BOG TURTLE *(Clemmys muhlenbergii)*
Northern Population

RECOVERY PLAN

U.S. Fish and Wildlife Service
Hadley, Massachusetts

BOG TURTLE *(Clemmys muhlenbergii)*, NORTHERN POPULATION

RECOVERY PLAN

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for

Region 5
U.S. Fish and Wildlife Service
Hadley, Massachusetts

Approved: Acting Dr. Richard O. Bennett

Date: 5-15-01 MAY 15 2001

EXECUTIVE SUMMARY
BOG TURTLE RECOVERY PLAN

Current Status: The northern population of the bog turtle was listed as a threatened species on November 4, 1997. This population is currently known to occur in Connecticut (5 sites), Delaware (4), Maryland (71), Massachusetts (3), New Jersey (165), New York (37), and Pennsylvania (75). The bog turtle has experienced at least a 50 percent reduction in range and numbers over the past 20 years. The greatest threats to its survival include the loss, degradation, and fragmentation of its habitat, compounded by the take of long-lived adult animals from wild populations for illegal wildlife trade.

Habitat Requirements and Limiting Factors: Bog turtles usually occur in small, discrete populations, generally occupying open-canopy, herbaceous sedge meadows and fens bordered by wooded areas. These wetlands are a mosaic of micro-habitats that include dry pockets, saturated areas, and areas that are periodically flooded. Bog turtles depend upon this diversity of micro-habitats for foraging, nesting, basking, hibernation and shelter. Unfragmented riparian systems that are sufficiently dynamic to allow the natural creation of open habitat are needed to compensate for ecological succession. Beaver, deer, and cattle may be instrumental in maintaining the open-canopy wetlands essential for this species' survival.

Recovery Objective: The overall objective of the bog turtle recovery program is to protect and maintain the northern population of this species and its habitat, enabling the eventual removal of the species from the Federal List of Endangered and Threatened Wildlife and Plants.

Recovery Criteria:

1. Long range protection is secured for at least 185 populations distributed among five recovery units: Prairie Peninsula/Lake Plain Recovery Unit (10), Outer Coastal Plain Recovery Unit (5), Hudson/Housatonic Recovery Unit (40), Susquehanna/Potomac Recovery Unit (50), and Delaware Recovery Unit (80).
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 this species' survival.
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.

Actions Needed:

1. Protect known extant populations and their habitat using existing regulations.
2. Secure long-term protection of bog turtle populations.
3. Conduct surveys of known, historical, and potential bog turtle habitat.
4. Investigate the genetic variability of the bog turtle throughout its range.
5. Reintroduce bog turtles into areas from which they have been extirpated or removed.
6. Manage and maintain bog turtle habitat to ensure its continuing suitability for bog turtles.
7. Manage bog turtle populations at extant sites, where necessary.
8. Conduct an effective law enforcement program to halt illicit take and commercialization of bog turtles.
9. Develop and implement an effective outreach and education program about bog turtles.

Estimated Costs ($000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Need 8	Need 9	Total
1	40	65	66			323	13.5	19.5	12	539
2	48	19	57	15		340	8	8	8	503
3	42	68	56	15	25	338	22	6	5.5	555
4-50	104	*	*		1*	20*	*	141*	*	266*
Total	234	152*	179*	30	26*	1001*	33.5*	174.5*	25.5*	1863*

* Future funding to be determined at later date

Date of Recovery: Delisting should be initiated in 2050, if recovery criteria are met.

* * *

The following recovery plan describes actions that should lead to the protection and recovery of the Federally listed northern population of the bog turtle *(Clemmys muhlenbergii)*. Attainment of recovery objectives and availability of funds are subject to budgetary and other constraints affecting plan implementation, as well as the need to address other priorities.

This approved plan was prepared through contract with Dr. Michael Klemens of the Wildlife Conservation Society in cooperation with Carole Copeyon of the U.S. Fish and Wildlife Service's Pennsylvania Field Office. Valuable input was also received from several resource experts. This document does not, however, necessarily represent the views or the official position of any individuals or agencies involved in its formulation other than the U.S. Fish and Wildlife Service. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 2001. Bog Turtle (*Clemmys muhlenbergii*), Northern Population, Recovery Plan. Hadley, Massachusetts. 103 pp.

Additional copies of this plan can be obtained from:

U.S. Fish and Wildlife Service
Pennsylvania Field Office
315 South Allen Street, Suite 322
State College, Pennsylvania 16801
(814) 234-4090

A copy of the plan will also be posted on the U.S. Fish and Wildlife Service's website:

http://www.fws.gov

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PART 1: INTRODUCTION

The northern allopatric population[1] of the bog turtle *(Clemmys muhlenbergii)*, which ranges through seven states from Massachusetts to Maryland, was listed as a threatened species on November 4, 1997, under the provisions of the Endangered Species Act of 1973, as amended (62 FR 59605-623). Concurrently, the southern allopatric population, which is found in five states from Virginia to Georgia, was listed as threatened due to similarity of appearance to the northern population. The bog turtle is threatened primarily by loss, fragmentation, and degradation of its fragile, early successional wet-meadow habitat, and by collection for the wildlife trade.

The recovery priority number[2] for this species is 12C. This ranking, determined in accordance with the recovery priority criteria in 48 FR 51985, is based on a moderate degree of threat, low potential for recovery (given current management technologies and legal protections), taxonomic standing as a distinct vertebrate population, and imminent conflict with development activity.

DESCRIPTION AND TAXONOMY

The bog turtle is the smallest member of the genus *Clemmys* and one of North America's smallest turtles. New England specimens are less than 100 millimeters in carapace length (Klemens 1990, 1993a), although farther south, bog turtles attain larger sizes up to a maximum of 115 mm (Ernst and Barbour 1989).

This turtle is recognized by a combination of two characters: a light brown to ebony, lightly sculptured carapace and a bright yellow, orange, or red blotch on each side of the head. The moderately domed and weakly keeled carapace may have a pattern of radiating light lines or be uniformly dark brown. The sides of the carapace are nearly parallel, giving the shell a distinctly oblong appearance when viewed from above. The plastron is variable in coloration,

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[1] "Northern population" in this document refers to the bog turtle population listed on November 4, 1997. This population occurs in the States of Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania.

[2] Recovery priority numbers from 1C to 18 are determined for all species listed pursuant to the Endangered Species Act. Species with a recovery priority of 1C ("C" = imminent conflict with development activity) receive the highest priority for preparation and implementation of recovery plans.

with strongly contrasting cream and black areas. The limbs are dark brown with reddish flecking; the feet are weakly webbed.

Hatchlings are similar in appearance to adults. Their tails are proportionately longer than those of adults. Sexual dimorphism is marked in adult animals. Males are characterized by a proportionately flatter carapace, concave plastron, and long, thick tail with the vent beyond the posterior carapace margin. Females are more highly domed and have a wider carapace for their size, have flat or slightly convex plastrons, relatively short and thinner tails, with the vent located beneath the posterior margin of the carapace.

The bog turtle was described as *Testudo muhlenbergii* by Schoepff (1801), from a specimen collected by Reverend Gotthilf Heinrich Ernst Muhlenberg. The type locality was "Pennsylvaniae"; the holotype was not designated and its location is unknown (Ernst and Bury 1977). Stejneger and Barbour (1917) restricted the type locality to "Lancaster, Pennsylvania." Fitzinger (1835) was the first to use the combination *Clemmys muhlenbergii*. Included in the synonymy of *Clemmys muhlenbergii* are *Emys biguttata* (Say 1825), lacking a designated holotype, type locality "United States," and restricted to the "vicinity of Philadelphia" by Schmidt (1953), and *Clemmys nuchalis* (Dunn 1917). The type specimen (American Museum of Natural History No. 8430) was collected by Dunn on August 17, 1916, on the "side of Yonahlossee Road, about 3 miles from Linville, North Carolina," at an altitude of 4,200 feet.

DISTRIBUTION AND STATUS

The species has been reported from twelve eastern states, with a discontinuous and localized distribution from western Massachusetts and Connecticut, southward through New York, New Jersey, Pennsylvania, Delaware and Maryland, and then southward in the Appalachian Mountains from southwestern Virginia, North Carolina, Tennessee and South Carolina to northern Georgia (Figure 1). There is a 250-mile gap in its current known distribution from northeastern Maryland to southern Virginia, creating two well-separated (i.e., allopatric) bog turtle populations ("northern population" and "southern population"). Disjunct populations (some of which are extirpated) have been reported from western Pennsylvania and the Lake George and Finger Lakes regions of New York.

Historical reports of bog turtles from Rhode Island and northern Virginia have been discounted. In Rhode Island, Babcock's (1917) report from an artificial pond at Newport is not generally accepted as representative of an indigenous population. In Virginia, Brady (1924) reported that a bog turtle had been collected in Fairfax County, near Washington, D.C. For many years, this record was considered to be the southern end of the range of the northern

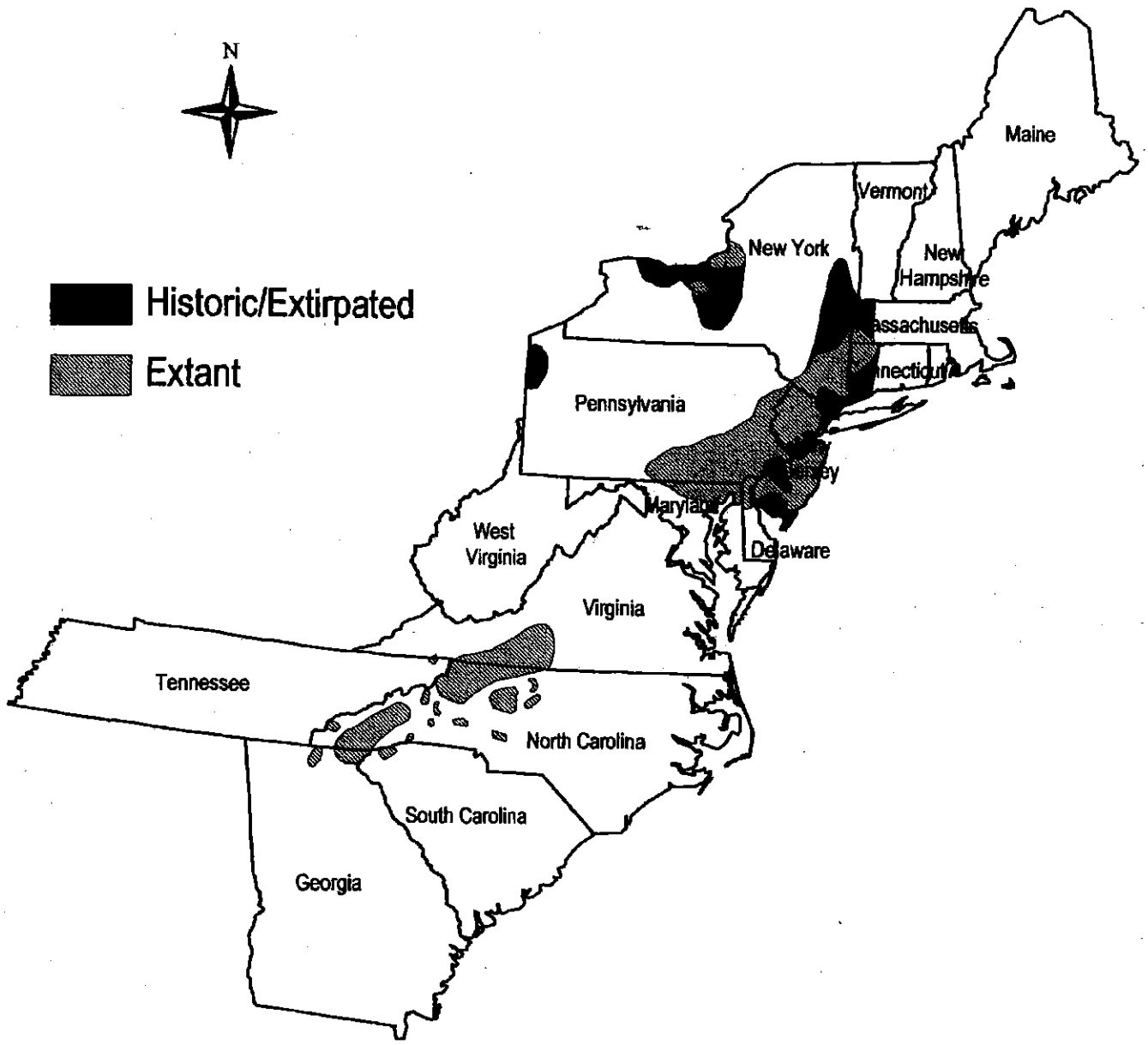

Figure 1. Bog Turtle Range Map

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population of the bog turtle; subsequently, however, Barton (1960) and Mitchell (1989) both reported that this specimen (deposited in the United States National Museum, No. 95195) was a juvenile wood turtle (*Clemmys insculpta)*. Mitchell (1989) found no evidence that bog turtles ever occurred in northern Virginia.

Bog turtles in the Northeast are found in the inter-montane valleys and rolling hills of the Piedmont. This coincides with the portions of the landscape that have the highest-value agricultural lands and with sites that are most useful for human settlement and transportation corridors. Whereas the more rugged and less fertile highland areas have large tracts of public lands (particularly state and federal forest lands), there is proportionately very little habitat of the type used by bog turtles in the public ownership portfolio. In addition, because of the high agricultural value of the land and historical settlement patterns, most bog turtle populations and their wetland habitats encompass lands held by multiple owners; in certain more urban areas, these ownerships can exceed 100 separate properties per bog turtle site. In contrast, many of the highest quality bog turtle sites encompass fewer ownership parcels, a direct correlation with a less urbanized landscape.

Barton and Price (1955), Nemuras (1967, 1975), Ernst and Bury (1977), and Bury (1979) reviewed the distribution of *Clemmys muhlenbergii*. Since Bury's (1979) paper, additional locality records, especially from the northern and southern limits of the range, have been published. Table 1 and Figure 2 indicate the historical and current distribution of the turtle within its northern range on a county-by-county basis.

The northern population of *Clemmys muhlenbergii* comprises 350 extant sites (PAS). This is an increase from the 191 known extant sites comprising the northern population in 1996, when the species' status was evaluated prior to federal listing. Many of the newly discovered sites, however, are small, marginally viable, and under threat of development. Considering this, the species' threatened status (which is based more on the nature, magnitude and immediacy of threats than the total number of occurrences) has not changed significantly since listing.

