maret 2018). The hydrological characteristics that make Bog Turtle sites suitable are poorly understood and the topic appears to be quite complicated. Prior to the establishment of federal wetland laws, many fen/wet meadow habitats had been ditched for agriculture, roads, and residential or commercial development. Many habitats were also turned into ponds for livestock, water sources for fighting structural fires, or other human use (e.g., fishing or swimming). At a few sites, habitat management has been conducted to remove pond berms, restoring a more natural flow of water through the system and converting the habitat back to wet meadow or scrub-shrub wetland that is more ideal for Bog Turtles. Restoration of hydrology can be challenging and research is needed to better understand how to best restore hydrology to Bog Turtle habitats.

4.4.3. ENGAGE IN LANDOWNER OUTREACH FOR HABITAT MANAGEMENT

Bog Turtle populations are often on private lands, so landowner outreach is extremely important. Partners should refer to the Communication Strategy outlined in section 4.2.8 above for talking points and strategies when approaching landowners. For example, neighboring partners (i.e., landowners or local land trusts) maybe be able to help make connections with landowners. Working with NRCS, state and local land agents can be beneficial in providing landowners with guidance and options. In order to ensure smooth working relationships with landowners, repeated contacts by multiple personnel with differing goals should be discouraged and points of contact established by the agencies.

4.4.4. RESTORE RELIC FENS

Relic fen restoration was ranked low as an effective conservation strategy for the Bog Turtle and therefore, should primarily be done opportunistically. Restoration and management of known Bog Turtle sites should be prioritized, but partners should also take advantage of stream restoration projects and projects that benefit other species to restore habitats that may have been occupied by Bog Turtles in the past. Geomorphology research suggests that the primary cause of fen and wet meadow habitat loss in the northeast may have been due to milldams that were present between the 17–19th centuries (Browne et al. 2013). Milldams would have flooded the fen and buried it in a layer of slack-water sediment. This may be important for understanding what methods to use and

how to target sites for restoring relic fens. Partners could identify locations with legacy soils, as these could be prime target sites for restoration. Potential partners include USGS and the Chesapeake Foundation is a possible funding source. In order to avoid direct conflicts that result in the degradation or destruction of potential Bog Turtle habitats, as has happened in the past, it is important that a process is developed to ensure collaboration.

4.5. RESEARCH NEEDS

It is recommended that the list of research needs below is distributed to academics to encourage graduate student projects to investigate these topics. With so many research needs it is also recommended that researchers are directed to the prioritization table in Section 4.1 (Table 3).

4.5.1. RESEARCH THE EFFECTIVENESS OF HABITAT MANAGEMENT

Habitat management is one of the primary recovery tools experts are currently using to maintain and improve Bog Turtle populations. Succession and invasive plants are a major threat of the Bog Turtle (USFWS 2001) and methods of control include mechanical removal, herbicide treatment, and/or prescribed grazing. These methods have been in use since the listing of this species; however, information is generally lacking regarding the effectiveness of these measures. Experts in the HH, DE, and SP Recovery Units identified two top priority tasks that should be evaluated, as well as lower priority needs and questions, listed below:

Top Priority Tasks

Monitoring Habitat Pre- and Post-Management

Monitoring vegetation changes to track the results of our habitat management actions is vital to elucidate the effectiveness of various habitat management methodologies. Monitoring has occurred in some cases;, however, a more concerted and standardized effort is needed to objectively evaluate specific habitat management techniques. It is assumed that management that improves or maintains a natural vegetation composition of native species will also improve the turtle population. Below is a list of habitat monitoring actions identified by experts to address this gap:

- Use the Regional Habitat Monitoring protocol (see Section 4.2.6) to evaluate pre-and post-habitat management actions within plots to track changes in habitat structure over time.
- Determine which methods are most effective, efficient, and cost-effective, due to the large number of degraded sites.
    - Evaluate the need to monitor turtle movements at every project site as opposed to monitoring long-term impacts at a few key sites.
        - Evaluating habitat use (including changes over time) will be important to determine success.
    - Investigate the need for vegetation monitoring over multiple times of the year.
- Conduct pre- and post- management monitoring with use of drone aerial photography.
- Map groundwater recharge and supply zones pre- and post-management.
- Enforce Biological Opinion (BO) reporting via NRCS and USFWS.
- Evaluate Arrow 2 EC as a control agent for Reed Canarygrass.

Create an Adaptive Management Framework for Habitat Management Projects

Development of guidelines for habitat management actions would be exceedingly beneficial to land manager and conservation partners. This should include information on which techniques are most effective for control of particular plant species and under varying conditions. For example, biologists typically have experiential knowledge regarding management techniques but currently have no way to preserve and share this information in a standardized manner. Additionally, it is essential that these guidelines be synthesized into an adaptive framework to allow periodic modification because: 1) additional research is needed to understand what methods of habitat management are most effective, 2) new information and techniques are likely to become available over time, and 3) habitat conditions at a given site are constantly changing. Therefore, it is recommended that a guidance document be developed now that can be revised periodically to include new information as it emerges. Below is a list of needed actions for this task:

- Develop a system to track management projects and follow up monitoring results.
- Develop a management handbook with detailed "how to" instructions based on lessons learned by experts for manual control, herbicide, and grazing management actions. This handbook, once drafted, could be inserted into the Conservation Plan.
    - Form a working group to draft this document.
    - This document should include guidance on the effectiveness of various methods and detailed instructions such as times of year for use of specific chemicals.
    - Create a decision tree that synthesizes project outcomes of already complete projects, and use that information to identify cases of "if A, then B."
    - Determine how to measure the success of management projects.
        - Increased nesting success = habitat management success
        - Increased turtle abundance = habitat management success
- Create a framework with action triggers, such as tracking of nest success years and specifying at what point action is needed to improve nesting success.
- Look into data from The Nature Conservancy's "Miradi" program to compile knowledge on what has worked and what has not.
- Use the regional database as a repository for habitat management data. Compile and organize data on management of specific plant species including methods used, outcomes, and future recommendations, into a central location.

Other Habitat Management Research Needs and Questions

<u>Grazing</u>:

Some studies have suggested grazing is beneficial to the maintenance of open-canopy Bog Turtle habitat (Tesauro and Ehrenfeld 2007, Travis et al. 2018). Goats and sheep have been successful in reducing *Phragmites* cover by 50–85%, which in turn increased native herbaceous vegetation (Tesauro 2001, Tesauro end Enhrenfeld 2007). In addition, Tesauro (2001) found that cows decreased Reed Canarygrass and Purple Loosestrife (*Lythrum salicaria*) cover and their hoofprints modified the microhabitat improving hollow-hummock topography. When comparing grazed to ungrazed sites, grazed sites supported higher densities of turtles, including a larger number of juveniles observed (Tesauro and Ehrenfeld 2007). Nests were found more often in grazed than in ungrazed areas of one New York wetland and some turtles used recently grazed areas that they had not used the season prior to grazing. In contrast, another recent study found greater variation in

vegetation between two grazed wetlands compared to differences between grazed and ungrazed wetlands (Roos and Maret 2018). There were some confounding factors in that study including different densities and intensities of grazing between the two grazed sites, concurrent chemical treatment of invasive plants, and a small sample size of sites. One mortality was observed from grazing (stepped on) at one study site in Pennsylvania (Roos and Maret 2018).

Future Directions for Evaluating Effects of Grazing

Tesauro (2001) recommended investigating the following:

- What type of livestock are most effective for controlling particular invasive plants?
- What is the most effective density of livestock per area of wetland?
- Can certain invasive species be eradicated or will livestock grazing have to be used indefinitely? This may be influenced by the length of a seed bank and distance to other sources of the invasive plant.
- Will the plant communities that regenerate once invasive species are controlled be suitable for Bog Turtles?
- Can Purple Loosestrife and *Phragmites* be effectively controlled without over-browsing the remainder of the plant community?

Roos and Maret (2018) recommended investigating the following:

- What effects, both positive and negative, do various invasive plant species have on Bog Turtles? How do these effects vary with plant density, soil type, and environmental conditions?
- How do various grazers (e.g., cattle, goats, sheep) differ in their impacts on invasive wetland plants, wetland hydrology, and Bog Turtles?
- What are the effects of differences in stocking density, frequency and duration of grazing, and the season during which grazing occurs, on invasive wetland plants, wetland hydrology, and Bog Turtles?

<u>Additional Habitat Management Research Needs:</u>

- Investigate other types of herbicide such as imazapyr and triclopyr for habitat management.
    - Determine if other herbicides work as effectively or better then glyphosate for controlling particular plant species.
    - Determine if a lesser volume of chemical spray is needed with imazapyr, triclopyr, or other herbicides in comparison to glyphosate.
- Restore and/or maintain natural hydrology and good water quality.
    - Determine if a relatively un-impacted or restored hydrology, in good condition, reduces or eliminates the need for vegetation management.
    - Determine a comparative hydrological baseline parameter for a given site.
        - What does baseline hydrology look like at our higher quality sites?
        - Map groundwater recharge and supply zones.
- Evaluate and test how to create artificial hibernacula.
- Develop restoration techniques to create artificial hibernacula that turtles use.
- Investigate wetland restoration projects globally to see how we can apply novel methods here in the U.S. (e.g., Lamers at al. 2014).

- Search published and gray literature as well as consulting with experts (e.g., via social media) to identify potential novel restoration methods.

4.5.2. CONDUCT INVENTORY/GAP SURVEYS

Although a considerable effort has been directed toward identifying and describing Bog Turtle distributions since the listing of this species in 1997, new populations are found every year. As a consequence, there is a continued need for inventory and gap surveys to better understand the distribution of the species, and to document and protect previously unknown populations. These surveys are meant to investigate potential habitat to determine if Bog Turtles are present and may also include surveying habitat where a population is considered historical (i.e., no turtle[s] have been observed in 30 years) or habitat is of "Unknown Occupancy" (e.g., sites adjacent to road observations). This would include Phase 1 and Phase 2 survey efforts where possible, as well as opportunistic surveys when site access may be limited. One important consideration is the need to balance time and resources devoted to these surveys with the survey and management needs of known sites, particularly those that ranked as "Good" and "Fair" for population viability.

Priority Locations for Inventory/Gap Surveys Include

- Potential habitat in key areas to build resiliency and connectedness.
    - Habitat between current metapopulations (within important habitat corridors).
    - Habitat within 1.5 km distance of existing "Good" or "Fair" ranked populations.
    - Habitat with "Unknown Occupancy" (e.g., adjacent to a road observation).
    - Habitat along the edge of the Northern population range.
- Populations that scored "2" for populations size in the population viability ranking project, indicating there has been insufficient survey effort to determine the population size. (Typically, there is a single turtle observation from these sites).

Methods to Locate Potential Habitat

- Use geospatial data (e.g., orthoimagery and/or wetlands data), previously developed models, and/or a state's observational data to select wetlands for inventory surveys.
- Use LiDAR methodology for a more refined assessment of wetlands.
- Use drone technology to investigate habitat types in remote areas. This may be particularly used for large protected tracks of wetland complexes.

4.5.3. RESEARCH THE EFFECTS OF AGRICULTURE, PESTICIDES, AND HERBICIDES

Many Bog Turtle populations are on or adjacent to agricultural lands. In fact, grazing may be contributing to the quality of some populations. However, other agricultural practices may have detrimental effects on Bog Turtle wetlands. Agricultural practices such as the use of pesticides and herbicides may negatively affect water quality, vegetation, invertebrate communities, and ultimately turtle populations. For example, increased use of pesticide applications in fields adjacent to Bog Turtle wetlands may decrease food resources for Bog Turtles, and we need more information to understand if this may be a factor affecting populations. In addition, many farms use

heavy equipment along the wetland edge. Bog Turtles are known to use wetland edges for basking, which can introduce the risk of injuring turtles due to tractor tires or mower blades.

Problems Observed

- Direct mortality of turtles by agricultural equipment or livestock.
- Sediment, fertilizer, and nutrient (e.g., nitrogen and phosphorus) runoff.
- Chemical contamination (herbicide and/or pesticide application).
- Altered hydrology due to ditching, drain tiles, ponding and increased water use for crops.

Tasks/Action Items

- Investigate potential herbicide, pesticide and nutrient agricultural impacts at Bog Turtle habitat and populations.
    - Review and summarize research of impacts attributed to excessive nutrient, herbicide, and pesticide use and draft BMPs.
    - Coordinate with contaminants biologists (e.g., USFWS, USGS).
    - Evaluate tissue samples from turtles at Bog Turtle sites for bioaccumulation of contaminants.
        - Snapping turtle tissue could be sampled as a surrogate species.
        - Permits and close coordination with the state leads would be required to collect tissue samples.
    - Determine what concentrations of chemicals are detrimental to Bog Turtle habitat and populations.
        - Are there effects to the food web?
        - Are there fitness concerns?
    - Determine an appropriate buffer distance to protect Bog Turtle habitat from agricultural influences.
- Identify methods to control or remediate agricultural runoff occurring within Bog Turtle habitat.
- Determine if water use for crops affects water levels in the core habitat.
- See also section 4.5.4 below on hydrology and water chemistry research needs.

4.5.4. RESEARCH HYDROLOGY & WATER CHEMISTRY

Hydrology is arguably the single most important feature of a Bog Turtle wetland. Mucky soils are a key feature of Bog Turtle wetland (USFWS 2001). These saturated soils with only small amounts of standing water are typically created where springheads and seeps occur. Human alteration of the landscape likely changes the hydrologic dynamic of many Bog Turtle wetlands. Residential wells may lower the water table and agriculture and/or roads can alter water flow and quality, which in turn alters wet meadow/fen habitat (e.g., Glaser et al. 1990, Trombulak and Frissell 2000). A hydrologist or geologist should be consulted when developing any hydrology guidance documents and prior to any on-the-ground hydrology restoration work.

Saturated soil and groundwater recharge are important hydrologic features for Bog Turtle wetlands according to previous research (Kivat 1978, Warner 1988, Tryon and Hermon 1990 via Lee and Norden 1996, Rosenbalm and Nelson 2010). Wetland hydrology is defined by the Army Corps of

Engineers (2005) as an area with a water table "*≤12 inches below the soil surface for ≥14 consecutive days during the growing season*" (for 5 out of 10 years). A recent study evaluated the hydrology at a site in Connecticut where the population appears to be in decline. Researchers found that the water table was within 30.5 cm of the soil surface for 88.4% of the one year it was monitored (Web et al. 2019). Additionally, the water table was only within 15 cm of the surface for <5% of the year. The relatively small drop in the water table may be important for the Bog Turtle. Fega (2012) found that Bog Turtles prefer wetland with a water depth of 10–15 cm. Additional research is needed to better understand the importance of the water table depth and the effects on turtles when the water table is lowered.

Furthermore, a study in Massachusetts observed that habitat alteration and shifts in home ranges were directly and/or indirectly responsible for a decrease in population size and survivorship (Sirois et al. 2014). Hibernacula that were used prior to flooding were not used post flooding when water levels were one foot higher at this location. Flooding resulted in more restricted home range sizes compared with pre-flooding home ranges. Additional studies are needed to determine when and where beaver flooding may be detrimental to the Bog Turtle and its habitat.

Top Priority Tasks

Restore hydrology at Bog Turtle sites (e.g., ponds could be restored) and monitor post-restoration changes to determine success or failure of a project

Restoring hydrological integrity at all impacted Bog Turtle sites is desirable, but may not always be feasible or practical. Conservation partners should refer to the Recovery Unit Action Plans to determine which sites should be a priority for these actions. Other considerations include an evaluation of the difficulty and/or practicality of restoring hydrology, and the cost of completing the work. Given limited resources these projects, while very important, will need to be balanced with other management needs. Consider collaborating with USFWS, USGS, The US Army Corp of Engineers and/or other organizations that have programs for stream and wetland restoration. Below is a list of the most common problems found at Bog Turtle wetlands and needed action items to address these issues:

<u>Problems Observed:</u>

- Development, retention basins, and impervious surface
- Residential wells
- Ecological succession
- Ditching and installation of drain tiles
- Headcutting and stream bank degradation
- Ponding by humans and beavers
- Agricultural and development runoff, pesticides, and herbicides
- Increased intensity and frequency of flooding due to climate change
- Roads, bridges, and culverts
- Subsurface drilling and mining

<u>Tasks/Action Items</u>

- Investigate and document the baseline hydrology at a variety of key locations.
    - Perform hydrologic monitoring at key sites within each recovery unit.

        - Collect reference data from high-quality core habitats with use of automated data loggers and other techniques.
        - Identify reference for groundwater stability at these sites.
- Determine what hydrologic issues make the habitat too dry or too wet for Bog Turtles.
    - It is important to understand why hydrology is impaired at a site in order to understand how to correct the problem.
    - Use the regional database to document hydrologic issues witnessed at each core habitat.
- Determine best techniques/BMPs to use to restore hydrology.
    - Efficient and effective methods to repair headcuts, remove drain tiles, pond removal, etc.
- Meet with permitting agencies regarding timeline, requirements, and help.
    - Discuss variables such as ponds vs. ditches vs. tiles, run off, etc.
- Develop a plan to address stormwater/watershed health.
    - Investigate stormwater management practices.
        - Minimize point-source discharge.
        - Maximize groundwater recharge.
        - Maximize containment of development runoff patterns.
- Identify priority populations/sites with hydrologic issues to address.
- Conduct pre-restoration background research.
    - Evaluate historical land use and impacts – historic well data, weirs, etc.
    - Talk to a hydrologist.
    - Set up monitoring wells.
    - Implement photo monitoring.
    - Trap and track turtles, as resources allow, to determine baseline habitat use.
- Conduct hydrologic restoration. Move forward with trial and error and monitor the success or failure of these projects. Also see Section 4.5.1 for research needs associated with better understanding the effects of our habitat management actions.
    - Control woody vegetation.
    - Conduct stream restoration.
    - Repair headcut streams.
    - Remove ponds and beaver dams.
    - Remove ditches and drain tiles.
    - Trap and track turtles, as resources allow, to determine the effects of restoration activities on Bog Turtle behavior, health, and habitat use.
- Perform post-restoration monitoring and document monitoring results.
    - Perform habitat monitoring.
    - Perform turtle population monitoring.
    - Perform aquatic invertebrate monitoring.
    - Trap and track turtles, as resources allow, to determine if habitat use changed due to the restoration work.

Investigate the impacts of development, roads, and agriculture projects at distances greater than the 300-ft buffer from a Bog Turtle core habitat

The Northern Population Recovery Plan defines three Bog Turtle Conservation Zones important for the conservation of the species (USFWS 2001). Zone 1 is equivalent to the core habitats, more recently developed and defined as the turtle activity area. Zone 2 is said to extend at least 300-ft

from the edge of Zone 1 and Zone 3 is the drainage basin. These zones have been used by state and federal leads for regulatory and conservation planning purposes. Rarely do states regulate activities beyond the 300-ft buffer area (Zone 2), in part because little is known about the impact of activities >300-ft from a Bog Turtle core habitat. Below is a list of research needs, identified by experts, to determine if activities beyond the 300-ft Zone 2 may negatively impact Bog Turtle wetlands:

Tasks/Action Items

- Compile data on case studies rangewide.
- Evaluate the number of core habitats with recharge zones that are under protection.
- Evaluate existing fisheries data to assess water quality and compare this with habitat and population condition of core habitat downstream of these locations but within the same basin (i.e., HUC12).
- Determine baseline hydrology at high quality sites and compare data to impacted Bog Turtle wetlands.
- Determine the recharge distance on residential wells (single and clusters).
    - Develop a hydrology model for groundwater.
- Evaluate and compare land use patterns upstream of "Good" and "Poor" populations.
- Research how different densities of impervious surface and development impact hydrology, in order to inform regulatory process.
    - Set up monitoring wells to monitor water levels pre- and post-development.
    - Perform water quality monitoring at varying distances from project sites.
        - Evaluate stormwater flows, water quality, and temperature.
- Investigate the effects of roads >300-ft away from Bog Turtle core habitat.
    - Monitor water quality in Bog Turtle wetland for salt concentrations and from petroleum-based substances (polycyclic aromatic hydrocarbons (PAHs)) at varying distances from roads.
- Investigate the effects of agricultural runoff of crop fields >300-ft away from Bog Turtle core habitat.
    - Evaluate water and sediment samples for levels of pesticide and herbicide residues in Bog Turtle core habitat at varying distances from row crop fields.
        - Determine what contaminants are of concern.
        - Test sites near different types of crops.
        - Develop partnerships with labs to perform the water quality tests.