A protocol known as the "Standardized Bog Turtle Site-quality Analysis" (Appendix C) was developed to assess the capacity of sites to maintain viable populations of bog turtles (Klemens 1993b). For purposes of bog turtle conservation, this protocol groups bog turtle occurrences into "population analysis sites (PAS)"[3] based on the likelihood of turtles moving

[3] "Site" and "Population Analysis Site" (or "PAS") are used interchangeably in this document. Both refer to the wetland or group of wetlands supporting bog turtles, as defined by Klemens' 1993 *Standardized Bog Turtle Site-quality Analysis* (Appendix C). Conversely, the term "occurrence" refers to a specific documented location (e.g., a single wetland occupied by bog turtles). "Population" in this plan usually refers to the bog turtles occupying a single site or PAS. As additional data become available regarding bog turtle movements between wetlands, and genetic variation within and between sites, this definition may be revised.

Table 1. Status of the Bog Turtle, Northern Population (as of 2000)

STATE	COUNTY	STATUS[1]
Connecticut	Fairfield	historical
	Litchfield	extant
Delaware	New Castle	extant
Maryland	Baltimore	extant
	Carroll	extant
	Cecil	extant
	Harford	extant
Massachusetts	Berkshire	extant
New Jersey	Atlantic	extant
	Bergen	extirpated
	Burlington	extant
	Camden	historical
	Cape May	extirpated
	Gloucester	extant
	Hunterdon	extant
	Mercer	historical
	Middlesex	historical
	Monmouth	extant
	Morris	extant
	Ocean	extant
	Passaic	extant
	Salem	extant
	Somerset	extant
	Sussex	extant
	Union	extant
	Warren	extant
New York	Albany	historical
	Columbia	extant
	Dutchess	extant
	Genessee	extant
	Monroe	historical
	Onondaga	historical
	Orange	extant
	Oswego	extant
	Otsego	extirpated
	Putnam	extant
	Rensselaer	historical
	Rockland	historical
	Seneca	extant
	Sullivan	extant
	Tompkins	extirpated
	Ulster	extant
	Warren	historical
	Wayne	historical
	Westchester	extant
Pennsylvania	Adams	extant
	Berks	extant
	Bucks	extant
	Chester	extant
	Crawford	historical
	Cumberland	extant
	Delaware	extant
	Franklin	extant
	Lancaster	extant
	Lebanon	extant
	Lehigh	extant
	Mercer	historical
	Monroe	extant
	Montgomery	extant
	Northampton	extant
	Philadelphia	extirpated
	York	extant

[1] "Extant" indicates the species has been documented to occur in the county within the past 25 years; in most cases, their presence and/or the presence of suitable habitat has been recently confirmed.
"Historical" indicates that bog turtles were documented to occur in the county more than 25 years ago; although their presence has not been recently confirmed, they may still be present.
"Extirpated" indicates that the species was documented to occur in the county historically, but is no longer likely to be present.

Figure 2. Distribution and status of the northern population of the bog turtle

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between documented occurrence locations and interbreeding (see discussion, Klemens 1993b). Under this rubric, each site, or PAS, may link individual bog turtle occurrences into larger groupings based upon a number of factors including proximity and lack of impediments to turtle movement. Due to widespread wetland habitat fragmentation, many PAS consist of only one small extant occurrence, often isolated from other such occurrences. It should be noted, however, that the loss of small isolated sites as they "blink out" is increasing the proportion of multi-occurrence PAS over time. For instance, out of a total of 94 PAS ever discovered in Maryland, including historical (Taylor *et al.* 1984; 90 PAS), 58 (or 62 percent) were reported as single occurrences; however, of the 61 extant Maryland PAS, 29 (48 percent) are single occurrences (S. Smith, Maryland Department of Natural Resources, *in litt.* 2001).

This approach recognizes that the ecologically functional unit in bog turtle populations is the metapopulation rather than an individual site occurrence. Buhlmann *et al.* (1997, p. 359), citing Levins (1970), state that "a metapopulation refers to a collection of populations that exist within a landscape matrix and are separated by areas of different or unsuitable habitat." They go on to state that this concept implies that individuals in the subpopulations (individual sites) are able to interact with other subpopulations and that the degree to which this occurs is a function of: (1) the proximity of adjacent populations; (2) the availability of corridor habitats, i.e., ecological connections within the landscape that enable individuals to travel between patches of suitable habitat; and (3) the ability and proclivity of individuals to disperse between habitat patches (Buhlmann *et al.* 1997).

A site is ranked according to four factors: (1) habitat size and degree of fragmentation; (2) the presence of invasive plants and later successional species; (3) immediate threats such as wetland ditching, draining, filling or excavation; and (4) the type and extent of land use in the area. Where adequate data are available, sites are also ranked according to population size and evidence of recruitment.

Using this site-quality analysis, the individuals most familiar with each site (i.e., the primary bog turtle researchers in each state) assessed and ranked the suitability of almost every known bog turtle site within the range of the northern population. Each site was assigned a numerical score, which was then translated into a good, fair, or poor ranking. By incorporating the four factors relating to habitat quality and threats, these rankings portray the suitability of the sites to maintain viable bog turtle populations (Table 2).

It should be noted that the site assessments were based on researchers' best professional judgments regarding site suitability, and that the classifications based upon these assessments are conservative for several reasons. For instance, threats from illegal collecting were not considered. Also, rankings were often based on interpretation of maps that are more than 10 years old; therefore, recent land use changes such as development were not considered. In addition, at some sites the presence of turtles had not been confirmed for more than 10 years.

Table 2. Quality of Extant Bog Turtle Sites[1] by State (as of 2000)

State	No. Good Sites	No. Fair Sites	No. Poor Sites	Total Sites
Connecticut	0	4	1	5
Delaware	0	4	0	4
Maryland	12	25	24	61
Massachusetts	2	0	1	3
New Jersey	72	n/a[2]	n/a	165
New York	8	15	12	37[3]
Pennsylvania	n/a	n/a	n/a	75
Northern Range	104[4]	48	38	350

1 Site = PAS. The PAS (Population Analysis Site) was developed by linking individual occurrences into larger groupings based upon a number of factors including proximity and lack of impediments to turtle movement.

2 Ranking information not available. In New Jersey, the 93 extant sites not ranked as good are not differentiated between fair and poor. Pennsylvania has not ranked its 75 sites.

3 Two of the 37 New York sites were not ranked.

4 Rangewide figures for each ranking are equal to or greater than the number displayed due to unranked sites in New Jersey and Pennsylvania.

The following summaries present information about the status and distribution of the 350 extant PAS comprising the northern population. It should be noted that the citations in this section do not constitute a complete state-by-state compilation of locality reports, but they do include pertinent references, especially those published since Bury (1979).

Connecticut: Bog turtles are restricted to extreme western Connecticut in Fairfield and Litchfield counties (Robinson 1956; Warner 1975; Klemens and Warner 1983; Warner 1988; Klemens 1990, 1993a). Klemens (1991) reported that "twelve populations have been found, but many of these have been extirpated since the 1970's, and the remaining bog turtles populations were now confined to two rural townships." The five remaining populations referenced above, four of which are classified as fair and one as poor (see Table 2), are found on private lands (J. Victoria, Connecticut Division of Wildlife, *in litt.* 1994). Additionally, in 1998 an adult female was found crossing a road in a third northwestern Connecticut township. Unlike the other occurrences, however, this sighting was on the east side of the Housatonic River in appropriate calcareous wetland habitat (J. Victoria, *in litt.* 1998). This is the first authentic bog turtle record east of the Housatonic River. Surveys in 1999 identified suitable bog turtle habitat in the vicinity of the sighting, but no bog turtles were found (J. Victoria, *in litt.* 2000). Additional field surveys will be required to determine the status of this species east of the Housatonic River in northwestern Connecticut.

Delaware: Arndt (1972, 1977) reported on the distribution of bog turtles in Delaware. He also (Arndt 1978, 1982) questioned whether the bog turtle was endangered in Delaware as well as in other parts of its range. Klemens (1991), reporting on information provided by L. Gelvin-Innvaer of the Delaware Nongame Wildlife Program, stated that of 11 known Delaware populations, only four are viable and considered to be extant. Of these four sites, two occur on state lands and two on private property, and all are designated as fair quality (L. Gelvin-Innvaer, J. Greenwood, and W. Zawaki, Delaware Division of Fish and Wildlife, *in litt.* 1994). L. Gelvin-Innvaer (*in litt.* 1998) reported bog turtle populations in four watersheds within the Piedmont, of which at least two watersheds had recent reports of bog turtle activity. She also cited five historical records from the Coastal Plain, albeit without any recent observations.

Maryland: Bog turtles are restricted to the four Piedmont counties surrounding Baltimore. They are widely distributed in Baltimore, Cecil, and Harford counties, and restricted to the northeastern corner of Carroll County (McCauley and Manseuti 1943; McCauley 1945; Cooper 1949; Reed 1956; Campbell 1960; Nemuras 1965, 1966; Harris 1975; Taylor *et al.* 1984; Chase *et al.* 1989.) From 1976-1978, a total of 689 wetlands in six counties were surveyed, resulting in 173 new occurrences in these four counties (Taylor *et al.* 1984). However, bog turtles were found at only four of the 23 pre-1976 locations surveyed (of 30 total). In 1992-93, S. Smith (unpubl. data submitted to USFWS in 1994) resurveyed 159 of the Taylor *et al.* (1984) occurrences following survey protocols similar to those in Appendix B. Bog turtles were found at only 91 wetlands, representing 56 PAS. Subsequent surveys from 1994-2000 identified eight new occurrences representing five additional PAS, for a total of 61 extant PAS. Bog turtles are extant in 11 watersheds in Maryland (Smith, *in litt.* 2001). Approximately 97 percent of the bog

turtle habitat in Maryland is privately owned and the other 3 percent is in state ownership (Smith, *in litt.* 1994). A total of 61 extant PAS was documented in Maryland as of August 2000.

Massachusetts: The bog turtle is restricted to a small area of southwestern Massachusetts, in Berkshire County (Blanchard 1970; Klemens and Mirick 1985; Klemens 1990, 1993a). Klemens (1991) reported that one population found in the 1960s is now extirpated. Of three populations recently discovered by Klemens (1990, 1993a), two are classified as good and one as poor. The two good-quality sites occur on protected lands, and the one poor population is on private lands.

New Jersey: Bog turtles were historically reported from throughout New Jersey, as documented by Anon. (1861), Fowler (1906, 1907), Street (1914), Myers (1930), Conant and Bailey (1936), Grant (1966), Zappalorti (1976), and Arndt (1986). Although these reports indicate that bog turtles once occurred in 18 counties, they are now found in only 13: Atlantic, Burlington, Gloucester, Hunterdon, Monmouth, Morris, Ocean, Passaic, Salem, Somerset, Sussex, Union and Warren (J. Sciascia, New Jersey Department of Fish, Game and Wildlife, and R. Zappalorti, Herpetological Associates, Inc., *in litt.* 1994; Sciascia, *in litt.* 1998; J. Tesauro, New Jersey Department of Fish, Game and Wildlife, *in litt.* 2000). Approximately 90 percent of the turtle habitat in New Jersey is privately owned, while the State and Federal governments own 5 percent each (Sciascia and Zappalorti, *in litt.* 1994).

The number of known extant populations in New Jersey has fluctuated significantly over time. In 1978, bog turtles were found at 68 localities, but a survey in 1989 found no turtles at 44 of these localities, representing a net loss of 65 percent of the known populations. Development was the major cause of habitat loss, followed by natural succession, then wetlands alteration and pollution (Zappalorti and Farrell 1989).

Prior to the 1993 initiation of the New Jersey Endangered and Nongame Species Program's bog turtle project, there were 196 documented bog turtle sites (PAS). Field inspections of 178 of these PAS were performed by the NJ-ENSP between 1995 and 1998. This survey concluded that 90 of the 178 PAS are extant and 88 are historical. Of the remaining 18 documented PAS's, 13 have not been surveyed and five are of vague geographic location (J. Tesauro, New Jersey Department of Fish and Wildlife, *in litt.* 2000).

Between 1993 and 2000, the NJ-ENSP conducted *de novo* searches of approximately 1400 wetlands in Burlington, Gloucester, Hunterdon, Monmouth, Salem, Somerset, Sussex and Warren counties for the presence of bog turtle habitat and/or bog turtles. These surveys resulted in the discovery of 75 new bog turtle PAS, increasing the total number of PAS to 165 as of August 15, 2000. Based upon habitat quality and population data, the NJ-ENSP has determined that 72 of these PAS are viable and 93 are potentially viable or non-viable. The 72 viable populations are the focus of the NJ-ENSP's long-term bog turtle conservation strategy, which includes habitat management and restoration, developing cooperative relationships with private landowners, and acquiring sites threatened by secondary impacts.

New York: The bog turtle's range in New York is concentrated primarily in the southeastern corner of the state, where they have been reported from both sides of the Hudson River as far north as Albany. Disjunct populations occur in the Lake George (northeastern New York) and Finger Lakes (western New York) regions and south-central New York (Fisher 1887; Eckel and Paulmier 1902; Reed and Wright 1909; Wright 1918a, 1918b, 1919; Bishop 1923; Myers 1930; Stewart 1947; Ashley 1948; Benton and Smiley 1961; Collins 1989). Mathewson (1955) did not consider the three specimens that were reported from Staten Island as representing an indigenous population.

The Lake George, Albany, and Rensselaer counties and south-central populations have been extirpated, and only one extant Seneca County site remains in the Finger Lakes region (A. Breisch and M. Kallaji, New York Department of Environmental Conservation, and P. Novak, New York Natural Heritage Program, *in litt.* 1994; P. Novak, *in litt.* 1997). Three new sites have been discovered since 1995 in Oswego County, New York, which represents the northern limit of this species' range (A. Breisch, *in litt.* 1998, P. Rosenbaum, State University of New York at Oswego, *in litt.*, 2000). Bog turtles are considered extirpated from Rockland County, one of the lower Hudson Valley counties closest to New York City. Regarding Westchester County, because bog turtles were still found there in the early 1990s, this county meets the USFWS criteria for "extant" (see Table 1). Four extant PAS remain in the disjunct portion of the bog turtle's range in New York, while 33 extant sites remain in southeastern New York. Of the 37 extant sites, eight are considered good, 15 fair, 12 poor, and two have not been ranked. Nearly all extant bog turtle sites (95 percent) occur on private lands; the remaining 5 percent is found on state lands (G. Barnhart, New York Department of Environmental Conservation, *in litt.* 2000).