Evaluate how climate change will affect habitat and populations throughout the range

Little is known regarding how climate change may impact Bog Turtle wetlands. However, recent observations and modeling of climate change impacts within the northeast may provide some insight (Frumhoff et al. 2007). Some climate models predict that the northeast will experience more frequent long droughts, lasting more than three months in duration (Frumhoff et al. 2007). This could result in a decreased water table every 6–10 years, particularly due to increased use of water for agriculture and residential dwellings during these times. In addition, the spring season is predicted to be wetter with increased frequency and severity of rain events (Frumhoff et al. 2007). A greater frequency of storm events and flash flooding during the spring months has the potential to decrease Bog Turtle nest success by drowning eggs and destroying nesting habitat due to an increased velocity of water flow through Bog Turtle wetlands. In fact, these storm effects have already been observed at some sites in recent years. For example, at one site in Pennsylvania

stormwater topped the stream bank and water rushed through the nesting habitat in great force, tearing up large mats of vegetation and inundating the tussock sedge. A similar event was observed at a streamside occupied wetland in Maryland.

Below are a set of action items recommended to better understand and combat the impacts of climate change on Bog Turtle populations and habitat:

Tasks/ Action Items

- Compile and summarize climate models for wet meadow/fen habitat in the northeast.
- Develop new models if existing ones are insufficient.
- Identify localities most likely to be negatively impacted by climate change and determine measures to reduce these impacts.
    - TNC has a climate change resiliency model that could be used to identify sites at risk, underlying factors, and/or stressors.
- Monitor severity and frequency of intense storms, 500 yr flood events, and drier summers.
    - Install stream gages and wildlife cameras to monitor depth, duration, and frequency of storm events at key sites.
- Compile information on what biologists observe in the field in terms of the impact of more frequent and intense flash floods.
    - Stream bank erosion adding sediment into wetlands.
    - Matts of shallow-rooted vegetation/tussock sedge mounds being destroyed (ripped up as the flood water moves through the wetland).
- Address how water moves through the system and determine potential water diversion methods.
- Establish best practices for reducing the intensity of stormwater flows as they enter the Bog Turtle wetlands.

Investigate the Effects of Bridge and Culvert Projects on Hydrology at adjacent Bog Turtle Wetlands.

The hydrology at many Bog Turtle wetlands has been altered by roads, bridges, and culverts to varying degrees. The following list of action items would be beneficial to the recovery of Bog Turtles. Also see Section 4.5.8. for additional research needs related to roads:

Tasks/ Action Items

- Determine how to modify culverts and bridges to mediate the negative hydrologic impacts of constricted water flow.
- Develop BMP's for best structure designs to use for Bog Turtle passage and to best restore or maintain natural water flow through the wetland system.
- Create a statewide list of priority culverts to be mediated for wildlife, prioritized by degree of damage or population need.

Evaluate Stream Restoration Projects

Stream restoration projects are on the rise in some states and these projects have the potential to cause turtle mortality and may cause negative impacts to adjacent Bog Turtle habitat. Stream restoration projects can also have long-term benefits to the Bog Turtle by restoring natural water

flow through the wetland. Experts identified the following research needs to minimize negative impacts to Bog Turtles and their habitat. Also see BMP needs for Stream Restoration in Section 4.8.3.

- Determine what time of year is best to avoid turtle mortalities.
- Determine guidelines if stream is used by Bog Turtles.
- Develop BMPs for stream restoration projects. We should first explore what recommendations may already exist (e.g., USFWS Partners program or Dave Rosgen stream fluvial geomorphology classes).

4.5.5. RESEARCH THE EFFECTS OF DEVELOPMENT

More information is needed regarding the indirect impact that development may have on Bog Turtle habitat. Below is a list of research needs which would help broaden our understanding of how development may indirectly affect Bog Turtle habitat. Research results in these areas may indicate a need for amending current state and municipal regulatory protections.

- Determine the average residential well recharge area in the vicinity of Bog Turtle wetlands.
    - Determine how this changes based on distance and with different densities of development.
    - Compare "Good" sites to "Poor" sites.
- Determine how impervious surface is altering hydrology and water chemistry.
    - Monitor water flow and chemistry at incremental distances from development projects and for developments or differing sizes.
        - Determine what contaminants or parameters may be of concern.
    - Develop impervious surface guidelines.
- Determine an appropriate buffer distance to protect Bog Turtle habitat from indirect influences of development.
    - Water monitoring results could be used as justification for revisions to expand or reduce the typical 300-ft buffer most states use (outlined as Zone 2 in the Northern Population Recovery Plan; USFWS 2001).
- Also see Section 4.5.4 for more information on research needs related to altered hydrology due to development.

4.5.6. RESEARCH MACRO AND MICROHABITAT USE

Numerous studies have examined Bog Turtle habitat use at specific sites across the range (e.g., Byers et al. 2018, Chase et al. 1989, Kiviat et al. 2010, Rosenbaum and Nelson 2010, and Whitlock 2002), but more information is needed to understand how habitat use differs across the range of this species and among multiple habitat types or compositions. Several studies indicate organic saturated soil is a key feature of Bog Turtle habitats (Anderson 2016, Feaga 2010). Nesting studies have shown that turtles nest in moist soil, moss and tussock sedge (Byer et al. 2018) and adults have also been found to select sedge, rush and other short herbaceous vegetation (Morro et al 2001).

The following research needs/questions have been identified on this subject:

- Evaluate microhabitat where turtles hibernate and nest within each population that ranked "Good" for viability.
    - Evaluate the diversity of hibernacula and nest structures.
- Investigate why turtles occur at one site but not adjacent sites where the habitat appears to be equivocal.
    - Are food resources an issue?
    - Are there differing concentrations of particular minerals in the water and sediment (e.g., calcium, potassium)?
- Investigate why Bog Turtles are restricted to calcareous fens.
- Investigate why Bog Turtle populations Monroe County, Pennsylvania populations are doing well relative to many other populations.
- Evaluate what stressors may cause shifts in vegetation composition at a given site.
    - Why does cattail become a problem?
    - How does nutrient input affect Bog Turtle habitat?
    - What part does atmospheric deposition play?
    - Why is Reed Canarygrass a problem at some sites but not others?
        - Is Reed Canarygrass establishment related to a perched water table?
- Map hydrology at key sites (those that ranked "Good" for viability) to protect them from hydrologic changes.
- Evaluate the average dispersal distance of Bog Turtles and type of habitat they use when dispersing.
- Investigate the use of subterranean tunnels by Bog Turtles.

4.5.7. DEVELOP AND EVALUATE eDNA TECHNIQUES

Dr. Hyatt Green of SUNY-Environmental Science and Forestry (ESF) and his students Maxwell Wilder and Anish Kirtane developed Environmental DNA (eDNA) qualitative polymerase chain-reaction (qPCR) assays and evaluated water and sediment samples from occupied Bog Turtle sites. Because traditional survey methods for Bog Turtles can be costly and ineffective due to the turtle's wetland habitat, small size, and burrowing nature, the quantification of minute amounts of turtle DNA left behind in the environment may provide an additional tool to help guide management efforts. They designed a qPCR assay (BT3) targeting the cytochrome oxidase I gene that correctly identifies Bog Turtles with 100% specificity and sensitivity when tested on 201 blood samples collected from six turtle species over a wide geographic range. Detection rates varied from site to site ranging from 0–75% chance of detection. High detection rates at some sites may be due to high turtle densities, knowledge of sampling personnel knowledge regarding precisely where/when to collect sediment samples, and/or slightly higher DNA recovery from sediment samples. To complete this work a blood collection protocol was also developed for the Bog Turtle and can be found in Appendix M.

Summary

- From a diagnostic perspective, the eDNA methods have very accurate positive-predictive value. When a signal is found, Bog Turtle(s) are at the site and likely very close to the sampling location.
- Possible barriers to implementation include:
    - Method sensitivity: This method needs better sensitivity to be useful in population assessment efforts.
    - Cost: A proper cost comparison between eDNA and traditional methods has not been conducted.
    - Required personnel: Best results came when experienced personnel did sample collecting.

Next Steps

- Further optimization of DNA extraction from sediments, possibly including chemical separation of DNA from particles or the use of magnetic beads.
- Further optimize the sampling and DNA extraction from water samples including tangential flow or hollow fiber filtration.
- Performing a detailed cost comparison for both traditional and eDNA methods to identify the maximum number of samples that can be analyzed for eDNA before it becomes cost-ineffective.
- Lowering the cost of eDNA methods by validating 2-in-1 tests (i.e., multiplexing). A 3-in-1 test for Bog, Wood, and Spotted Turtles has already been developed but needs further testing.
- Explore the utility of a sequencing-based approach such as metabarcoding for the detection of a wide range of species simultaneously.
- Identification of location-specific genetic markers that can be targeted with PCR (versus using microsatellites) that could be used to quickly and cost-effectively determine the origin of an individual turtle (e.g., post rescue from illicit trade).
- Identifying variation in eDNA shedding rates as a function of season or other factors so eDNA sampling can be timed with high shedding rates.
- Controlled experiments on the persistence of eDNA in sediment and water to allow more clear interpretations of positive signals. For example, does a positive result mean a turtle was present one hour ago, one month ago, or one year ago?
- Investigate prevalence of eDNA markers focusing on one or two sites with high-density sampling to see if patterns of detection correlate with the locations of tagged individuals. This would help distinguish effective vs ineffective eDNA sampling procedures.