Pennsylvania: Along with New Jersey and Maryland, eastern Pennsylvania has been long considered the stronghold of this species. Apart from numerous locality reports (Surface 1908, Dunn 1915, Mattern and Mattern 1917, Roddy 1928, Burger 1933, Heilman 1951, Swanson 1952, Hudson 1954, Behler 1970, 1972), several ecological studies and life history studies (e.g., Barton and Price 1955, Ernst 1977) were undertaken in southeastern Pennsylvania. A disjunct population of bog turtles occurred in northwestern Pennsylvania. A. Wilkinson (Nature Conservancy, Pennsylvania Natural Heritage Program, pers. comm. 1992) considered this isolated population, first reported by Netting (1927), to be extirpated.

Bog turtles are still found in 14 of the 17 counties from which the species was previously reported (Adams, Berks, Bucks, Chester, Cumberland, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, and York). A total of 75 extant PAS was documented as of 2000, almost all of which are located in the Delaware and Susquehanna River watersheds. A single site occurs in the Potomac River watershed. Approximately 85 percent of the bog turtle's habitat is found on private lands, with the remainder occurring on state and federal lands (10 percent and 5 percent, respectively) (B. Barton, Pennsylvania Chapter of The Nature Conservancy, *in litt.* 1994).

BIOLOGY

Habitat

Bog turtles have been found at elevations ranging from near sea level in the north to 1500 meters in the south (Herman and George 1986). They usually occur in small, discrete populations occupying suitable wetland habitat dispersed along a watershed. These wetlands are a mosaic of micro-habitats that include dry pockets, saturated areas, and areas that are periodically flooded. The turtles depend upon this diversity of micro-habitats for foraging, nesting, basking, hibernation, shelter, and other needs. Unless disrupted by fire, beaver activity, grazing, or periodic wet years, open-canopy wetlands are slowly invaded by woody vegetation and undergo a transition into closed-canopy, wooded swamplands that are unsuitable for habitation by bog turtles (Tryon and Herman 1990, Klemens 1993a). Historically, bog turtles probably moved from one open-canopy wetland patch to another, as succession closed wetland canopies in some areas and natural processes (e.g., beaver activity or fire) opened canopies in other areas (Klemens 1989).

Bog turtles inhabit a variety of wetland types throughout their range, but generally these are small, open-canopy, herbaceous sedge meadows and fens bordered by more thickly vegetated and wooded areas. Throughout the bog turtle's northern range, seepage or spring-fed emergent wetlands associated with streams are the primary habitat (S. Smith, *in litt.* 2000). These are often at or near the headwaters of streams or small tributaries. The habitats are often elongate or strip-like transitional zones between drier upland areas and more thickly vegetated, wetter, wooded swamp or marsh. Although bog turtles are dependent upon suitable open-canopy sedge meadows and fens for many of their ecological requirements such as foraging, reproduction, and thermoregulation, they also utilize more densely vegetated areas for hibernation (see Hibernation, p. 15) and may be incidentally found in a wide variety of habitats when making relatively long-distance movements (Buhlmann *et al.* 1997; Carter *et al.* 1999, 2000; Morrow *et al.* 2001). The continued existence of these habitat mosaics, as well as the ecological connections between these areas, is required to maintain bog turtle populations.

Bog turtles inhabit sub-climax seral wetland stages and are dependent on riparian systems that are unfragmented and sufficiently dynamic to allow the natural creation of meadows and open habitat to compensate for the closing-over of habitats caused by ecological succession. Kiviat (1978) reported that bog turtles were able to disperse between habitat patches of changing vegetation within a long-term, stable, wetland complex. He found that beaver, deer, and cattle may be instrumental in maintaining the open-canopy wetlands essential for this species' survival. Muskrat (*Ondatra zibethicus*) and meadow vole (*Microtus pennsylvanicus*) also play an important role in maintaining bog turtle habitat and providing travel pathways (C. Ernst, *in litt.*, 2000). Succession of many wetlands from open-canopy fens to closed-canopy red maple swamps may account for the bog turtle's irregular and shrinking distribution. The "trapping out" of beaver in many areas during colonial and early post-colonial times undoubtedly

accelerated successional changes in wetland vegetation by fostering the unimpeded growth of wooded swamps, with an associated decline of bog turtles.

Currently, many wetlands occupied by bog turtles in agricultural areas are subject to livestock grazing. Light to moderate grazing may function to impede succession by preventing or minimizing the encroachment of invasive native and exotic plant species, thereby maintaining an intermediate stage of succession (Tryon and Herman 1990). It has been suggested that in pre-colonial times the grazing activities of large herbivores such as bison (*Bison bison*) and elk (*Cervus canadensis*) may have been important in maintaining bog turtle habitat (Lee and Norden 1996). The occurrence of bog turtles in wetlands grazed by livestock is probably an instance where grazing by livestock has either replaced grazing by native herbivores or replaced one of the other historical factors (e.g., beaver, fire) that would have acted to maintain the wetlands in an early successional stage.

In some areas, fire may have played an important role in maintaining the open nature of bog turtle wetlands. For example, annual spring burns were used by farmers at two Massachusetts bog turtle sites to maintain the wetlands in an open state (F. Lowenstein, Massachusetts Chapter of The Nature Conservancy, *in litt.* 2000). In fact, aerial photos show that the extent of these wetlands has declined significantly since this routine burning was discontinued in the late 1960s. Evidence suggests that fire also occurred in these wetlands during pre-settlement times; these fires may also have been set by humans to maintain open habitat (Lowenstein, *in litt.* 2000).

The following descriptions of bog turtle habitats from New England and Maryland show the overall similarity of these sites, although there is variation due to local conditions, topography, and land use. Klemens (1990, 1993a) reported that New England bog turtles inhabited calcareous wet meadows, pastures, and fens, usually bordered by shrub and red-maple swamps. These wetlands were characterized by a continuous flow of water seeping through the saturated surface soil and contained an extremely diverse vegetational community. Bog turtles inhabited small pockets of open-canopy habitat located within these diverse and dynamic wetland ecosystems. All New England bog turtle sites drained directly into a riparian system. In addition, Lowenstein (*in litt.* 2000) noted that at several Massachusetts, Connecticut, and New York bog turtle sites, "hydrology is driven by extensive recharge from high bedrock ridges, with such recharge temporarily stored by stratified glacial drift deposits on the lower slopes of the ridges and then gradually discharged to wetlands below that include bog turtle sites." He noted that this hydrologic system could be affected by changes in imperviousness and water withdrawal extending for more than a mile from wetlands inhabited by bog turtles.

Some of the stream valleys in the Piedmont of Maryland are underlain with marble; thus, some of Maryland's bog turtle wetlands are circumneutral/calcareous (S. Smith, *in litt.* 2000). Taylor *et al.* (1984) reported that Maryland bog turtle sites were small (usually less than 2 acres) tussock sedge meadows, often bordered by wooded swamp, with a soft, saturated substratum and a fairly constant supply of seeping water running in well-defined rivulets. They reported that 67

species of herbaceous plants occurred in bog turtle sites. Chase *et al.* (1989) reported that bog turtles in Maryland were found in circular basins with spring-fed pockets of shallow water, a substrate of soft mud, dominant vegetation of low grasses and sedges, and interspersed wet and dry pockets. Bog turtles often utilize the runways of muskrats and meadow voles (Barton and Price 1955, Nemuras 1967, Taylor *et al.* 1984).

Tryon and Herman (1990) noted that bog turtle habitats in the species' southern range are typically small in acreage and disjunct, with many sites located in small mountain valleys. Turtles seemed to be associated with "Old Southern Appalachian Bog" habitat, characterized by thick sphagnum moss, crested fern, rhododendron and laurel, or an associated marsh dominated by ferns, sedges, rushes, sweet flag, and cattails. In the southern range, higher turtle population densities occur in areas that are grazed than in areas that have no grazing or where grazing has been discontinued. Presently, 81 percent of all southern bog turtle sites are known to occur in currently grazed and formerly grazed sites (D. Herman, North Carolina Museum of Natural Sciences, *in litt.* 2000). Furthermore, 94 percent of wetlands supporting 20 or more (observed) bog turtles are grazed or recently grazed sites (Herman *in litt.* 2000).

Several plant species commonly associated with bog turtle habitats include alders (*Alnus* sp.), willows (*Salix* sp.), sedges (*Carex* sp.), spike rushes (*Eleocharis* sp.), sphagnum moss (*Sphagnum* sp.), jewelweed (*Impatiens capensis*), rice cut-grass (*Leersia oryzoides*), tearthumb (*Polygonum sagittatum*), arrow arum (*Peltandra virginica*), red maple (*Acer rubrum*), skunk cabbage (*Symplocarpus foetidus*), cattails (*Typha* sp.), and bulrushes (*Juncus* sp. and *Scirpus* sp.) (Barton and Price 1955; Arndt 1977; Taylor *et al.* 1984; Herman and George 1986; Carter *et al.* 1999, 2000). Pedestal vegetation, such as tussock sedge (*C. stricta*) and sphagnum moss, is utilized for nesting and basking (Klemens 1993a).

Annual Activity Patterns

Bog turtles become active in late March to late April, depending upon latitude, elevation, and seasonal weather conditions. At the northern limit of their range, Klemens (1990, 1993a) found New England bog turtles active from April 26 through September 26, with 85 percent of all observations occurring in May and June. In southeastern New York, where a population has been under observation since 1974 (J. Behler, pers. comm.), aberrant surface activity has been noted both in late February and March as well as in early October, but activity typically commences in the first or second week of April and ends in mid-September. In Pennsylvania, Ernst (1977) reported that bog turtles were active from late March through late September. In Maryland, S. Smith (in litt. 2001) reports that bog turtles are hard to find before late April, although in 1998 and 1999 following exceedingly warm winters they emerged in early April (Smith *in litt.* 2001); further, about 80 percent of the 933 bog turtle captures in Maryland from 1976-1995 occurred in May, June, or July (Taylor *et al.* 1984, Chase 1989, Smith unpubl. data). Lovich *et al.* (1992) reported that most bog turtle captures in North Carolina occurred between April and July.

Hibernation

Bog turtles generally retreat back into more densely vegetated areas to hibernate. In Massachusetts, Klemens (1993a) reported that early season captures of bog turtles were concentrated on and near shrubby hummocks that served as hibernacula at the interface zone between open fen habitats and shrub and wooded swamp. These hummocks were covered with small trees and shrubs (primarily alder, gray birch, red maple, and tamarack) with springs percolating up around them. Narrow, tunnel-like cavities were angled downward through these hummocks, passing in between the tangled tree roots, and then down into the water. Bog turtles were observed basking at the mouths of these tunnels in early May, but by mid-May most turtles had moved from the sheltered hummock areas out into the open fen, although a few turtles remained around a spring-fed alder clump throughout the spring and summer activity season.

Ernst *et al.* (1989) reported on bog turtle hibernation sites in New Jersey and Pennsylvania. They found turtles hibernating in spring-fed rivulets under soft mud, in muskrat burrows, under sedge clumps, at the base of tree stumps, and in meadow vole burrows. J.L. Morrow reported finding 17 bog turtles and one spotted turtle in a communal hibernaculum in Harford County, Maryland (S. Smith, *in litt.* 2000). In southeastern New York, J. L. Behler (pers. comm.) found numbers of bog turtles over-wintering together with spotted turtles (*Clemmys guttata*) in an old muskrat lodge, muskrat burrows, and a stone wall. The turtles demonstrated strong fidelity to their hibernacula. All hibernacula were flooded throughout the year, but were never judged to be anoxic as they were located along spring-fed rivulets, or in a stream on a flood plain. Hibernating turtles were found under water in soft mud, in crevices between rocks, or between tangled roots.

Daily Activity Patterns

Klemens (1990, 1993a) reported that daily activity in Massachusetts's populations varied considerably with the time of year, prevailing weather conditions, and the previous night's temperature. During periods of warm weather in late May and June, bog turtles usually emerged between 0800-0900 h and basked for several hours. However, during spring and autumn, or during periods of cool weather, turtles emerged in mid-morning and were found basking throughout the day; on windy days, bog turtles basked under the dead, dry vegetation atop tussocks. In southeastern New York, J. L. Behler (pers. comm.) found that bog turtles are primarily active between 0800-1700 h; however, following mild May-June nights, turtles were observed to leave their nocturnal retreats as early as 0600-0700 h to bask in the early morning sun, and in June, nesting females were active until 2000-2100 h. Basking behavior was affected by weather conditions. Sluggish, early season basking turtles were usually found well-exposed on the side or top of a tussock. On cooler, windy days, basking turtles were often partially hidden under dry vegetation, and during warm summer days, individuals were most frequently observed basking half-buried in a self-made depression on a shallow, flooded mud flat, with only a small portion of their carapace breaking the water's surface.

Population Densities and Home Range

Eglis (1967) reported that densities of bog turtles have been estimated from 5 to 125 individuals per ha. A number of studies have reported especially high densities, including Chase *et al.* (1989) who estimated density at one of their sites at 213 turtles per ha, and Bury (1979) who report 140 per ha. Such densities are exceptional and many populations contain fewer than 50 animals (Klemens 1990, 1993a; Tryon 1990a).

Movement and home ranges reported are variable. Klemens (1990, 1993a) reported that a Massachusetts female moved 335 m between capture and recapture points within a month. Breisch *et al.* (1988) found that bog turtles in southeastern New York ranged as far as 750 m in a single year. Ernst (1977) calculated a mean home range of 1.28 ha for 19 bog turtles in eastern Pennsylvania. Males averaged 1.33 ha and females 1.26 ha. Chase *et al.* (1989) reported that the home range of Maryland males averaged 0.176 ha and the home range of females averaged 0.066 ha. Chase *et al.* (1989) also reported that although turtles had small activity ranges, they moved extensively within these ranges, and that these home ranges rarely extended beyond the habitat's transitional zone. Morrow *et al.* (2001) reported home ranges varying from 0.003 - 3.12 ha (N=50) at two sites in Maryland. One of these sites was previously studied by Chase *et al.* (1989), who reported much smaller home ranges (see above). Morrow *et al.* (2001) suggest that the observed expansion in home range size may indicate a decrease in habitat quality, in this case due to an increase in invasive vegetation, primarily multiflora rose. Although some studies have shown male turtles to have a larger home range than females (e.g., Ernst 1977; Chase *et al.* 1989), Carter *et al.* (1999, 2000) and Morrow *et al.* (2001) contradict these findings. They found that home range sizes and distances traveled were not significantly different between sexes, although Morrow *et al.* (2001) did find that males expand their home ranges during the mating season.

Occasionally, individual bog turtles are found crossing roads a considerable distance from any apparently suitable habitat. These apparent long distance movements may result from emigration out of habitats declining in quality through disturbances or succession. Carter *et al.* (2000) report capturing a marked nine-year-old male crossing a road 2,700 m (straight-line distance) from where it was captured the year before. Over the next 24 hours, it traveled 375 m from its capture point, through a white pine (*Pinus sorbus*) plantation, after which time radio contact was lost.

Reproduction

Most researchers have reported a fairly even sex ratio. Although Klemens (1990, 1993a) found significantly more adult females than males at two of his Massachusetts study sites, subsequent fieldwork by A. Whitlock (pers. comm.) at these sites has produced more even sex ratios. J. L. Behler (pers. comm.) observed a 1:2 male to female ratio at his southeastern New York study site. The smallest sexually mature Massachusetts turtles reported by Klemens (1990, 1993a) was a male with fully developed secondary sexual characteristics in his ninth year,

measuring 73 mm plastron length, and two gravid females which measured 76 mm and 79 mm plastron length, in their fifteenth and tenth years, respectively. In eastern Pennsylvania, Ernst (1977) reported that both sexes attained sexual maturity at 70 mm plastron length, with some individuals maturing in their sixth year.

Klemens (1990, 1993a) observed copulating Massachusetts bog turtles, both on tussocks and in shallow rivulets, in mid-May. Other authors (e.g., Barton and Price 1955, Campbell 1960, Robotham 1963, Arndt 1977) have observed copulation in the field in May and early June. Ernst (1983) reported a natural hybrid between *Clemmys muhlenbergii* and *Clemmys guttata*. Klemens (1990, 1993a) found gravid (containing fully shelled eggs ready for laying) Massachusetts females as early as May 24 and as late as June 16. J.L. Behler (pers. comm.) found that southeastern New York females nested between June 9 and 21.

Nesting usually occurs in the late afternoon or early evening and takes approximately three hours (Holub and Bloomer 1977). A cavity is dug with alternating scoops of the hind feet, the eggs deposited, and then back-filled with the hind feet, and smoothed over by moving the plastron over the covered nest, although Mitchell *et al.* (1991) reported that "often no formal nest is dug, but instead eggs are merely laid in the top of sedge tussocks." Bury (1979) reported that clutch size varied from 1-5 eggs, with 3-5 eggs the normal number (Bury 1979). Ryan (1981) reported a clutch of six eggs deposited by a large (106 mm) Pennsylvania female. Bury (1979) reported that bog turtles nested on elevated areas including tussocks, depositing their eggs in moss and moist earth. Breisch *et al.* (1988) found that females in a southern New York population used a common nesting area less than 100 m^2 in size. Klemens (1990, 1993a) found bog turtle eggs in the tops of tussocks. The tussocks used for nesting were clustered in nursery areas, characterized by a complete absence of woody shrubs and an extremely low and sparse cover of herbaceous vegetation. Klemens (pers. obs.) also noted similar egg deposition sites and nursery areas on Virginia's Blue Ridge Plateau.

Klemens (1990, 1993a) observed a Massachusetts hatchling emerging from an egg under natural conditions on September 2. This hatchling remained in the tussock-top nest until September 13. Barton and Price (1955) reported a nest hatching under natural conditions on September 7 in eastern Pennsylvania. Ten Massachusetts hatchlings measured between 18.5-21.6 mm (average 20.4 mm) plastron length (Klemens, 1990, 1993a). Ernst (1977) reported a size range of 17.2-28.5 mm plastron length for Pennsylvania hatchlings. J. L. Behler (pers. comm.) found hatchlings in southeastern New York ranging between 24-38 mm in carapace length.

In Massachusetts, Klemens (1990, 1993a) found hatchlings in May, June, and September. Hatchlings found in September had fresh yolk sac scars and caruncles, whereas those found in May and June had well-healed yolk sac scars and no caruncles. J. L. Behler (pers. comm.) noted a similar pattern in southeastern New York. These data indicate that Massachusetts and New York bog turtles hatch in the autumn, but do not commence growth until the following summer. Klemens (1990, 1993a) reported that a Massachusetts hatchling marked

in mid-May had increased in size from 25 mm to 30.5 mm carapace length when recaptured less than two months later. In the southern part of the northern range, however, there may be instances of eggs overwintering. Smith (*in litt.* 2000) reported finding a hatchling bog turtle with fresh yolk sac scars and caruncles on May 11, 1995, in Carroll County, Maryland. Other researchers have anecdotally told him that there have been instances of some eggs overwintering and hatching the following spring.

Regional Size Variation

Ernst and Barbour (1972) reported adult carapace lengths of 80-115 mm. Northern turtles do not appear to grow as large as southern individuals, and males average slightly larger than females. Klemens (1990, 1993a) measured 65 adult Massachusetts turtles at three study sites. The largest male was 97 mm straight-line carapace (SLC) and the largest female 96 mm SLC. J.L. Behler's (pers. comm.) largest southeastern New York specimens were a 101 mm SLC male and a 97 mm SLC female. In New Jersey, the largest male found by Holub and Bloomer (1977) was 101 mm SLC and the largest female 91 mm SLC. The largest male found by Zappalorti and Farrell (1980) in New Jersey was 104 mm SLC, the largest female 95 mm SLC. Nemuras (1967) reported a 106 mm SLC male and 95 mm SLC female from Maryland. Ryan (1981) reported a large Pennsylvania female measuring 106 mm SLC. Taylor *et al.* (1984) reported that their largest Maryland male bog turtle measured 100 mm SLC, whereas the largest female was 107 mm SLC, but males were on average larger than females. The largest Tennessee male bog turtle was 112 mm SLC (Tryon, 1990b), the largest female 100 mm SLC (Tryon 1990a).

Longevity

Klemens (1993) provided evidence that New England bog turtles are long-lived, as annuli counts of Massachusetts adults indicated that many animals were in their mid-teens or older. In 1991, Klemens (1993) revisited a wetland where three adult bog turtles had been marked in 1980-81. In 1992, all three turtles were recaptured in the same general area where they had been marked ten years earlier. As they were fully-grown when first captured, and it takes at least ten years to reach full adult size in New England, these turtles had survived under natural conditions for a minimum of 20 years. No fewer than seven of 24 adults that J. L. Behler (pers. comm.) marked in 1974 at his study site in southeastern New York survived between 13-16 additional seasons. Bog turtles marked on a Nature Conservancy preserve were reported to still be alive in the wild 25 years later (J. Thorne, The Nature Conservancy, *in litt.* 2000). Herman (1990) reported that a pair of bog turtles purchased by Zoo Atlanta in 1967 was still in their collection in 1990. Evidence from the field and captivity records suggest that bog turtles may live 40 or more years.

Food Habits

Bury (1979) stated that the bog turtle's diet consists primarily of insects but also included

plants, frogs, and carrion. Klemens (1993a) reported that feces voided by Massachusetts bog turtles contained Arachnida (spiders), Coleoptera (beetles), Diplopoda (millipedes), Diptera (flies), Gastropoda (snails), Hymenoptera (ants), Lepidoperta (moths), Odonata (dragonflies), Trichoptera (caddisflies), insects (unidentifiable), cuticular material (reptile?), plant stems and fragments, root hairs, moss, and soil/sand grains. J.L. Behler (pers. comm.) observed numerous instances of bog turtle predation on slugs (*Arion subflavus*) in southeastern New York. Zappalorti and Johnson (1981) observed bog turtles eating slugs and crayfish in North Carolina. Smith (*in litt.* 2000) indicated that most of his observations of feeding bog turtles have been on slugs, with earthworms being the second most common prey.

REASONS FOR DECLINE AND THREATS TO CONTINUED EXISTENCE

Groombridge (1982) identified the greatest threats to the survival of this species as the continued loss, alteration, and fragmentation of its highly specialized wetland habitat, compounded by the loss of long-lived adult animals from wild populations for a lucrative, illegal wildlife trade. Habitat fragmentation and alteration expose adult turtles to elevated risk of incidental mortality including being crushed on roads, as well as increased exposure to predation and collection. In addition to these direct threats, misinterpretation of the biological significance of bog turtle occurrences (i.e., as populations versus components of populations) has, until recently, been a major impediment to conserving this species (Mitchell and Klemens 2000) and could be considered a collateral threat to the species' survival.

Factors leading to the listing of the bog turtle continue to affect its long-term viability. The first two factors considered below, Adverse Changes to Bog Turtle Habitat and Inadequacy of Existing Regulatory Mechanisms, make clear the importance of planning for the conservation of bog turtle populations within the context of the watershed and the activities occurring withing the watershed, rather than on a site-by-site basis. The following discussion of threats thus addresses each of these factors in turn.

Adverse Changes to Bog Turtle Habitat

The most significant threat to the survival of this species is outright loss and alteration of its habitat, as well as the ecological systems that sustain these habitats. The shallow wetlands inhabited by bog turtles are easily drained, as shown by "before and after" photographs in Herman (1989a), and Tryon and Herman (1990). Conversely, farm ponds, reservoirs, and other impoundments are created by inundating the shallow, open wet meadows and fens required for bog turtle survival.

Alterations to local hydrologic systems are an important threat to bog turtle populations. Bog turtle habitats are sustained by groundwater regimes that are sensitive to changes in subsurface water supplies. Development occurring in groundwater recharge areas results in increases in impervious surfaces and the number of wells, which can, in turn, lower water tables,

affecting groundwater discharges into bog turtle habitats (in terms of both quantity and quality) and accelerating succession (Lowenstein *in litt.* 2000). Patterns of subsurface water flow can be altered by infrastructure construction and other development projects. Drilling under wetlands (e.g., to install utility lines or fiber optic cable) has the potential to disrupt the flow of water and even fracture bedrock and significantly impact a small wetland system.

Even if the patches of open wetlands occupied by bog turtles are protected, they are threatened by a variety of problems stemming from a landscape that is subject to increasing levels of human use, including habitat fragmentation, nutrient enrichment, and contaminant inputs from septic, road, and fertilizer runoff. The latter causes rapid growth of vegetation with subsequent canopy closure (Klemens 1989, 1990, 1991, 1993a).

Although light grazing may be beneficial in controlling succession, intensive pasturing adds excessive nutrient loading from fecal material, results in significant soil disturbance, (which may accelerate exotic plant invasion), destroys the unique plant community by overgrazing, and will result in bog turtles being crushed. The type and density of grazers determines the effect on the habitat. For example, horses appear to cause more damage to a pasture than cows, animal for animal. Smith (*in litt.* 2000) has observed that horses "graze lower to the soil, like sheep, and this coupled with their hoofs somehow appear to damage the substrate more – areas become mud holes with only a few horses whereas it would take many more cows to inflict the same amount of damage."

Protected areas are usually relatively small and, although encompassing the turtle's primary habitat, leave the drainage basin largely unprotected. Therefore, although the core habitat may be protected, these wetland drainage basins are vulnerable to a host of external factors, including subdivisions, wells, and road construction activities. These activities may alter both the supply and quality of the water entering the turtle's habitat and impede the dispersal of turtles within a drainage basin. Ultimately, external activities at the landscape level can greatly diminish the suitability of any one wetland to support bog turtles.

Some of the most persistent and widespread problems associated with maintaining bog turtle habitat are succession of open meadows to wooded swamps, drainage and flooding of habitats through diversion or damming of feeder streams, chemical and heavy metal pollution, nutrient enrichment from fertilizer and septic runoff, and the establishment of alien plants. Disturbance of surface soils and degraded water quality may result in the establishment and spread of invasive wetland plant species such as the alien purple loosestrife (*Lythrum salicaria*) or native giant reed (*Phragmites australis*). These aggressive species rapidly invade wetlands when areas of disturbance and/or impaired water quality are created. Favored colonization sites are the piles of excavated soil placed alongside ponds and ditches. After taking root in a disturbed microhabitat, these plants quickly spread into the adjacent wetlands, replacing a diverse botanical community with a dense monoculture. This monoculture is unsuitable for many wetland species, including bog turtles (Klemens, 1990, 1993a). Other invasive species implicated in reducing the value of bog turtle habitats include reed canary grass (*Phalaris arundinacea*) and multiflora rose (*Rosa multiflora*).

Inadequacy of Existing Regulatory Mechanisms

This threat is closely tied to loss of habitat. It is the inadequacy and conflicting nature of regulations and screening mechanisms that, in many instances, are failing to halt the loss of bog turtle habitat. The actions of a multiplicity of federal, state, and local agencies that deal with land-use and development issues often have competing purposes, resulting in the incremental loss and destruction of bog turtle habitat as well as the larger, dynamic ecosystems upon which the mosaic of wetlands used by bog turtles depend. Review of site-specific projects and permit applications frequently does not fully consider their landscape scale cumulative impacts. Screening mechanisms and environmental reviews that use the presence/absence data contained in various state Natural Heritage data bases are often confined to the point of occurrence, without considering connected or adjacent habitat, resulting in approval of projects that do not take into account the potential occurrence of bog turtles or other rare species. For instance, if a bog turtle is found at point x and a development is planned 1000 meters away from point x at point y in the same corridor of interconnected wetland habitats, point y may also serve as bog turtle habitat. However, this ecological approach to the interpretation of presence data has been the exception rather than the norm.

Furthermore, although knowledge of extant and historical species occurrences at the site-specific or drainage basin level is consistent among jurisdictional agencies, best professional judgments as to the significance of a particular site and/or the potential presence of bog turtles often vary among agencies and individuals. This coordination issue may compromise the effectiveness of environmental guidance and project reviews (M.M. Ryan, Pennsylvania Department of Transportation, *in litt.* 2001).