4.5.8. RESEARCH THE EFFECTS OF ROADS

Large roads with high traffic volume act as barriers to migration and dispersal for turtles species (e.g., Gibbs and Shirver 2002). Bog Turtles tend to have relatively small home ranges compared to other turtle species, including closely related species like the Spotted Turtle (e.g., Chase et al. 1989, Milam and Melvin 2001). A smaller relative home range minimizes the influence of roads on Bog Turtles in comparison to other turtle species; however, roads can still be problematic when Bog Turtle wetlands are adjacent to or intersect with roads. Bog Turtles may cross roads to migrate

between patches of habitat on either side of the road, to disperse to "new" locations, or may bask along the roadside shoulders.

Habitat under bridges often lacks shallow water and upland edges that may provide better passageway corridors for Bog Turtles. Additionally, many culverts are small, dark and easy to bypass by traveling up and over the road, suggesting Bog Turtle may not frequently utilize these structures as passageway corridors under roadways. For example, studies have shown that other, similar turtle species (i.e., Spotted Turtles) are reluctant to enter small, dark culverts (e.g., Yorks 2015). Other more recent efforts are underway to reduce the effects of roads on turtle populations. The Northeast Partners in Amphibian and Reptile Conservation (NEPARC) and Tom Langen of Clarkson College, via a Regional Conservation Need Grant, are developing guidelines for designing turtle passageways and best management practices for the most common roadway mitigation practices. Below is a list of specific needs for the Bog Turtle.

- Identify locations where roads intersect habitat, particularly at sites that ranked "Good" or "Fair" for population viability.
    - Determine if culverts are present and get cleaned out (by who, how often, and by what methods).
    - Determine what improvements are needed (e.g., better water flow or turtle passageways).
    - Prioritize sites for action.
- Investigate the effects of roadside herbicide and road salts.
    - Evaluate water and sediment samples of locations in Bog Turtle wetlands at incremental distances from roads.
    - Evaluate how turtle eggs are impacted by road runoff chemicals/materials.
    - Evaluate tissue samples from turtles in wetlands adjacent to and far from roads.
        - Snapping turtles could be used as a surrogate species.
- Determine if roadside mowing is causing Bog Turtle mortality, and if so, how frequently.
- Review and compile road literature on other reptile species and mitigation measures used (e.g., crossing structure types that were effective) to determine if any may be used for Bog Turtles.
- Evaluate the effects of bridge and culvert projects.
    - Also see Section 4.5.4 for research needs related to hydrologic alterations of wetlands by bridges and culverts.
    - Modify the turtle passage guidance document being developed by NEPARC and Tom Langen (mentioned above) and include it in the road related BMP document.
- Modify/Adapt New Jersey's Bog Turtle road related guidance document as BMPs for the entire Northern population.

4.5.9. CONDUCT HEALTH ASSESSMENTS

Several recent studies have examined the health of Bog Turtles. Bacterial Pneumonia was observed in two fresh carcasses of wild Bog Turtles in North Carolina and Virginia (Carter et al. 2005). Significant recent findings include the observation of a high incidence of herpesvirus in wild Bog Turtles in the northeast. Three turtle herpesviruses were recently identified and described by Ossiboff et al. (2015). Two of these were found to infect Bog Turtles, *Glyptemys* herpesvirus 1 (the predominant virus detected in Bog Turtle) and *Emydid* herpesvirus 2. All turtles were

asymptomatic during handling and appear to have only mild infections. However, the authors warn that significant disease could result if a species were exposed to a host-adapted virus of a closely related species. Recent research has also indicated a high incidence of Mycoplasma in wild Bog Turtles, with 70% being positive of the 83 individuals tested in the northeast. No turtles were asymptomatic during processing. To reduce the risk of diseases and fungus, disinfection protocols and procedures are required now by many state agencies. A Regional Bog Turtle Health Bulletin is available to provide guideance (USFWS 2018b), which is largely based on a protocol developed by the Emerging Disease Working Group of the Northeast Partners in Amphibian and Reptile Conservation (e.g. NEPARC 2014). Baldwin et al. (2009) found that with one minute of contact with Nolvassan (0.75% concentration), Virkon S (1.0%) and Bleach (3.0%) were all effective against Ranavirus.

From 2011–2017, the Wildlife Conservation Society/Bronx Zoo collected baseline data on disease and general health of 387 Bog Turtles in 31 populations. The following is a list of future disease-related research needs.

- Continue periodic health assessments of a sub-set of Bog Turtle populations.
    - Develop and draft a disease surveillance plan.
        - Determine the minimum number of sites to be sampled.
        - Sampling should be well-distributed throughout the range.
        - Evaluate a subset of populations in all three viability ranking categories: “Good”, “Fair, and “Poor” and any populations that have, or may experience in the future, a mass mortality event (>5 mortalities within a month) not known to have been caused by depredation.
        - Determine the frequency of re-evaluation (e.g., every 5 or 10 years).
    - Determine baseline disease prevalence and track changes in prevalence as well as the percent of asymptomatic individuals.
    - Determine if and how disease may be affecting populations.
    - Identify the prevalence and distribution of diseases within Bog Turtle populations.
    - Determine how environmental stressors may contribute to disease outbreaks (turtles going from carriers to symptomatic).
- Determine disease mode of transmission for identified pathogens.
- Distribution of disinfection? protocols to wetland delineators and otherwise more broadly to reduce the risk of humans assisted migration of disease agents.

4.5.10. RESEARCH THE EFFECTS OF DEPREDATION

Bog Turtle mortalities are infrequently observed in the field. Often when a carcass is found, the remains are too degraded to determine the cause of death. Depredation is rarely witnessed or determined to be the cause of a specific mortality event. In general, more information is needed to evaluate the impacts of depredation on Bog Turtle populations, such as the research needs listed below:

- Determine the composition and density of predators at Bog Turtle sites.
    - Wildlife cameras could be used to monitor predator populations in core habitat.
    - Is there a difference in predator population densities in more urban areas?
    - Do we see more predators at sites with low turtle population densities?

- Compile literature and/or test predator excluder (e.g., wire mesh protective covering) design types for effectiveness.
- Determine the effects of depredation on population size, structure, and recruitment.
- Examine predator exclusion fencing to determine what type/design works best.
- Evaluate whether our presence in wetland or contact with nests increases the risk of depredation.

4.5.11. EVALUATE PIT TAGGING TECHNIQUES

PIT tagging turtles can be beneficial to assist law enforcement by allowing them to determine the origin of confiscated turtles containing tags. The USFWS has encouraged the use of PIT tags in Bog Turtle and distributed tags to the lead state biologists throughout the northeast. However, many biologists have been reluctant to implant PIT tags in Bog Turtles due to their small size and a lack of information on the potential of PIT tagging to cause health problems and/or mortalities. The only data available to date is from North Carolina where researchers have been PIT tagging Bog Turtles for 10 yrs. Their recapture data indicates that PIT tags have not negatively impacted the Bog Turtle populations in that state. PIT-tagged individuals were recaptured slightly more frequently than notched Bog Turtles. It is important to note that non-PIT tagged turtles make up a larger percentage of most populations, because they did not tag the smaller turtles and gravid adult females. There have been a few observations of PIT tags that migrated within the turtle or were lost (expelled from the turtle).

- Draft and implement a PIT tag protocol. We would benefit from standardizing our methods (types of tags used and same readers, etc.). Two other turtle working groups are working on a similar protocol, the Collaborative to Combat the Illegal Trade in Turtles and the Spotted Turtle Working Group. These protocols should be evaluated for use for the Bog Turtle.
    - Evaluate and modify as needed the protocols developed by the southern Bog Turtle group and Spotted Turtle Work Group.
    - Identify individuals that should not be tagged.
        - Bog Turtles < 50 mm SCL and <50 g
        - Gravid females
        - Turtles in poor health condition
    - Determine the best location on Bog Turtles to insert the tags.
    - Determine a turtle-holding period. For example, hold turtles for 15–20 minutes to evaluate turtle condition post-implementation.
- Evaluate if PIT tags are causing any injuries or mortalities.
    - Investigate (or gather existing data on) the effectiveness and risks of PIT tagging Bog Turtles
        - Do tags migrate and if so, how often?
        - Does tagging increase mortality or decrease fitness in any way?
    - Use radio-telemetry to monitor the health of turtles PIT tagged. For example, track tagged turtles weekly throughout the first active season.
- Determine ways to reduce the risk of poachers using new long rage readers to find PIT tagged turtles in the wild. New long-range readers (Biomark HPR Plus) can detect turtles 4–12 inches deep into mud.

- Determine if Biomark could make specific screening questions and require state/federal/academic credentials to allow purchase of the equipment.
- Determine types of readers and tags that should be recommended to researchers.

4.5.12. RESEARCH THE EFFECTS OF BEAVER

Beaver flooding was identified by experts as a moderate risk to the Bog Turtle. More research is needed to understand how beaver flooding may impact Bog Turtle habitat and populations. At many sites it is presumed that Bog Turtles would be able to move to more habitable areas during periods of flooding. However, Bog Turtles are adapted to wetlands with relatively stable water tables and this relocation may push them closer to roads or increase depredation by bringing higher water closer to nesting sites and hibernacula (Sirois et al. 2015). In addition, nesting areas may become inundated due to beaver flooding, drowning nests. Beaver ponds can also alter water chemistry and vegetation communities. Water quality problems are known to cause health issues in captive turtles and may be a concern in beaver-impacted areas. It is likely that populations in larger wetland complexes may adapt to such changes better than populations constrained within small, isolated wetlands.