To complicate matters, although all states within the northern range of the bog turtle provide regulatory protection to the species as "threatened" or "endangered," this protection often does not extend to the species' habitat. Rather, protection for the species' habitat is often incidentally provided under other laws and regulations whose intent is to protect environmental resources (e.g., wetlands, flood plains) or specific geographic features (e.g., Pinelands, coastal areas). Thus, protection of threatened and endangered species habitat is limited by jurisdiction of these laws. This shortfall in protection is especially acute when trying to address indirect adverse effects to the bog turtle and its habitat (e.g., due to activities occurring in uplands).

Although some states have been successful in avoiding or minimizing encroachments (e.g., filling, ditching, draining, development) into bog turtle habitat, significant habitat degradation and fragmentation has resulted from indirect effects to wetlands caused by activities in the adjacent uplands. Despite the recognition of regulated upland buffers around wetlands (in all northern range states except Pennsylvania), activities that contribute to habitat loss, including development, farming, and placement of detention or storm water basins, are often allowed to proceed within the buffer. These activities can degrade water quality, accelerate succession, encourage the invasion and spread of exotic plants, and change wetland hydrology.

Illegal Collection and Trade

Exploitation of bog turtles for commercial or private use ranks second in threats to this species, after habitat loss. Their small size, attractive shell and coloration, and rarity make the bog turtle a prize eagerly pursued by unscrupulous collectors, both in the United States and overseas, resulting in illegal collecting for an illicit pet trade. Tryon (1989), Strong (1989), and Herman (1989b) described one incident where a series of southern Appalachian study sites was decimated by a group of collectors who had specifically traveled south to capture bog turtles. Apart from removing large numbers of adults, these collectors seriously compromised at least one long-term mark and recapture study site by removing marked turtles (Herman 1989b). Klemens (1991) reviewed reports of illegal collecting activities from Delaware, Massachusetts, Maryland, New Jersey, New York, North Carolina, and Pennsylvania.

In 1975, the bog turtle was added to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in order to monitor trade in the species. In 1992, the bog turtle was transferred from Appendix II to Appendix I due to the increased number of bog turtles being advertised for sale, the increased price being paid for individuals and pairs, and illegal trade not being reported under CITES (57 FR 7722, March 4, 1992). Both import and export permits are required from the importing and exporting countries before an Appendix I species can be transported, and an Appendix I species cannot be exported for primarily commercial purposes.

Disease and Predation

Vulnerability to predators may be greater for the relatively small bog turtle, in comparison to larger species such as the wood turtle. Bury's (1979) literature review revealed that bog turtle nests, young, and adults are preyed on by raccoons, skunks, dogs, foxes, and other large predators. Bullfrogs, snapping turtles, water snakes, egrets, herons, crows, birds of prey, mink, and muskrats are also potential predators of bog turtle eggs, hatchlings, and adults. In a sample of 65 adult Massachusetts bog turtles (41 females, 24 males), 21 females and 8 males had well-healed predation injuries varying from tooth marks to missing marginals and limbs (Klemens 1990, 1993a). The Massachusetts data indicated that more than 50 percent of females versus 33 percent of males had predation injuries. Klemens (1990, 1993a) found predated bog turtles with their heads and limbs chewed off (probably by raccoons, *Procyon lotor*).

Many of the primary predators on bog turtles and their nests are human commensals, i.e., they flourish in the presence of humans and the landscapes that they alter. This is particularly acute for species such as the bog turtle, which occurs primarily in agricultural landscapes where the presence of raccoons, skunks, opossums, and crows can pose a significant threat. How significant a threat these subsidized species pose to bog turtles is hard to determine, although in certain populations it is speculated that predation of adults and eggs is a serious problem.

At present, there are no substantiated reports of disease affecting a wild population of bog turtles, although at one site in Columbia County, New York (J.L. Behler, pers. comm.) the number of dead turtles is cause for concern; eight dead bog turtles were collected during three visits to the site in 1988 and 1989 (A. Breisch, *in litt.* 2000). A sick turtle removed from that population and held for several years in captivity tested positive for upper respiratory distress syndrome (URDS) upon necropsy (J. L. Behler, pers. comm.). Although this could indicate a health problem within that population, it is also possible that the turtle contracted this disease while in captivity. Disease issues have the potential to become a much larger threat to wild bog turtle populations as they are subjected to more handling by researchers or if manipulation of turtle populations is undertaken through the deliberate release into the wild of bog turtles from other areas, zoological collections, or those seized by law enforcement activities. It should be noted that thorough health screening of wild-caught bog turtles has not been a standard practice of researchers, although it may be warranted (Smith *in litt.* 2001).

Other Factors: Assessing the Species' Status

The bog turtle has always been considered a rare and secretive species. Widespread concern as to its future began to be voiced in the late 1960s and early 1970s (e.g., Nemuras 1967; Behler 1971; Zovickian 1971; Nemuras and Weaver 1974a, 1974b; Nemuras 1976). Klemens (1989) expressed concerns that certain populations of long-lived turtle species in the northeastern United States were composed almost totally of aged adults. He stated that these populations were certainly destined to become extirpated, but because of the individual longevity of these animals, these extinctions may take half a century to become manifest, even though the population is already functionally extinct.

The discovery of many new occurrences of bog turtles in the last 20 years has led to unfounded optimism (e.g., Arndt 1978, 1982; Behler and King 1979) that bog turtles are more secretive than they are rare. Many of the newly found occurrences represent the last remnants of functionally extinct (*sensu* Klemens 1989) populations; however, these data have resulted in a reduced emphasis on bog turtle conservation by various organizations and agencies (e.g., Bourg 1992, reviewed by Mitchell and Klemens 2000; Klemens 2000). Klemens (1991) gave strong evidence that despite the discovery of many new occurrences throughout its range, only a small percentage of these populations were sufficiently robust to be considered self-sustaining over the next 50-100 years. Tryon (1990a) and Tryon and Herman (1990) reviewed the conservation status of this species in the southern Appalachians, noting declines in the number of viable populations.

CONSERVATION MEASURES

A small number of wetlands containing bog turtle populations have been purchased with public and private funds at locations throughout this species' range; habitat management has been warranted at some of these sites to offset accelerated succession resulting from disturbance

or to restore habitats damaged by ditching and draining. Grazing by cattle, sheep, and goats has been used as a management technique to control succession. In addition, burning and pruning regimes have been used at some northern and southern sites to control succession (A. Breisch, pers. comm.; Tryon and Herman 1990). Techniques are being developed to control purple loosestrife (Malecki 1993, Smith 1964, Thompson *et al.* 1987, Wilcox 1989) and reed grass (Cross 1983). Drainage basin protection plans for small streams draining bog turtle habitats have been proposed for several New England sites, with a composite of habitat protection mechanisms including outright ownership by state or private conservation agencies, acquisition of easements that cede control in perpetuity over land use and key resources without actual land ownership, and voluntary management agreements with private landowners. Many states are increasing their efforts to protect bog turtles and their habitat (e.g., via habitat protection, habitat management, permit reviews). On-the-ground enforcement to control illegal collection and trade, however, is highly limited in most areas.

The following paragraphs summarize the conservation measures that the states within the range of the northern population of the bog turtle have undertaken to date to conserve this species. This summary is based largely on an informal survey conducted by this plan's author to ascertain the various conservation efforts among the range states.

Law Enforcement/Interdiction

To stem the illegal collection of bog turtles, all seven states have conducted outreach to their local and state conservation officers to inform them about the threat to bog turtles posed by collection. Connecticut, Maryland, New Jersey, and Pennsylvania deliver this information as part of a more structured, targeted training program about state-listed species; others have had more informal discussions with relevant conservation officers. Delaware, Maryland, New York, New Jersey, and Pennsylvania also have worked with federal agents to curb illegal bog turtle collection in their states. None of the seven range states has specifically targeted local, county, or state police as part of their overall enforcement efforts.

Land-use Permitting Decisions

To provide better protection of bog turtle habitat, five of the range states have conducted outreach to the various agencies and tiers of government that permit land-use and wetlands, including state agencies other than their own (e.g., state departments of transportation). Levels of government contacted include local and municipal, county, regional, state, and federal. Delaware has worked at all five levels but feels that much more is needed. Most of Delaware's interactions have occurred as a result of the environmental review process; however, some have been "more pre-emptive." Maryland also has worked at all five levels, while New Jersey reported working at the regional and state level with future plans to target municipalities and counties. New York reported working at the local, state, and federal levels, and Pennsylvania reported that it was working at all five levels of governmental organization to incorporate bog turtle conservation into land-use permitting decisions.

Land Protection Activities

Five of the range states have purchased habitat to protect bog turtles in their state. In the remaining two states, Delaware and New Jersey, bog turtles are a factor in land acquisitions. Connecticut, Maryland, Massachusetts, New Jersey, and Pennsylvania have acquired conservation easements to protect bog turtles. Connecticut, Delaware, Maryland, Massachusetts, New Jersey, and Pennsylvania have entered into voluntary cooperative management agreements with landowners to protect bog turtles and have formed partnerships with other organizations and agencies to achieve habitat protection goals. Of the six states that have formed partnerships, all except Delaware have worked with the various chapters of The Nature Conservancy. Maryland and New Jersey have each worked with multiple partners, including various non-government organization, state agencies, and the USFWS, to protect bog turtle habitats.

Land Management Activities

Table 3 shows activities that have been undertaken in the northern range of the bog turtle to arrest succession of open wetlands to wooded swamp and to control invasive plants in bog turtle habitats.

Table 3. Land Management Activities

State	Methods Used to Control Succession	Methods Used to Control Invasive Exotic Plants
Connecticut	none	none
Delaware	pruning and selective removal; brush hog during winter; tree girdling	manual removal
Massachusetts	none	manual removal
Maryland	pruning and selective removal; use of herbicides to control red maple; tree girdling; grazing; fire (planning to use in future)	manual removal; grazing; selective herbicide applications
New Jersey	pruning and selective removal; grazing; selective hatchet injection of Rodeo to woody stems near end of growing season	manual removal; selective herbicide applications; grazing; biological control (insects)
New York	pruning and selective removal; fire	fire
Pennsylvania	tree girdling; fire; grazing	selective herbicide applications

The New Jersey Endangered and Nongame Species Program (ENSP), through Natural Resources Conservation Service (NRCS) and U.S. Fish and Wildlife Service cost-share programs, has provided farmers with opportunities to expand existing pastures into bog turtle habitats that would benefit from light grazing. Additionally, the ENSP is compensating farmers for the lease and transport of livestock (cows, goats, and sheep) to selected bog turtle sites. Both the farmers and the landowners reap benefits from this opportunity; farmers gain free pasture and landowners can qualify for farmland tax assessment (J. Tesauro, New Jersey Department of Fish, Game and Wildlife, *in litt.* 2000).

New York has introduced beaver into wetlands as part of its bog turtle habitat management program. Beavers were trapped and a beaver dam removed at a bog turtle site in Massachusetts after the water level had risen two feet.

At a bog turtle site in New York managed by burning, it appeared that burning encouraged the growth of *Phragmites* but reduced the density of purple loosestrife. This site has been burned every 2-3 years for a total of 4-5 burns (A. Breisch, pers. comm.).

Turtle Protection and Management Activities

Five of the range states have engaged in some form of hands-on turtle management activities, although three of the states (Connecticut, Maryland, and New Jersey) have conducted these types of activities on a very limited basis. Connecticut protected a tussock that had three clutches of bog turtle eggs, and although the enclosure protected the eggs from predation by large animals, the eggs were preyed upon by rodents and/or insectivores; this measure was thus considered to be ineffective. Such activities have not been undertaken to date in Delaware or Massachusetts.

New Jersey reported permitting (in the late 1970s and early 1980s) the removal of eggs from nests and gravid females and the subsequent release of these head-started hatchlings back into the wetland where the eggs were collected, adding that this practice has stopped. New Jersey concluded their report by stating that there were "no data concerning the conservation effectiveness of these practices."

New York and Pennsylvania have both conducted more extensive and ongoing programs to manage turtle populations. Both states have removed eggs from the wild or from wild-caught gravid females, and have released head-started young back into the wetland where the eggs were gathered. Both states have also released adults of known origin back into their natal wetland, as well as having released adults of unknown origin into the wild. With respect to the latter, Pennsylvania reported that although "we did not know the specific wetland in some cases, but we did feel confident that we were in the correct watershed." New York also "released adults of known origin (held in captivity 20+ years) into other sites because their natal habitat no longer seemed suitable," and Pennsylvania reported that The Nature Conservancy had protected eggs *in*

situ on some of their preserves. Neither of these states indicated the effectiveness of these efforts in protecting and restoring bog turtle populations.

In Pennsylvania, The Nature Conservancy has worked in partnership with the U.S. Fish and Wildlife Service Partners for Wildlife Program to exclude egg predators by constructing a predator exclusion fence around a bog turtle nesting area; the effectiveness of the fence, however, has not been evaluated (Thorne, *in litt.* 2000). The Nature Conservancy has also actively controlled predators of eggs and turtles at one location, and has surveyed for nest predator activity by enclosing half of known nests in wire mesh cages and followed the fate of eggs in enclosed and unenclosed nests. The cages appear to have been effective in limiting predation (Thorne, *in litt.* 2000).

Headstarting has been used at a bog turtle site in Seneca County, New York (A. Breisch, pers. comm.), where the turtle population exhibited a skewed sex ratio (4 males: 1 female), and no evidence of recruitment. Female bog turtles were collected from the site in May, kept at a zoo until eggs were laid, and then released in the area from which they were taken. The eggs were then incubated in captivity, and the young raised in captivity for 1-2 years (with no hibernation interval) until they reached a size of 60-70 mm. Rosenbaum (*in litt.* 2000) reported that there were two releases over a two-year span (four turtles in 1997 and six in 1998). He also indicated that "headstarters were released in July and some turtles from each year were monitored over the winter. Most monitored turtles overwintered successfully. One death due to predation (1997) and one from overwintering and/or predation (1998) was documented. Further research is needed."

Reintroduction has been attempted at a site in Monroe County, New York (A. Breisch, pers. comm.). No bog turtles had been seen at this site for 60 years. Four male bog turtles confiscated by law enforcement officials and held at the Bronx Zoo for a few years were released into this wetland. One turtle was predated, and the other two were recaptured after about one year due to their inability to select a good hibernation site. These turtles were put in the Seneca Park Zoo.

At another site in New York, four bog turtles that had apparently been collected as adults in New York but kept in captivity at a private New Jersey residence for at least 20 years were released in 1991 (A. Breisch, pers. comm.). Based on radio telemetry study results, one turtle died, and the other three stayed in the wetland for several months with the other resident turtles (even hibernating with them). These turtles, however, have not been seen since.

Educational Activities

All seven range states have engaged in educational and outreach activities, including lectures and granting interviews to reporters, press releases, and articles in state wildlife magazines. In addition, Maryland has used television as part of its outreach and information campaign to conserve bog turtles. All states except Massachusetts have prepared information

pamphlets or fact sheets concerning conservation needs of bog turtles and their habitats, and Maryland and Pennsylvania have produced videos to expand the reach of their information programs.

Presence/Absence Bog Turtle Surveys

Programs that conduct, contract out, or facilitate surveys are implemented on an ongoing basis by various agencies throughout the bog turtle's range. The intensity and coverage of these surveys are in large part a function of the amount of funding available and the availability of qualified surveyors. Each state was asked to give a rough estimate of how efforts were divided among (1) reconfirming presence at active sites where turtles have been observed in the last decade, (2) trying to relocate/reconfirm turtle use at historical sites where turtles were observed more than ten years ago, and (3) searching for new sites in previously unexplored areas and wetland systems. These estimates are provided below:

State	1	2	3
Connecticut	75%	10%	15%
Delaware	50%	5%	45%
Maryland	70%	10%	20%
Massachusetts	10%	5%	85%
New Jersey	10%	10%	80%
New York	30%	30%	40%
Pennsylvania	25%	25%	50%

In New York, a three-year grant (1998-2000) was used by the New York Natural Heritage Program and the New York Department of Environmental Conservation to conduct bog turtle surveys in Orange, Dutchess, Columbia, and Putnam Counties (A. Breisch, pers. comm.).

Bog Turtle Research

All states have engaged in, contracted out, or in some way facilitated bog turtle research. For each state, research results have had various benefits, grouped into four areas based on the type and level of research conducted, i.e., did the studies contribute to a better understanding of (1) life history, ecology, and population size; (2) intra-habitat use; (3) inter-habitat movements and migration; and/or (4) landscape-scale ecological processes as they relate to bog turtle habitat and ecology. The scope of these studies is indicated below. These state-sponsored studies have contributed significantly to the background information contained in Part 1 of this recovery plan (see Literature Cited).

State	1	2	3	4
Connecticut	X	X	X	
Delaware	X			
Maryland	X	X	X	X
Massachusetts	X	X	X	X
New Jersey	X	X		
New York	X	X	X	
Pennsylvania	X			

As an example of this research, the Pennsylvania Department of Transportation and the Maryland State Highway Administration are facilitating radio telemetry research associated with improvement projects to examine bog turtle population size, intra-habitat use, inter-habitat movements, and migration for confirmed populations affected by the project (Ryan *in litt.* 2001).

In addition to state-sponsored research, Dr. Tim King of the U.S. Geological Survey Biological Research Division's Leetown (West Virginia) Science Center has developed a genetic marker for bog turtles that should allow identification of turtles of unknown origin to the correct state, county, and watershed levels (Smith *in litt.* 2001).

Protocol for Presence/Absence Surveys

Delaware, Maryland, New Jersey, and Pennsylvania have developed protocols for determining the presence/absence of bog turtles in wetlands that will be affected by projects. All of these states recommend that the protocol be used by consultants to ensure that survey results will be considered valid. The States of Delaware, Maryland, New Jersey, and Pennsylvania maintain a list of qualified bog turtle surveyors, which is available upon request.

Landscape-scale Effectiveness of Project Reviews

States vary in their effectiveness in incorporating ecosystem and landscape-scale factors in project reviews that are conducted to identify known and potential bog turtle habitats. All states except Massachusetts and Pennsylvania employ this most critical conservation parameter less than half the time. Connecticut and New Jersey rarely include these factors in their reviews. Delaware and New York give slightly more consideration to landscape-level factors, while Maryland does so "less than 50% of the time and then only for large-scale projects such as highway construction;" Massachusetts considers these factors "more than 50% of the time." Of the core range states, only Pennsylvania conducts reviews that are effective in this regard "most of the time." These generally low levels of review correspond with the position that the loss of large, intact blocks of bog turtle habitat through development and fragmentation, with the concomitant loss of ecosystem function and dynamism, is a major factor in the decline of this species.

RECOVERY STRATEGY

The primary strategy for the recovery of the northern allopatric population of the bog turtle is to first stabilize the ongoing decline of this species, then restore its rangewide distribution through protection of extant populations. This will be accomplished by: (1) focusing attention on certain key watersheds that contain multiple, viable occurrences of bog turtles imbedded in wetland systems that are relatively pristine and dynamic; (2) conducting searches for new populations; and (3) aggressively halting illegal collection and trade in this species.

In order to ensure the long-term viability of this species, investigations into its landscape-scale requirements, as well as land-use management and stewardship programs that attempt to balance human uses within the bog turtle's agricultural wetland landscape, will be given high priority. As the bulk of bog turtle wetland habitat is currently in private ownership, programs that engage landowners in voluntary or incentive-driven cooperative management will be an essential part of recovery, as will be improving the coordination and responses of the various tiers and agencies of government that permit wetland uses in bog turtle watersheds.

The presence of a captive bog turtle population (e.g., at zoological institutions and residences of private collectors), including adults of unknown origins and captive-bred offspring, poses a special challenge in developing the recovery strategy for this species. Releasing captive turtles into the wild can trigger a series of conservation problems involving the carrying capacity of the target population, genetic compatibility, transmission of diseases, and fitness of animals that have been held in artificial conditions. The threat of disease transmission cannot be overemphasized, as evidenced by situations involving other species. For example, Rosenbaum (*in litt.* 2000) indicated that "John Behler has reported on a nearly undetectable and currently incurable pathogen found in some of his captive tortoises which prevented him from repatriating them." Apparently, the assay for this disease is very expensive and only available from one or two labs in the world. However, there may be exceptional situations, where with adequate controls and screening, the release of bog turtles into the wild may form part of an overall recovery strategy. Nevertheless, it is the position of the U.S. Fish and Wildlife Service that this option is to be exercised only as part of a controlled study (i.e., on an experimental basis) and only when other avenues for recovery of a population (e.g., presence/absence surveys, habitat management, predator management) have been exhausted.

The present position of the U.S. Fish and Wildlife Service is to not allow trade in captive-bred bog turtles, because this may substantially increase the collection threat to wild turtles. Captive breeding and marketing of the relatively small captive population of bog turtles is not likely to meet market demands for the species, further threatening the species' survival in the wild by making gravid females, eggs, and hatchlings particularly vulnerable to illegal collection. In the case of an endangered species that has all or part of its range in the United States, the Service may only allow interstate commerce in captive-bred stock provided:

(1) there is a low demand for taking animals from the wild, and (2) wild populations are effectively protected from unauthorized take because of the inaccessibility of their habitat or as the result of an effective law enforcement program. At this time neither of these conditions has been met.

In order to facilitate recovery, the northern allopatric population of the bog turtle is divided into five recovery units:

- Prairie Peninsula/Lake Plain
- Outer Coastal Plain
- Hudson/Housatonic
- Susquehanna/Potomac
- Delaware

These recovery units, mapped in Figures 3-8, are distinguished from one another by a combination of the following characteristics: habitat distinctiveness, biogeographical and ecological affinities, and variation in the intensity and severity of the multiple threats to the species' survival.. The total number of extant bog turtle sites by state and recovery unit (as of August 2000) is depicted in Table 4. A description of each recovery unit and its distinct attributes follows the recovery unit maps.

Table 4. Extant Bog Turtle PAS by State and Recovery Unit

State	Prairie Peninsula/ Lake Plain	Outer Coastal Plain	Hudson/ Housatonic	Susquehanna /Potomac	Delaware	Total PAS
Connecticut			5			5
Delaware					4	4
Maryland				61		61
Massachusetts			3			3
New Jersey		3	46		116	165
New York	4		33			37
Pennsylvania	0			31	44	75
TOTAL	4	3	87	102	164	350

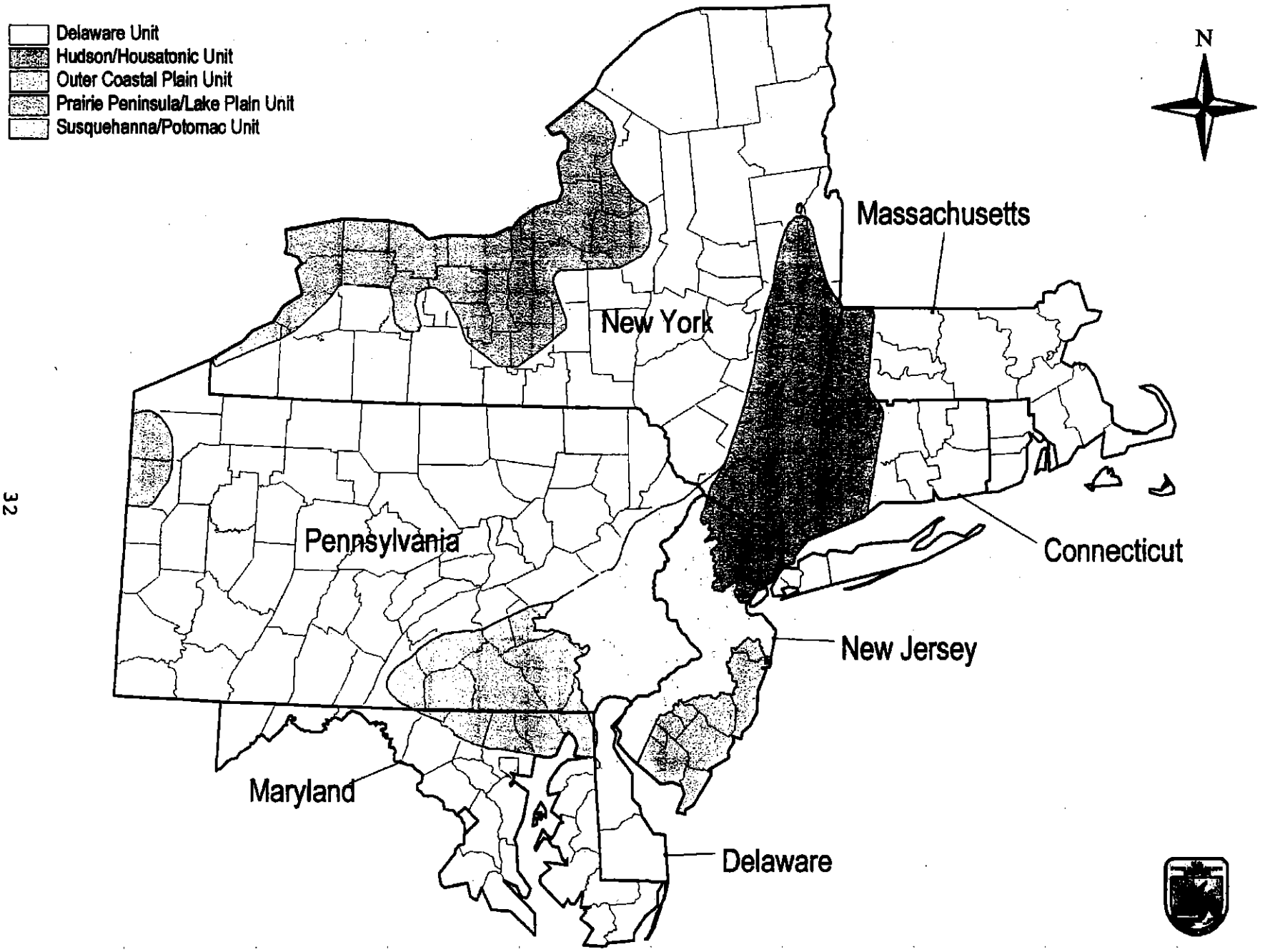

Figure 3. Bog Turtle Recovery Units (Northern Range)