4.5.13. EVALUATE POPULATION GENETICS AND DEVELOP A GENETIC LIBRARY

Genetics is a useful tool to determine biologically meaningful conservation units and a genetic library may assist law enforcement in confiscation cases. It is also important to consider genetics prior to performing population management actions. Previously published studies have evaluated the genetic structure of Bog Turtle populations. King et al. (2004) developed microsatellite DNA markers for Bog Turtles and Rosenbaum et al. (2007) investigated mitochondrial DNA sequences from 21 localities to evaluate rangewide population structure. Rosenbaum et al. (2007) discovered low genetic variation in mitochondrial DNA among populations of Bog Turtles. Studies have also found a range of levels of mitochondrial allelic diversity within populations of Bog Turtles (Pittman et al. 2011, Shoemaker 2011). It was suggested that a minimum viable population for the Bog Turtle may be as low as a population that includes 15 or more reproductive females (Shoemaker et al. 2013). That study was of one metapopulation in New York. Additional studies are needed repeating this methodology with other metapopulations and a few isolated populations to determine if this holds true of other populations. Research of the southern population indicates that genetic differentiation is primarily related to the distance between the southern sites (Dresser 2017). Dresser found low genetic diversity, low effective population size and local adaptation in some populations.

In more recent years, Tim King was evaluating population structure across the Bog Turtle's range with use of microsatellite data. However, this work needs to be expanded. Specifically, the following are needed action items to expand our understanding of the conservation genetics of this species. Also note that a protocol for bleeding turtles to collect genetic data was developed and can be found in Appendix M.

- Collect additional genetic samples in key areas throughout the Northern population range to determine boundaries of biologically significant conservation units.
- Determine the effective population size.

- Perform an isolation-by-distance assessment using Tim King's data and the samples collected in key areas mentioned above.
- Map biologically significant units and adopt these as the Bog Turtle recovery units
- Incorporate these recovery units into the Conservation Plan and Recovery Plan in future revisions of these documents.
- Re-evaluate and improve upon the minimum population viability model developed by Shoemaker et al. (2014) using similar methods to evaluate additional metapopulations in other regions of the range and with varying population conditions and configuration.
- Consult with other turtle working groups (e.g., Wood Turtle and Blanding's Turtle) that recently performed genetic assessments for lessons learned.

4.5.14. RESEARCH LIFE HISTORY TRAITS

Several studies have evaluated life history traits of Bog Turtles (e.g., Locvich et al. 1998, Whitlock 2002, Macey 2015). However, because the Bog Turtle is a long-lived and secretive species, researching life history traits can be challenging. In many cases, this will require long-term studies of specific populations. The following is a list of research needs on life history traits:

- Research long-term study sites to better understand longevity.
- Perform a baseline assessment of mortality (similar to health assessments).
- Investigate the frequency of winter kill and the specific weather conditions associated with winter kill.
- Research life history at different life stages (juveniles vs. adults).
    - The current record (as of 2019) is of a 61 year old male at a long-term study site in Pennsylvania.
- Evaluate life history traits at the Northern-most edge of the range in the Lake Plain area.
    - Determine growth rates and age/size at maturity.
    - Determine average number of eggs laid by females.
    - Evaluate the frequency of nesting in females.

4.6. LAWS AND REGULATIONS

Laws and regulations are vitally important for the recovery of the Bog Turtles. The introduction of the Clean Water Act in 1972, the Endangered Species Act in 1973, and the federal listing of the Bog Turtle in 1997 were three of the most important conservation measures that helped to reduce the decline of the Bog Turtle by providing important protections to the species and its habitat. Below are additional laws and regulations that will further these efforts.

4.6.1. SEEK MAX PENALTIES FOR VIOLATIONS OF THE ESA

Federally listed species receive protections under section 9 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C *et seq*.; ESA), the Lacey Act (18 U.S.C 42–43; 16 U.S.C. 3371–3378), and various state environmental conservation laws from activities ranging from interstate transport, destruction of habitat to take of listed species. Fines and penalties for illegal activities involving federally listed species can vary depending on the severity of the activity and how they are viewed during court proceedings. For example, section 11 of the ESA states that any violations of section 9

can result in civil penalties of up to $25,000 per violation or criminal penalties of up to $50,000 or imprisonment of up to one year per violation. Often, fines are a fraction of what collectors can make monetarily by selling just a few turtles and thus, do not provide enough incentive to stop the illegal activity. When wildlife cases are reviewed in court, judges may not view them as serious offenses as compared to violent crimes, but in some cases illegal wildlife trade is intertwined with violent crimes such as dealing drugs, weapons, and/or human trafficking. Finding ways to help address this disparity is a high priority. Outreach is needed on the judicial side to demonstrate how pervious sentencing hasn't been sufficient to deter poaching and how these cases are often linked to other major crimes (e.g., gun smuggling).

In addition, increased law enforcement engagement to help address illegal collection and protect turtles before they are removed from the wild is another high priority. However, releasing confiscated turtles back into the wild poses substantial challenges due to the potential for the turtles to have contracted a disease while in captivity and potentially spreading it to other wild turtles. Additionally, the original location of the confiscated turtles may be unknown, eliminating the possibility of repatriation.

4.6.2. REVISE THE NORTHERN POPULATION RECOVERY PLAN AND RE-EVALUATE THE RECOVERY CRITERIA

The Bog Turtle Northern Population Recovery Plan was released in 2001 (USFWS 2001). Re-evaluation of the recovery plan every 10–20 years is advisable and as such the USFWS is planning to update the plan in fiscal year 2020. Over the past 18 years, much data has been collected on the species distribution, threats, and conservation strategies that can help inform revisions. For example, the current conservation zones should be revisited to determine if the distances are adequate to protect Bog Turtle habitat. Other recommended revisions include reducing the number of populations to be secured in the Prairie Peninsula/Lake Plain Recovery Unit and removing the Philadelphia and Trenton city limits from the recovery unit maps.

4.6.3. REQUIRE SURVEYOR QUALIFICATIONS

The USFWS, in close collaboration with state wildlife agency leads, developed recommendations for minimum experience and skill need to consider a surveyor qualified to perform Bog Turtle surveys (Phase 2 Presence/Probable Absence Surveys) as part of environmental project reviews . State and federal regulators agree that surveyor qualifications are needed due to the difficulty in finding Bog Turtles in the wild. Bog Turtles are a secretive species and spend much time hidden from view in underground tunnels or under dead vegetation when basking at the surface. These recommendations should be updated periodically. The current version of the USFWS guidelines and guidelines by state can be found at:

USFWS:
https://www.fws.gov/northeast/nyfo/es/REVISED%20Phase%201%20and%202%20Protocols_10.26.18_FINAL.pdf

Delaware: See USFWS guidelines

Maryland: See USFWS guidelines

New Jersey: https://www.fws.gov/northeast/njfieldoffice/pdf/bogturtlesurveyors.pdf

New York, Massachusetts, and Connecticut: https://www.fws.gov/northeast/nyfo/es/Surveyor%20Lists/HHRU_Bog%20Turtle%20Phase%202%20Surveyors%20List%202019.pdf

Pennsylvania: https://www.fws.gov/northeast/pafo/pdf/BT%20Surveyors%2010-29-2018.pdf

4.6.4. IMPLEMENT REGIONAL SURVEY GUIDELINES FOR CONSULTANTS

Surveyor guidelines for consultants were originally developed as part of the Northern Population Recovery Plan (2001) and have since been updated several times, the last being this past year (USFWS 2018a). The survey guidelines include guidance on habitat assessment surveys (Phase 1 surveys) and visual turtle surveys (Phase 2 surveys). Phase 1 surveys are to determine if potential Bog Turtle habitat is present at a given location and the Phase 2 surveys are designed to determine if turtles are present. These guidelines were developed to standardize survey methods used by contractors across the Northern range. All seven states within the Northern range of the Bog Turtle have adopted these protocols and require surveyors (consultants) to use them to determine if Bog Turtles or Bog Turtle habitat is present near proposed development project sites. These guidelines are not designed to determine population size or to determine absence, but are usually sufficient to detect Bog Turtles when they are present. Considerations regarding the guidelines are as follows:

- Can the number of Phase I Habitat Assessment Surveys recommended for environmental review purposes be reduced?
- Consider not conducting Phase 1 Habitat Assessment Survey during the nesting season to avoid crushing eggs or provide the necessary training so surveyors can avoid potential nesting areas.

4.6.5. DRAFT GUIDELINES TO REDUCE ADVERSE EFFECTS

The following are considerations for improving the environmental review process of development projects conducted by USFWS field offices and states:

- Develop a guidance document to perform turtle sweeps prior to ditch maintenance along road sides (Pending)
- Consider evaluating development projects beyond the 300-ft buffer (see Conservation Zones 2001) from potential Bog Turtle sites to assess hydrologic impacts. Thoughts to consider include:
    - Consider landscape context and expand the 300-ft buffer based on slope, type of development activity, and temporary vs. permanent disturbances.
    - Revise the Conservation Zones document to include additional measures so applicants have predictability in what is required of them.
    - Develop guidance regarding placement of adequate buffers to avoid impacts from water diversions or changes in hydrology, as well as to address a potential increase in predators resulting from development.
    -

4.6.6. IMPROVE ENVIRONMENTAL REVIEW TOOLS AND OTHER GUIDANCE DOCUMENTS

The following are additional considerations for improving the environmental review process of development projects conducted by USFWS field offices and states:

- Continue improving the efficiency of the USFWS's Information, Planning, and Consultation (IPaC) program for environmental review of development projects:
    - Develop determination keys based on programmatic consultations (e.g., USFWS Bog Turtle Habitat Restoration Biological Opinion, Pending) to streamline consultation process for self-certifications and automated tracking of development projects.
    - To track Phase 1 habitat surveys and Phase 2 presence/probable absence survey efforts (particularly for negative surveys), as well as Phase 3 trapping surveys.
    - To track the number of habitat management projects completed, practices that were implemented per project and projects where habitat management plans were developed.
- Build partnerships with utility companies to maintain right-of-ways. For example, Maryland has a cooperative agreement and management plan with utility companies that contain avoidance measures for projects. Consider developing similar agreements and management plans for other states in the Bog Turtle range.
- Consider developing a Safe Harbor Agreement with private landowners and other non-federal landowners for projects that contribute to the recovery of Bog Turtles. More information can be found at:
    - https://www.fws.gov/endangered/landowners/safe-harbor-agreements.html
- Continue and expand training opportunities for consultants and agency biologists for Phase 1, 2, and 3 surveys.
- Develop a comprehensive compilation of avoidance, minimization, and mitigation measures (AMMs) for various project types.
    - Further expand upon Bog Turtle AMMs currently available in IPaC.
    - Develop AMMs for potential indirect hydrology impacts (e.g., new wells, water withdrawals, septic systems, stormwater infrastructure), particularly in Conservation Zone 3.
- Develop guidance document for projects where there may be no federal nexus or state permits needed. The USFWS Pennsylvania Field Office may have a document to work from.
- Develop guidance document for horizontal directional drilling near a potential/known Bog Turtle site. Consider including:
    - Procedure for preventing and/or responding to inadvertent returns.
    - Procedure for preventing and/or responding to trench collapses or presence of sinkholes during drilling.
    - Procedure for handling/disposal of contaminated water.
    - Procedure for appropriate size and depth of open cut trenches.
    - Consider mapping out the hydrology of the site, if possible, and installing monitoring wells to assess water levels and flow at a known Bog Turtle wetland.
- Develop guidelines for pre-construction telemetry of Bog Turtles to better understand habitat use and where there is potential overlap with use of construction equipment.
    - Recommend limits to fence installation for staging equipment.
    - Land needs to be graded before timber mats are put down.

    - Should be careful of timber mats being used from one site to the next (reuse).
- Develop guidelines for when monitoring biologists are needed at a project site. Multiple monitors may be needed for larger construction projects near sensitive Bog Turtle sites.
- Develop recommendations for herbicide applications near known Bog Turtle wetlands. Herbicides should be applied at or below EPA recommended concentrations and during low-flow times of year. If not possible, then sandbags can be placed during application to temporarily slow the egress of water and allow the target plants to take up the herbicide.
- Develop guidelines for transportation activities, such as culvert replacements/repairs in and around potential or known Bog Turtle habitat.
    - Create a template for consultant pre-construction debriefing field meetings to ensure consistency in educating construction works about Bog Turtles and implementation of conservation measures. NJ DOT has a programmatic containing some of these guidelines.

4.7. POPULATION MANAGEMENT STRATEGIES

Population management is recognized as a potential conservation tool for recovery of the Bog Turtle, but most experts agree that this action is a low priority relative to other conservation measures. Because resources are limited, conservation funds must be prioritized first towards actions that efficiently and substantially move us forward in terms of achieving rangewide recovery criteria. For example, good habitat condition is essential to support a Bog Turtle population and the majority of known core habitats are in need of some degree of habitat management. Therefore, habitat management and other high priority needs should be initiated at core habitat sites prior to focusing on lower priority actions such as population management strategies.

4.7.1. IDENTIFY THE BEST POPULATION MANAGEMENT TECHNIQUES

Although performing population management actions ranked low as a conservation strategy to recover the Bog Turtle, evaluating and identifying the most effective, efficient, and least invasive techniques to use when population management is appropriate ranked much higher as a regional priority. Some captive management research has occurred, primarily in the southern population. Bern Tryon (formerly of the Knoxville Zoo) had performed captive breeding and head-started Bog Turtles (Tryon and Hulsey 1977). Ten Bog Turtles were headstarted by the former Burnet Park Zoo (now the Rosamond Gifford Zoo) in collaboration with Peter Rosenbaum for a population in the Lake Plain area and a handful of other minor efforts. North Carolina has also recently started to evaluate population management as a recovery tool. In addition to captive breeding, many researchers have protected nests, which successfully increased hatching success (e.g., Macey 2015, Zappalorti et al. 2017). This prior and ongoing work should be expanded upon to evaluate effective population management needs. Next steps should include the following:

- Develop a well-planned approach to determine which methods of population augmentation (i.e., nest protection, using protective nest tub in the field, and headstarting hatchlings in captivity for one year) are most efficient and effective.
- Create a priority list of populations for population augmentation or management.
- Follow progress and results of the research from North Carolina.
- Draft a BMPs document once we elucidate what methods are most effective.

4.7.2. DRAFT A POPULATION MANAGEMENT DECISION TREE

A decision tree is needed to help guide decision making related to population management actions. Guidance is provided for both proactive (regional or statewide conservation planning) and reactive (project proposal review) projects. Recommendations are made for priority recipient and donor populations for proactive projects. The decision tree provides a set of questions and consideration when determining where and when it would be most beneficial to perform population management actions.

Proactive Projects

Proactive efforts should be carefully planned at a rangewide scale by state and federal Bog Turtle experts. Priority recipient and donor populations would be identified using our population viability ranking described in Section 4.2.2 and the following guidelines. In addition, decision makers should consider all of the questions and elements outlined in the following Population Management Decision Tree.

Priority Recipient Populations

Priority Recipient Populations are populations that ranked "Poor" for population quality and "Good" for habitat quality based on results from the population viability ranking project.

Priority Donor Populations

Priority Donor Populations are populations that scored a 5 for both population size and recruitment, and were ranked as "Good" for both Habitat Quality and Population Viability.

Reactive Projects

A reactive effort is when one or more parties are interested in performing population management to improve conditions for a particular population or populations and submit a project proposal to the appropriate state and federal Bog Turtle experts. The following Population Management Decision Tree was drafted to assist the regulatory agencies when determining if a project is appropriate and likely to contribute towards reaching the recovery criteria outlined in the Bog Turtle Northern Population Recovery Plan:

Population Management Decision Tree

This provides a decision framework by which Bog Turtle population management projects should be evaluated. Population management could include headstarting, translocation, repatriation, and/or captive breeding. Headstarting is when eggs or hatchlings are raised in captivity to allow increased growth within the turtle's first year, thereby increasing survivorship. Predation rates are lower for larger turtles. Translocation is when turtles are captured from one population and released into another population. Repatriation is when turtles are captured from one population (or from captivity) and released at a historical, but currently unoccupied, Bog Turtle wetland. Captive breeding is when captive adults (confiscated or collected from the wild for this purpose) are allowed to reproduce.

Project applicants need to have an approved plan prior to obtaining state and/or federal permits. These permits must be obtained prior to commencement of any work. This decision framework serves two purposes 1) to assist researchers in developing a robust proposal and 2) to assist the review committee and decision makers (i.e., state and/or federal staff) in determining under what circumstances these activities would be approved. Determining a favorable outcome using this decision framework does not guarantee project approval by the state and federal agencies as they may deny approval for reasons not outlined in this document.

The following guidelines are for use by all partners for all aspects of population management. A project proposal should be developed and should provide answers to the series of questions below and include a proposed long-term monitoring plan.

These questions are meant to guide the decision-making process however it should be understood that the decision ultimately involves a complex cost-benefit analysis with the potential for a great deal of uncertainty in the underlying information. Vetting of proposals by an established review committee (state and/or federal Bog Turtle experts) will be useful to ensure a reasonable level of consistency in how we apply this decision framework. A diagram of the decision process has also been provided (Fig. 20).

Figure 20. Diagram of the Decision Framework

Decision Framework

Regional Benefit
Will the increased range, number of populations, or population security make the status within the Northern population more secure within the next 28 years (a Bog Turtle generation time [Shoemaker et al. 2013] and the approximate amount of time for an offspring of a headstarted turtle to become a reproductive adult)?
Will the increased range, number of populations, or population security make the status within the recovery unit (RU) more secure within the next 28 years? a) Is the core habitat identified as a priority population within the RU based on the population viability-ranking project? You may need to coordinate with your state agency and USFWS Field Office to obtain this information. b) Will the core habitat become part of a metapopulation with a priority population within the RU? c) Is the core habitat within an identified Important Corridor?

Local Benefit
Is there evidence at or in the vicinity of the target core habitat (s) that the local population has been reduced or extirpated?
Is the local population small and vulnerable to local extinction in the next 28 years?
If the local/regional population has been extirpated or is very low, is natural re-establishment, re-population through migration, and or population growth likely to occur in the near future (i.e., next 5 years)?
Will the translocation or management restore a self-sustaining population to a core habitat or a portion of its range, or reduce the risk of local extinction within the next 28 years?
Limiting Factors
Are the limiting factor(s) likely responsible for the decline known and have they been addressed?
If the limiting factor(s) are unknown or uncertain, how will the reintroduction program help to identify the limiting factors?
Habitat Suitability
Is the proposed location a current or historical core habitat? Is the core habitat within the historical range?
In current condition, does the release location and its surroundings provide suitable and sufficient habitat to support a population? If not, will habitat restoration occur before release? Do you have a habitat management plan?
Is the core habitat permanently protected and surrounding area (i.e., 300-ft from the wetland edge)? Is there an easement on the core habitat and/or surrounding area?
Source Population
How will you assure the source population will not be harmed? Provide evidence and support (PVA model simulations preferred [e.g. using Vortex software, see Lacy and Pollak 2014]). a) Is the location of the source turtles known or is it captive turtle of unknown origin? Specify if the source turtles are no long free-ranging wild turtles. b) Is source population the same as the recipient population? c) Provide information about the intensity and duration of the project. (i.e., how many adults, juvenile, hatchlings would be removed each year and over how many years in order to complete the project)

d) How will your activities benefit the source population?

e) Evaluate alternatives (e.g., nest protection, nest tubs, and direct releases vs. headstarting, use of juveniles vs. hatchlings, etc.)

Recipient Population

How will your project benefit the recipient population (Vortex model simulation preferred)?