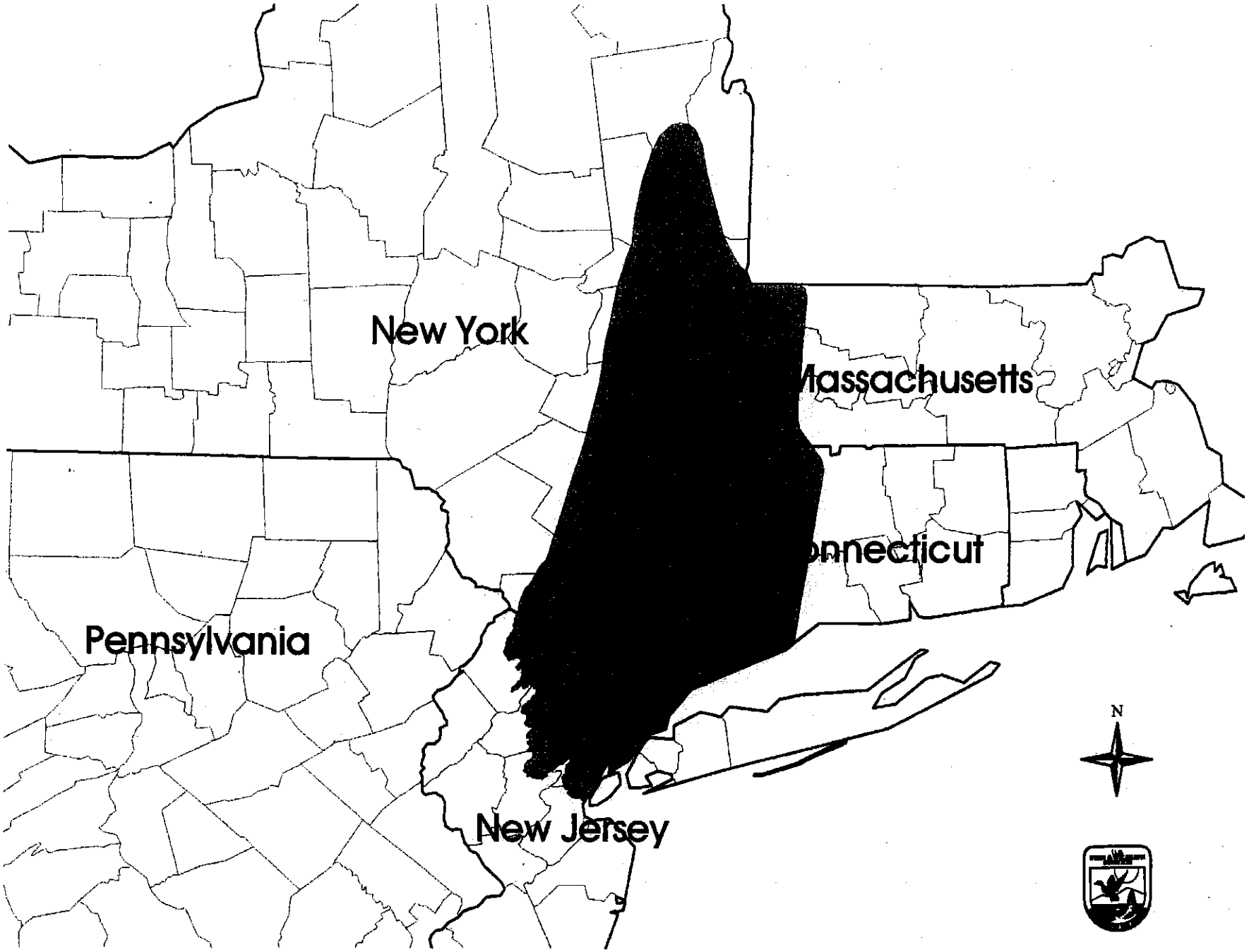

Figure 6. Hudson/Housatonic Recovery Unit

Delaware Bay Estuary Project
May 2001

Recovery Unit Descriptions

1. The PRAIRIE PENINSULA/LAKE PLAIN recovery unit has a strong midwestern faunal component. It encompasses the westernmost disjunct sites of the species, and some of the habitats where turtles are found are unique, e.g., floating bog mats in Oswego County, New York. Turtles in these northern sites experience slower growth rates, and likely reach sexual maturity later than other bog turtle populations. As these disjunct sites are scattered in an arc considerably west of the continuous range of this species, they have been subject to very different evolutionary forces. Since many of these sites are extirpated, reintroduction of turtles, as well as intensive manipulation of both turtles and habitat, will factor far more prominently into the recovery strategy here than elsewhere in the range.

2. The OUTER COASTAL PLAIN recovery unit is unique in that turtles occur in tidally-influenced wetlands, some located on barrier islands. Sites are sandy and highly acidic, and include cranberry bogs. Agricultural practices focused on production of blueberries and cranberries are also unique to these wetlands.

3. The HUDSON/HOUSATONIC recovery unit is distinguished by having a large number of its turtle populations concentrated in calcareous fens, which are fed by groundwater percolating through glacial sand and gravel deposits. Populations of bog turtles appear naturally more widely separated over the landscape in discrete wetlands, with turtles absent in many apparently suitable sites. There are generally fewer occurrences comprising subpopulations or sites. The entire region was glaciated, and the landscape has been strongly affected by agriculture, especially dairy farming. Agriculture is rapidly disappearing, and now suburban sprawl threatens many sites. Gravel and sand mining in those glacial terraces that feed groundwater into bog turtle habitats is a serious threat in this recovery unit.

4. The SUSQUEHANNA/POTOMAC recovery unit is characterized by active agriculture including both grazing and crop farming. The agricultural influence is both historical and current, although agricultural abandonment is resulting in habitat change through succession, development, and invasive species. This recovery unit has the highest densities of bog turtle sightings. The recovery unit is primarily unglaciated and, at least historically, encompassed the largest contiguous distribution of this species. The wetland habitats in this recovery unit are more generalized, and almost all sites are disturbed. Major threats within this recovery unit include conversion of wetlands to farm ponds, non-point source pollution, lack of buffers around wetlands, and hydrological impacts from residential development. The invasive plant community is different from the more northerly sites, with multiflora rose and reed canary grass as the dominant invaders; mile-a-minute weed is also a serious threat at some sites. This contrasts with northern populations where purple loosestrife and giant reed are the dominant invasive species.

5. The DELAWARE recovery unit is the most ecologically diverse of the five recovery units, encompassing inner Coastal Plain, Piedmont, river valleys, Appalachian plateau areas, and fens. It contains both glaciated and non-glaciated habitats. Lying at the heart of the Northeast megalopolis, this unit contains the highest densities of roads and major urban areas and has the highest number of lost sites range wide. There is less agricultural pressure here; however, urban sprawl and habitat fragmentation are major conservation challenges, as is maintaining ground water quality and quantity.

PART 2: RECOVERY

RECOVERY OBJECTIVE

The overall objective of the bog turtle recovery program is to protect and maintain the northern allopatric population of this threatened species and its habitat, enabling the eventual removal of the species from the Federal List of Endangered and Threatened Wildlife and Plants.

RECOVERY CRITERIA

The northern population of *Clemmys muhlenbergii* will be considered recovered when:

1. Long-term protection is secured for no fewer than 185 viable (see Recovery Task 7.1.1) populations (= Population Analysis Sites, PAS) distributed among the five recovery units described in the preceding section. Protection of 185 of the 350 extant bog turtle sites and their populations (refer to Table 4) has been determined to be appropriate to meet the recovery goal, since protection of this many sites across the species' range will significantly reduce the species' risk of extinction due to anthropogenic and non-anthropogenic threats and allow its eventual delisting. It should also be noted that some of the existing sites may not be capable of sustaining viable bog turtle populations due to small population size, and/or habitat loss, degradation and fragmentation.

   Some of the recovery units have been partitioned into subunits for the purpose of ensuring that an adequate number of PAS populations are protected across the species' range. The specific recovery criteria for each unit and subunit are summarized in Table 5, followed by more detailed descriptions of the criteria for each unit.

   Prairie Peninsula/Lake Plain Recovery Unit. Conclusively determine the presence of any remnant bog turtle populations at historical sites and in suitable wetland habitats within watersheds of historical occurrence. Based upon these data, restore and maintain the geographic range of the species by protecting no fewer than 10 viable bog turtle populations and sufficient habitat to ensure the sustainability of those populations. If an insufficient number of extant sites is found during surveys, the reintroduction of turtles into suitable habitats should be considered to meet these targets. To meet the recovery

Table 5. Recovery Targets (PAS per Recovery Unit)

Recovery Unit	Extant PAS	Recovery Objective	Subunits	Extant Subunit PAS	Subunit Objective
Prairie Peninsula/ Lake Plain	4	10	New York	4	≥2
			Pennsylvania	0	≥2
Outer Coastal Plain	3	5	--	--	--
Hudson/Housatonic	87	40	Hudson	26	≥10
			Housatonic	20	≥10
			Wallkill	41	≥10
Susquehanna/Potomac	92	50	Potomac	5	≥3
			Susquehanna West	69	≥30
			Susquehanna East	28	≥10
Delaware	164	80	Delaware West	48	≥20
			Delaware East	116	≥40
TOTAL	350	185	–	--	--

criterion of 10 protected populations for this unit, no fewer than two populations should be protected/established in each of the states (New York, Pennsylvania) within the unit.

Outer Coastal Plain Recovery Unit. Protect five viable bog turtle populations and sufficient habitat to ensure the sustainability of these populations.

Hudson/Housatonic Recovery Unit. Protect 40 viable bog turtle populations and sufficient habitat to ensure the sustainability of these populations, including at least 10 populations in each of the following subunits: the Wallkill River watershed, the Hudson River watershed, and the Housatonic River watershed.

Susquehanna/Potomoc Recovery Unit. Protect 50 viable bog turtle populations and sufficient habitat to ensure the sustainability of these populations. This recovery unit is divided into the following subunits: (1) Potomac (consisting of the Potomac River watershed), (2) Susquehanna West (consisting of the Susquehanna watershed west of the Susquehanna River), and (3) Susquehanna East (consisting of the Susquehanna watershed east of the Susquehanna River, including sites draining directly to the Chesapeake Bay). To meet the recovery criterion for this recovery unit, at least three populations must be protected in the Potomac subunit, at least 30 in the Susquehanna West subunit, and at least 10 in the Susquehanna East subunit.

Delaware Recovery Unit. Protect 80 viable bog turtle populations and sufficient habitat to ensure the sustainability of these populations. This recovery unit is divided into the following subunits: (1) Delaware West (consisting of the Delaware River watershed west of the Delaware River, which occurs in Pennsylvania and Delaware), and (2) Delaware East (consisting of the Delaware, Raritan and Manasquan River watersheds in New Jersey). To meet the recovery criterion for this unit, at least 20 populations must be protected in the Delaware West subunit and at least 40 in the Delaware East subunit.

The 185 populations should be protected from present and foreseeable anthropogenic and natural threats that may interfere with their survival. Adequate protection measures include conservation easements and cooperative management agreements, habitat acquisition, and other measures that will protect the watersheds inhabited by this species. Where needed, habitat protection will be augmented by habitat restoration, protection from predators, reintroduction of turtles at selected sites, and a heightened emphasis on law enforcement actions to curb illicit trade in this species. At a minimum, long-term protection requires that:

a. The habitat areas used by a population are under conservation management and are protected by conservation ownership (or other binding agreements) against adverse effects (e.g., wetland draining, ditching, filling or excavation; drawdown by water supply wells; pollution from point and non-point sources; succession to woody vegetation; invasive plant species).

b. Recharge areas and buffer zones are protected by conservation ownership (or other binding agreements) to prevent adverse hydrological alterations due to, e.g., stream diversions, mining, wells, roads, and impervious surfaces.

2. Monitoring at five-year intervals over a 25-year period shows that these 185 populations are stable or increasing. This 25-year monitoring period will be triggered when populations and their habitat are considered secure from external threats such as habitat loss and destruction, collection of turtles, or elevated levels of predation. Therefore, monitoring at some sites could be initiated immediately, whereas other sites may require considerable protection and management efforts prior to the initiation of the 25-year

monitoring period. Monitoring will track general population health, reproduction, age structure, and habitat trends. These parameters should indicate that the population and its habitat have the capacity for being self-sustaining in the wild over the long term, with regular monitoring (and where necessary management) regimes in place.

3. Illicit collection and trade in this species have been eliminated or reduced to a minimal level (i.e., a level that no longer constitutes a threat to the survival of this species). Indications that this criterion has been attained would include: (a) implementation of an effective law enforcement program that reduces illicit take of this species, (b) a demonstrated success rate associated with the law enforcement program, and (c) consensus among federal and state enforcement agencies, state non-game programs, and the research community that illicit trade has been brought under control.

4. Long-term habitat dynamics are sufficiently understood to manage and monitor threats to both habitats and turtles, including succession, invasive wetland plants, and predation by species that are sustained by human activities.

RECOVERY TASKS

The following tasks (shown in outline form in Table 6) apply in varying degrees to all recovery units, unless otherwise indicated. In addition, although this recovery plan is not intended to address the southern population of the bog turtle, it would be beneficial to implement many of the research tasks in both the northern and southern ranges.

Table 6. Recovery Task Outline

1. Protect known extant populations and their habitat using existing regulations.

- 1.1 Adequately screen projects/permits that may affect bog turtles and their habitat.
  - 1.1.1 Map contiguous wetland habitat.
  - 1.1.2 Map/identify watersheds or wetland systems of occurrence.
  - 1.1.3 As appropriate, include all extant bog turtle sites on state freshwater wetland maps.
  - 1.1.4 Ensure that adequate screening tools are used so that projects that may affect bog turtles are identified early in the planning process.
- 1.2 Improve the effectiveness of regulatory reviews in protecting bog turtles and their habitats, specifically to address agencies working at cross purposes when permitting activities in wetlands.
  - 1.2.1 Identify project/permit categories that may adversely affect bog turtles and their habitat.
  - 1.2.2 Train appropriate federal, state, and local agency staff in the recognition of bog turtle habitat, and threats to the species and its habitat.
- 1.3 Avoid and minimize direct and indirect adverse effects to bog turtles and their habitat.
- 1.4 Consider amending and/or clarifying the scope of state and municipal regulatory protections afforded to bog turtles and their habitat.

2. Secure the long-term protection of bog turtle sites.

- 2.1 In each recovery unit, identify and prioritize sites for appropriate conservation efforts.
- 2.2 Develop voluntary, cooperative stewardship programs to conserve the bog turtle and its habitat on private property.
- 2.3 Protect bog turtle sites through purchase and conservation easements.

3. Conduct surveys of known, historical, and potential bog turtle habitat.

- 3.1 Increase the effectiveness of surveys to determine the presence/absence of bog turtles within specific wetland sites.
  - 3.1.1 Develop a model to identify potential bog turtle habitat and locate additional bog turtle sites.
  - 3.1.2 Develop and use a standardized bog turtle survey protocol.
  - 3.1.3 Ensure that qualified searchers conduct bog turtle surveys.
- 3.2 Investigate the effectiveness, risks, and benefits of additional survey techniques to determine bog turtle presence.
- 3.3 Conduct surveys to re-evaluate the presence of bog turtles at historical sites.
  - 3.3.1 Prairie Peninsula/Lake Plain Recovery Unit.
  - 3.3.2 Other recovery units.
- 3.4 Conduct surveys to locate additional populations of bog turtles.
- 3.5 Monitor the status of and threats to extant populations.

4. Investigate the genetic variability of the bog turtle throughout its range.

- 4.1 Determine family size.
- 4.2 Determine effective population size.
- 4.3 Re-evaluate recovery criteria.
- 4.4 Use available genetic data to assist conservation efforts.

5. Reintroduce bog turtles into areas from which they had been extirpated or removed.

- 5.1 Develop a protocol to assess the health of bog turtles prior to release or reintroduction.
- 5.2 Ensure that only healthy bog turtles are released into the wild during reintroduction or repatriation efforts.
- 5.3 Develop a strategy for reintroducing bog turtles into areas from which they have been extirpated.
- 5.4 Restore bog turtle populations within the Prairie Peninsula/Lake Plain Recovery Unit through reintroductions.