How will you minimize the risk of and/or screen turtles (planned for release) for disease and parasites?

Are source turtles similar genetically to individuals remaining in the recipient population? Provide location information for the source and recipient populations (i.e., latitude, longitude, and/or a detailed map). Is the source population in the same or adjacent watershed?

Monitoring

Attach a monitoring plan designed to track results of the project. Monitoring should be done to determine if and when you have reached your goal of a self-sustaining population (short-term survival is not sufficient).

a) Periodic re-evaluation of the program (every 5 years). Is progress being made and are you meeting your objectives? (i.e., re-run/re-evaluate the Vortex model - if applicable).

b) Do headstart individuals have similar annual reproduction (i.e., similar percentage of headstart females nesting annually and with normal clutch sizes compared to wild Bog Turtles).

c) Is longevity similar in translocated or headstarted individuals compared with wild Bog Turtles? Although this is difficult to get at there should be a plan in place to attempt to help answer this question.

Will trapping or telemetry be used?

Documentation and Reporting

Please provide a proposal narrative that addresses the above questions, including details on project goal, timeframe, and costs, permitting and model inputs and results.

Will this project draw financial funds from other higher priority projects for the Bog Turtle?

Will this project require state or federal staff time? If so, how much time?

Have you applied for a state permit? Who have you been in contact with?

Have you applied for a federal permit? Who have you been in contact with?

Other Considerations

Other Benefits
Is this a pilot study? If so what it the importance of the study?
Will the project otherwise enhance conservation of the target species? How? Does the project have educational or conservation program value?
Will this project benefit other SGCN species?
Controlled Propagation (also see USFWS Propagation Policy [USFWS 2000] at this link: https://www.fws.gov/endangered/laws-policies/policy-controlled-propagation.html)
Answer these questions only if your project involves propagation
Does the project address any of the recovery action outlined in the Northern Population Recovery Plan or sub-unit Action Plan (if one has been developed)?
Have all other recovery strategies been employed and failed? Or are other strategies alone determined to be likely to fail at full recovery (e.g., area ineffective in overcoming extant limiting factors)?
Are other recovery measures being implemented to secure suitable habitat? (e.g., habitat management, restoration, and other recovery efforts)
How are you dealing with maintaining genetic diversity?
Has funding been secured for this activity?
How long will adults be in captivity?
Captive Turtles
Answer these question only if your project involves turtle in captivity
How will you control for risk of spreading disease or parasites? a) Will captive Bog Turtles be housed with or near any other species? b) Will Bog Turtles from different core habitats be housed with or near each other? c) Provide an outline of weekly health assessment plans, includingdocumentation and reporting mortalities, weights and general health of extant individuals, etc.
Provide a dietary plan a) Applicants should review existing guidelines (Herman and George 1986, Herman 1991, Tryon and Hulse 1977)
Provide information on housing

a) At how many facilities? b) What is the structure of the enclosures? How will you prevent escape? c) What will the environmental conditions be (e.g., temperature range, soil type, availability of basking lamps, etc.) d) What is your security plan to ensure protection of captive turtles?
e) Have all partners (internal and external agencies) been involved in the decision? What affiliation do you have with veterinary or other support institutions?
How long will young turtles be in captivity and what time of year will releases occur?
What is your plan for providing periodic reports?

4.7.3. DRAFT GUIDELINES FOR POPULATION MANAGEMENT

Population management guidelines would aid in facilitating the success of these projects and provide guidance to minimize any risk to the turtles (e.g., introducing a disease to the native population). These guidelines should describe the following options in detail for conservation partners to use to improve Bog Turtle population number and recruitment:

- Methods most appropriate under various population conditions.
    - When is nest protection appropriate vs. headstarting?
- How do we develop and maintain a good working relationship with the landowner?
- How to construct and install predator excluder devices to protect nests.
    - Which designs work best and under what conditions.
- How to construct and install predator excluder fencing.
    - Which designs work best and in which habitat types.
- How frequently to check covered nests.
- Husbandry guidelines:
    - How to house turtles that are brought into captivity, including substrate, temperature, and moisture guidelines.
    - What and how frequently to feed turtles (adults and young).
    - What handling precautions should be made?
    - If morphometric measurements should be taken periodically, and which measurements should be taken.
    - How to monitor the health of the turtles.
    - How long should turtles be kept in captivity?
- How and when turtles should be released.

4.7.4. PERFORM POPULATION MANAGEMENT

When managing Bog Turtle populations, the first priority should always be determining the cause of population decline and ensure negative influences on the population have been sufficiently improved to support the population over a long-term period. Once the population management

guidelines are developed (see 4.7.3 above), these guidelines should be followed to carry out one or more of the following actions, as deemed appropriate. Actions are listed in order of increasing invasiveness:

- Protect nests with predator excluder (wire mesh caging).
- Move nests to nest tubs in the field, to protect eggs and hatchlings for one active season.
- Headstart eggs/hatchlings in captivity for one season.
- Headstart hatchlings in captivity for multiple seasons.
- Bring adult females into captivity to use for breeding/headstarting.

4.8. PREDATOR, BEAVER, AND COLLECTION THREAT MANAGEMENT

Predators and/or beaver activity can cause a dramatic increase in turtle mortalities, causing a population decline, on a site-by-site basis. Typically, predators will only be a periodic concern, but there may be some localities where predator control will be needed on a regular basis. Poaching and incidental collection can also cause precipitous declines in populations, particularly in small populations and locations in which collection occurs more than once.

4.8.1. PROTECT NESTS AND PERFORM PREDATOR CONTROL

Protecting nests from predators and removal of predator species by trapping can improve recruitment and survivorship of all age classes (depending on the focal predator species) (e.g., Macey 2015, Zappalorti 2017). In many cases, this can be attributed to only one or two individual predators that begin to target turtles, perhaps due to a decline on their preferred (non-turtle) prey. One such example regarding another turtle species was a single fox in Cape Cod that began to prey on Diamond-backed Terrapins. Over the course of one nesting season, more than a hundred terrapin carcasses were found. After trapping and removing the fox, the high depredation events ceased. For this reason, it is recommended that BMPs be developed for controlling problematic predators. Also see Section 4.9.7 below.

4.8.2. PERFORM BEAVER CONTROL

North American Beaver (*Castor Canadensis*) activity and flooding can have detrimental effects on a Bog Turtle population (Sirois et al. 2015). In many states, beavers had nearly become extirpated due to overexploitation for their pelts in the early 1900's. In recent decades, beaver populations have rebounded due to the implementation of trapping regulations and other conservation measures, as well as a decreased demand for furs. With the expanse of beaver populations, more individuals and family units are moving into marginal beaver habitats such as wet meadows and fens. In addition, roads and development have now reduced the plasticity of these wetland habitats to accommodate increased water levels and still maintain appropriate Bog Turtle habitat along the edges. At sites were this is the case, land managers may reduce the water levels by removing beaver, but continuous management of the beaver population will likely be needed. It is recommended that BMPs be developed for managing beaver in Bog Turtle habitats. Also see Section 4.9.8 below.

4.8.3. DEVELOP AN ANTI-POACHING/COLLECTION STRATEGY

The illegal trade in Emydidae turtles is of great concern for many turtle researchers throughout the northeastern U.S. No confiscations of Bog Turtle had occurred for many years prior to our Bog Turtle expert surveys in 2016–2017 and the general sentiment was that illegal collection may be a low-level threat for this species, as indicated by the expert survey results. However, in 2018 a confiscation occurred in New York State consisting of a large number of native turtles, including several Bog Turtles, among other turtle species of concern. Unfortunately, just one or two incidences of illegal collection can have severe consequences on a Bog Turtle population, particularly because many populations typically consists of less than 30 individuals.

Tasks/Action Items

- Engage law enforcement
    - Increase awareness and understanding of illicit collection.
    - Build collaborations among law enforcement, state and federal wildlife agencies, university researchers, non-profit conservation organizations, and zoos.
    - Determine means to assist law enforcement.
- Build collaborations with other turtle working groups (e.g., Northeastern Wood Turtle Working Group and Collaborative to Combat the Illegal Trade in Turtles).
- Determine if there are "hot spot" locations in which collection pressure may be greater
    - Increase surveillance in these areas by law enforcement.
- Genetics database
    - Create a workshop to train researchers in blood collection techniques.
- Compile records of confiscation/collection cases in the regional database.
- Pit tagging Bog Turtles:
    - See Section 4.5.11for research needs related to PIT tagging.
    - Create a training video to demonstrate how to pit tag Bog Turtles.
    - Hold training workshops for researchers.
    - Enter PIT tag numbers for all tagged Bog Turtles in the regional database.
        - This may aid in identifying the origin of confiscated turtles.
- Develop protocols for handling, housing, and (where possible) repatriation of confiscated turtles.
- Use cameras and other means of increased surveillance to monitor high-quality populations.
- Increase internet surveillance.
- Conduct broad public outreach/education (e.g., press releases).
- Perform an economic analysis and create supporting material to provide support for higher penalties and increase awareness among Judges.

4.8.4. TRAIN LAW ENFORCEMENT

Law enforcement personnel, particularly Federal and State natural resource/environmental police officers, are important conservation partners in efforts to protect populations of Bog Turtles and other imperiled species. Many wildlife agencies have staff members who hold trainings and workshops for natural resource police officers. It would be beneficial for USFWS law enforcement to take on a larger role in training state and local wildlife officers. These trainings aim to increase

awareness of the species at risk and inform of issues regarding the conservation of that species. Increased efforts to highlight and focus on the issue of illegal turtle collection are needed. Turtle or reptile specific workshops would be valuable to allow officers to learn more about the identification, habitats, and threats of native turtle species of concern.

4.9. BEST MANAGEMENT PRACTICES (BMPS)

The development of numerous best management practices (BMPs) would be useful to reduce impacts from roadside mowing, development, stream restoration, road culvert, bridge, and pipeline projects on Bog Turtle populations and habitat. Additionally, BMPs could be developed to improve road passageways, reduce mortality or injury risk from performing radio-telemetry, and control predators and beaver. These BMPs are outlined here and any BMPs that have been already been developed can be found in the Appendices section.

4.9.1. BMPS TO IMPROVE ROAD PASSAGEWAYS

Maintaining and improving connectivity among core habitats within the same population or metapopulation is desirable because many Bog Turtle populations are small and isolated. Presently, there are only 82 known extant Bog Turtle metapopulations in the Northern range. The Important Habitat Corridor spatial data identifies these locations of greatest importance to protect for connectivity (see Section 4.2.4). Within these areas, roads should be identified where improved turtle passageways are most needed. In addition, these areas should be protected from the construction of new roads unless these include adequate turtle passageways. Guidelines or BMPs are needed on passageway design recommendations, ways to retrofit or improve existing culverts and bridges, and recommendations for maintaining these structures over long periods of time. Brian Zarate of the New Jersey Department of Environmental Protection and several members of the NEPARC Roads Working Groups drafted the guidelines. Those recommendations have been slightly modified to be more specific for Bog Turtles. They can be found in Appendix F.

4.9.2. BMPS TO REDUCE IMPACTS FROM ROADSIDE MOWING PRACTICES

Mowing roadsides can cause mortality of Bog Turtles if turtles utilize roadside habitat. This is of particular concern on roads that are adjacent to or intersect with Bog Turtle core habitat. BMPs could provide recommendations regarding ways to reduce the risk of mortality. Depending on the configuration of a site, such guidelines could suggest providing an un-mowed buffer between the road and core habitat, specifying the time(s) of year when mowing should occur (when turtles would be unlikely to use the roadside habitat), and raising the mower blade to a height taller than a Bog Turtle. Guidelines exist in the USFWS BO and could be extracted for use in a more public friendly document to distribute to municipalities and land managers.

4.9.3. BMPS TO REDUCE IMPACTS FROM DEVELOPMENT PROJECTS

Development projects pose numerous potential direct and indirect negative impacts to Bog Turtle populations and habitat. Such impacts range from the destruction of habitat and crushing of turtles by heavy equipment to modification of water chemistry due to runoff and lawn chemical treatments. BMPs could provide guidance to minimize these impacts from the planning stage

through to completion of the project. For example, the BMPs could address how to deal with cumulative effects of land use decisions and development and potential conflicts of floodplain expansion to meet Total Maximum Daily Load standards for waters entering the Chesapeake Bay. These issues are ranked as high priority by experts and thus, are arguably the most important BMPs to develop in the near future.

4.9.4. BMPS TO REDUCE IMPACTS FROM STREAM RESTORATION, ROAD CULVERT, OR BRIDGE PROJECTS

Stream restoration may cause direct mortality to Bog Turtles by disturbing or dislodging turtles out of their hibernacula. Additionally, large machinery can damage Bog Turtle wetland habitat. Recommendations regarding reducing the impacts of stream restoration on Bog Turtles were drafted by Scott Smith of the Maryland Department of Natural Resources, Wildlife and Heritage Service and are in use in Maryland. These can be found in Appendix G.

4.9.5. BMPS TO REDUCE IMPACTS FROM PIPELINE PROJECTS

Numerous Bog Turtle populations inhabit utility company pipeline right-of-ways. Work done on pipelines such as installing new pipes or vegetation maintenance along the right-of-way can have negative impacts on the turtles and their habitat. These activities can result in crushing of turtles by the tires of heavy equipment such as excavators or mowers. Horizontal drilling to install pipes may pose a risk of habitat destruction by altering the hydrology or causing an inadvertent return (the release of drilling fluid). These activities are becoming more common due to the expansion of the natural gas industry in recent years. BMPs should be developed to minimize these risks to Bog Turtle populations.

4.9.6. BMPS FOR RADIO-TELEMETRY RESEARCH

Radio-telemetry research is a crucial methodology to understand habitat use and seasonal/annual movements of Bog Turtles. However, attachment of radio-transmitters may present some risk to turtles. The antennae of a transmitter can become entangled in vegetation or downed woody debris, entrapping the turtle. This can cause mortality risk due to sun exposure, dehydration, or depredation. In addition, there may be an impact on the turtle's health if the transmitter and epoxy package is too heavy for the turtle. Conventionally, researchers recommend that transmitter weight does not exceed 7% of the individual turtle's body weight. However, Bog Turtles may be able to accommodate a greater transmitted weight relative to other turtle species because they primarily crawl (as opposed to swim) and have relatively small home ranges. More research is needed to evaluate what is an appropriate transmitter weight limit for Bog Turtles. BMPs should be developed to provide standardized guidelines and identify where more research is needed regarding telemetry risk.

4.9.7. BMPS FOR CONTROLLING PREDATORS

Protecting Bog Turtle nests from predators and removal of predators at problematic sites can temporarily improve recruitment and survivorship of all age classes (depending on the species of predator). Nests can be protected with the use of wire mesh predator excluders and predators can

be trapped for removal. Past experiences have indicated that mortalities can be driven by one or two individual predators that begin to target turtles as a food resource. In removing these individuals, the problem is often rectified. Below are some considerations when developing these BMPs:

- If the habitat is in good condition and recruitment is low, consider trapping the site to reduce predators.
- Determine the predator species that are preying on turtles.
- Protect nests with hardware cloth cages. See section 4.8.1 for details.
- Trap and remove the predator species for one or two seasons.
- Communicate with adjacent landowners.
    - Talk with neighbors and ask them not to leave trash out or feed wildlife, particularly species that can increase predator populations. For example, raccoons and other predator species may eat cat food that is left outdoors.

4.9.8. BMPS FOR BEAVER MANAGEMENT

Beaver flooding and habitat alteration can impact Bog Turtle populations, particularly at sites where the wetland is restricted from natural expansion due to roads or development. Based on expert surveys, concerns of the impact from beaver are more prominent in the Hudson-Housatonic Recovery Unit. Beaver flooding not only raises the water level but can also change water chemistry, increase water level fluctuations, push turtles towards habitat adjacent to roads, and increase depredation risk due to a reduced turtle habitat area. BMPs should be developed for use at sites where beaver flooding and habitat alteration is of particular concern. Consideration should be given to the timing of removing beaver to avoid dropping water levels while turtles are in their hibernacula. In addition, recommendations should be made regarding the methodology for the release of water in the impoundment to avoid incising a nearby stream channel, which in turn can drain the wetland.

V. IMPLEMENTATION PLAN

A Recovery Unit Action Plan has been developed for each of the five recovery units (see Appendix A–E). These documents are for use by state and federal partners to guide their conservation efforts over the next 5–10 years. Most importantly, the action plans provide an implementation schedule that indicates priority actions for each recovery unit, potential partners to help accomplish these tasks, and a timeline for completing each action.

5.1. RECOVERY UNIT ACTION PLANS

The Recovery Unit Action Plans in Appendix A–E 1) identify and prioritize conservation strategies to be implemented; 2) identify populations and important habitat corridors to target for these conservation actions; and 3) articulate an implementation plan and benchmarks recommended for each recovery unit. This approach is based both on broad-scale and local perspectives, which are important to obtain recovery of the Bog Turtle across the Northern range while maintaining populations within each region.

5.1.1. IMPLEMENTATION AND BENCHMARKS

Each Recovery Unit Action Plan includes an implementation table to help guide conservation partners in their efforts to address the most pressing conservation needs. As funding and resources become available, conservation partners should use the Recovery Unit Action Plans to address those highest priority actions that have not yet been completed in each recovery unit. Additionally, conservation partners should use the priority population lists within each Recovery Unit Action Plan to maintain and recover populations.

Bog Turtle expert surveys were used to rank conservation strategies in order of their effectiveness and/or need. Experts within each Recovery Unit were polled to determine what conservation strategies would be most effective and are in greatest need for the recovery of the species within that unit. Based on the experts' responses, mean scores were calculated and used to group conservation strategies into the following categories:

> Priority 1: Strategies experts deemed to be the most urgent and effective for recovery. These actions should be completed before all other conservation strategies. Some of these actions have already been completed, are currently being implemented, or are planned for implementation in the next few years.
>
> Priority 2: Strategies that should be implemented after priority 1 strategies are underway or have been completed.
>
> Priority 3: Strategies that are of lowest priority for implementation. However, these strategies have been identified as being useful for the recovery of Bog Turtles. While these measures are considered of lesser need, they may be valuable in some circumstances. In general, these actions should only be implemented after priority 1 and 2 strategies are underway or have been completed.

The implementation table also contains a timeline for the completion of each conservation strategy. Conservation partners should work towards achieving these deadlines, particularly for the top priority actions. Some actions are currently underway and will be ongoing into the foreseeable future, such as monitoring of populations to track trends in populations status. Other actions are both of high priority and were identified as actions that should be completed within the next 5 years. However, some actions were considered to be of high priority but were to be completed within a longer timeframe (i.e., 5–10 years). Typically, this indicates that these actions were not considered achievable within a shorter period of time for practical reasons.

5.1.2. ADAPTIVE APPROACH AND PLAN UPDATES

This Conservation Plan and the associated Recovery Unit Action Plans should be considered a living document that will be updated as needed. At a minimum, it is recommended that they are reviewed and updated every 5–10 years. An adaptive approach is encouraged to ensure innovative new ideas and the most up-to-date research are implemented to aid in the recovery of the Bog Turtle. While this document lists priority actions, lower priority conservation actions or priority actions implemented at lower priority populations may still be warranted based on opportunities that arise and other agency priorities.

5.2. RECOVERY UNIT ACTION PLANS

A Recovery Unit Action Plan has been developed for each of the five recovery units (see Appendix A–E). These documents are for use by state and federal partners to guide their conservation efforts over the next 5–10 years. Most importantly the action plans provide an implementation schedule that indicates priority actions for each recovery unit, potential partners to help accomplish the tasks, and a timeline for completing each action.

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