6. Manage and maintain bog turtle habitat to ensure its suitability for bog turtles.

- 6.1 Monitor the status of and threats to habitat at known bog turtle sites.
  - 6.1.1 Use a standardized protocol to evaluate bog turtle sites.
  - 6.1.2 Identify and map the groundwater recharge and supply zones associated with bog turtle sites.
- 6.2 Conduct research/studies to understand and identify the degree to which land-use activities alter bog turtle habitat.
- 6.3 Identify the safest and most effective methods to manage, maintain and restore bog turtle habitat.
  - 6.3.1 Identify the safest and most effective methods for controlling invasive native and exotic plants, and setting back succession.
  - 6.3.2 Determine the safest and most effective methods for using grazing to restore and maintain bog turtle habitat.
  - 6.3.3 Identify methods to prevent adverse hydrological changes to bog turtle habitat, and restore hydrology at altered sites.
  - 6.3.4 Identify methods to reconnect fragmented habitat.
- 6.4 Manage, restore, and maintain bog turtle habitat, as appropriate.
  - 6.4.1 Where succession and/or invasive exotic plants pose a threat to bog turtle habitat, implement safe methods to control invasive native and exotic plant species.
  - 6.4.2 Restore hydrology to altered bog turtle sites.
  - 6.4.3 Reconnect fragmented habitats (using methods identified in Task 6.3.4).

7. Manage bog turtle populations at extant sites, where necessary.

7.1 Develop a strategy for evaluating bog turtle populations and managing those populations (where necessary).
- 7.1.1 Determine what constitutes a "viable" bog turtle population.
- 7.1.2 Develop a survey protocol to evaluate the population status of bog turtle sites.
- 7.1.3 Determine the baseline health parameters of free-ranging bog turtles.
- 7.1.4 Develop a protocol to assess the role of disease in wild bog turtle populations.
- 7.1.5 Determine the effects of predation on populations size, structure, and recruitment.
- 7.1.6 Identify appropriate population management techniques.

7.2 Using techniques identified in Task 7.1, manage bog turtle populations to improve their health and status, as appropriate.

8. Conduct an effective interagency law enforcement program to halt illicit take and commercialization of bog turtles.

8.1 Identify protocols to be followed as to the disposition of confiscated turtles.

8.2 Train law enforcement personnel.

8.3 Create a centralized repository of information that could assist law enforcement personnel in identifying the areas from which turtles have been taken.

8.4 Investigate the effectiveness, risks, and benefits of PIT tagging wild and captive bog turtles as a research tool and deterrent to collection/trade.

8.5 Investigate the potential for using neighborhood watches to monitor bog turtle sites for illegal collecting activity.

8.6 Seek maximum penalties for offenses relating to the illegal collection, trade, and possession of bog turtles.

8.7 Promote the development and implementation of laws regulating intra- and interstate commerce in state and federally listed species.

8.8 Develop and use genetic markers to identify the origin of seized turtles.

9. Develop and implement an effective outreach and education program about bog turtles.

9.1 Develop and implement public awareness programs.
- 9.1.1 Develop and distribute educational materials about the bog turtle.
- 9.1.2 Make effective sue of the media in conducting outreach efforts.

9.2 Develop and implement programs targeted specifically at local decision makers (municipal, county, and state).
- 9.2.1 Provide local decision makers with information about the general location of bog turtles/bog turtle habitat.
- 9.2.2 Provide local decision makers with guidance about avoiding adverse effects to bog turtles.

9.3 Inform and educate individuals/entities who own or manage bog turtle habitat about the species and threats to its existence.

9.3.1 Inform and educate landowners about the status of and threats to bog turtle populations on their property.

9.3.2 Prepare bog turtle habitat management guidelines for landowners and land managers.

10. Develop and implement recovery-unit specific recovery tasks recognizing that each recovery unit will require a different prioritization of approaches.

1. Protect known extant populations and their habitat using existing regulations.

Many bog turtle sites are threatened by habitat destruction, degradation, and fragmentation due to various activities authorized, permitted, funded, or carried out by federal, state, and municipal governments. Coordinated implementation of the diverse laws and regulations related to wetlands, endangered species, and land use is needed to prevent and minimize adverse effects to bog turtle populations and their habitat.

1.1 Adequately screen projects/permits that may affect bog turtles and their habitat. Inadequacy of regulatory screenings results in the loss, fragmentation, and degradation of bog turtle habitat. Some range states require that a search be made of their Natural Heritage program "species of concern" databases prior to issuing/approving certain permits/projects. However, there is little opportunity or ability to extrapolate out from bog turtle sightings (occurrences) to encompass the actual habitat required by the turtle population. Proposals to incorporate a polygon or buffer around turtle locations have been made, but they still do not go far enough to map the entire habitat that could be potentially used by the turtle or contain undiscovered turtle populations.

1.1.1 Map contiguous wetland habitat. Improve the effectiveness of project/permit screening and reduce the potential for project/permit delays by creating species occurrence zones in the state Natural Heritage databases. This would be done by adding value to the element occurrence data contained in data bases, that is, by extrapolating outward from defined element occurrence points or polygons to encompass continuous, contiguous (i.e., unfragmented), wetland habitats that are appropriate for bog turtles. Mapping should also include streams connecting occurrences comprising population sites. A search of the Natural

Heritage database during project/permit review should then focus on this habitat block, and such habitats should be assessed in the field as to their suitability for bog turtles. Note that this regulatory review data layer or coverage would supplement, not replace, the heritage programs' element occurrence coverage for bog turtles. Development of such a layer would require collaboration between the heritage programs, U.S. Fish and Wildlife Service, and state nongame programs.

1.1.2 **Map/identify watersheds or wetland systems of occurrence.** Taking the contiguous habitat mapping one step further, identify and map watersheds or wetland systems of bog turtle occurrence to facilitate project/permit reviews. These larger zones would contain within them known and potential bog turtle habitat, and would assist planners and agencies in quickly identifying areas within which projects/permits would require additional review for bog turtles and their habitat.

1.1.3 **As appropriate, include all extant bog turtle sites on state freshwater wetland maps.** In states that rely on state wetland maps to trigger regulatory reviews, small bog turtle wetlands are in danger of being overlooked. In New York, for instance, wetlands are regulated by the State only if they are mapped on the New York State Freshwater Wetlands Maps, and wetlands less than 12.4 acres are not mapped unless they are "of unusual local importance." Wetlands with endangered or threatened species meet this requirement, but it takes years to amend the maps when new sites are discovered. Because of this process, many bog turtle wetlands are not included on these maps and are therefore not recognized or considered during project and permit reviews. Mapping should include contiguous wetland habitat and streams connecting occurrences comprising population sites (task 1.1.1).

In all cases, care must be taken to preserve the necessary security of the data. If bog turtle site security cannot be maintained by including bog turtle habitats on state freshwater wetland maps, then maps of bog turtle habitat should be made available to appropriate agency personnel conducting reviews of projects that may affect bog turtles or their habitat.

1.1.4 **Ensure that adequate screening tools are used so that projects that may affect bog turtles are identified early in the planning process.** The identification and mapping of wetlands and watersheds of bog turtle occurrences to facilitate project planning is critical to the avoidance or minimization of potential impacts. It is imperative that this information

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APPENDIX A

BOG TURTLE CONSERVATION ZONES

(revised April 18, 2001)

Projects in and adjacent to bog turtle habitat can cause habitat destruction, degradation, and fragmentation. Of critical importance is evaluating the potential direct and indirect effects of activities that occur in or are proposed for upland areas adjacent to bog turtle habitat. Even if the wetland impacts from an activity are avoided (i.e., the activity does not result in encroachment into the wetland), activities in adjacent upland areas can seriously compromise wetland habitat quality, fragment travel corridors, and alter wetland hydrology, thereby adversely affecting bog turtles.

The following bog turtle conservation zones have been designated with the intent of protecting and recovering known bog turtle populations within the northern range of this species. The conservation suggestions for each zone are meant to guide the evaluation of activities that may affect high-potential bog turtle habitat, potential travel corridors, and adjacent upland habitat that may serve to buffer bog turtles from indirect effects. *Nevertheless, it is important to recognize that consultations and project reviews will continue to be conducted on a case-by-case basis, taking into account site- and project-specific characteristics.*

Zone 1

This zone includes the wetland and visible spring seeps occupied by bog turtles. Bog turtles rely upon different portions of the wetland at different times of year to fulfill various needs; therefore, this zone includes the entire wetland (the delineation of which will be scientifically based), not just those portions that have been identified as, or appear to be, optimal for nesting, basking or hibernating. In this zone, bog turtles and their habitat are most vulnerable to disturbance, therefore, the greatest degree of protection is necessary.

Within this zone, the following activities are likely to result in habitat destruction or degradation and should be avoided. These activities (not in priority order) include:

- development (e.g., roads, sewer lines, utility lines, storm water or sedimentation basins, residences, driveways, parking lots, and other structures)
- wetland draining, ditching, tiling, filling, excavation, stream diversion and construction of impoundments
- heavy grazing
- herbicide, pesticide or fertilizer application[1]
- mowing or cutting of vegetation[1]
- mining
- delineation of lot lines (e.g., for development, even if the proposed building or structure will not be in the wetland)

Some activities within this zone may be compatible with bog turtle conservation but warrant careful evaluation on a case-by-case basis:

- light to moderate grazing
- non-motorized recreational use (e.g., hiking, hunting, fishing)

Zone 2

The boundary of this zone extends *at least 300 feet* from the edge of Zone 1 and includes upland areas adjacent to Zone 1. Activities in this zone could indirectly destroy or degrade wetland habitat over the short or long-term, thereby adversely affecting bog turtles. In addition, activities in this zone have the potential to cut off travel corridors between wetlands occupied or likely to be occupied by bog turtles, thereby isolating or dividing populations and increasing the risk of turtles being killed while attempting to disperse. Some of the indirect effects to wetlands resulting from activities in the adjacent uplands include: changes in hydrology (e.g., from roads, detention basins, irrigation, increases in impervious surfaces, sand and gravel mining); degradation of water quality (e.g., due to herbicides, pesticides, oil and salt from various sources including roads, agricultural fields, parking lots and residential developments); acceleration of succession (e.g., from fertilizer runoff); and introduction of exotic plants (e.g., due to soil disturbance and roads). This zone acts as a filter and buffer, preventing or minimizing the effects of land-use activities on bog turtles and their habitat. This zone is also likely to include at least a portion of the groundwater recharge/supply area for the wetland.

Activities that should be avoided in this zone due to their potential for adverse effects to bog turtles and their habitat include:

- development (e.g., roads, sewer lines, utility lines, storm water or sedimentation basins, residences, driveways, parking lots, and other structures)
- mining
- herbicide application[1]
- pesticide or fertilizer application
- farming (with the exception of light to moderate grazing - see below)
- certain types of stream-bank stabilization techniques (e.g., rip-rapping)
- delineation of lot lines (e.g., for development, even if the proposed building or structure will not be in the wetland)

Careful evaluation of proposed activities on a case-by-case basis will reveal the manner in which, and degree to which activities in this zone would affect bog turtles and their habitat. Assuming impacts within Zone 1 have been avoided, evaluation of proposed activities within Zone 2 will often require an assessment of anticipated impacts on wetland hydrology, water quality, and habitat continuity.

Activities that are likely to be compatible with bog turtle conservation but that should be evaluated on a case-by-case basis within this zone include:

- light to moderate grazing
- non-motorized recreational use (e.g., hiking, hunting, fishing)
- mowing or cutting of vegetation

Zone 3

This zone includes upland, wetland, and riparian areas extending either to the geomorphic edge of the drainage basin or at least one-half mile beyond the boundary of Zone 2. Despite the distance from Zone 1, activities in these areas have the potential to adversely affect bog turtles and their habitat. This particularly applies to activities affecting wetlands or streams connected to or contiguous with Zone 1, because these areas may support undocumented occurrences of bog turtles and/or provide travel corridors. In addition, some activities (e.g., roads, groundwater withdrawal, water/stream diversions, mining, impoundments, dams, "pump-and-treat" activities) far beyond Zone 1 have the potential to alter the hydrology of bog turtle habitat, therefore, another purpose of Zone 3 is to protect the ground and surface water recharge zones for bog turtle wetlands. Where the integrity of Zone 2 has been compromised (e.g., through increases in impervious surfaces, heavy grazing, channelization of stormwater runoff), there is also a higher risk of activities in Zone 3 altering the water chemistry of bog turtle wetlands (e.g., via nutrient loading, sedimentation, and contaminants).

Activities occurring in this zone should be carefully assessed in consultation with the Fish and Wildlife Service and/or appropriate State wildlife agency to determine their potential for adverse effects to bog turtles and their habitat. Prior to conducting activities that may directly or indirectly affect wetlands, bog turtles and/or bog turtle habitat surveys should be conducted in accordance with accepted survey guidelines.

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[1] Except when conducted as part of a bog turtle habitat management plan approved by the Fish and Wildlife Service or State wildlife agency

APPENDIX B

GUIDELINES FOR BOG TURTLE SURVEYS [1]

(revised May 2001)

RATIONALE

A bog turtle survey (when conducted according to these guidelines) is an attempt to determine presence or probable absence of the species; it does not provide sufficient data to determine population size or structure. Following these guidelines will standardize survey procedures. It will help maximize the potential for detection of bog turtles at previously undocumented sites at a minimum acceptable level of effort. Although the detection of bog turtles confirms their presence, failure to detect them does not absolutely confirm their absence (likewise, bog turtles do not occur in all appropriate habitats and many seemingly suitable sites are devoid of the species). Surveys as extensive as outlined below usually suffice to detect bog turtles; however, there have been instances in which additional effort was necessary to detect bog turtles, especially when habitat was less than optimum, survey conditions were less than ideal, or turtle densities were low.

PRIOR TO CONDUCTING ANY SURVEYS

If a project is proposed to occur in a county of known bog turtle occurrence (see attachment 1), contact the U.S. Fish and Wildlife Service (Service) and/or the appropriate State wildlife agency (see attachment 2). They will determine whether or not any known bog turtle sites occur in or near the project area, and will determine the need for surveys.

- If a wetland in or near the project area is *known* to support bog turtles, measures must be taken to avoid impacts to the species. The Service and State wildlife agency will work with federal, state and local regulatory agencies, permit applicants, and project proponents to ensure that adverse effects to bog turtles are avoided or minimized.

- If wetlands in or adjacent to the project area are *not* known bog turtle habitat, conduct a bog turtle habitat survey (Phase 1 survey) if:

  1. The wetland(s) have an emergent and/or scrub-shrub wetland component, and

  2. Direct and indirect adverse effects to the wetland(s) cannot be avoided.

  See *Bog Turtle Conservation Zones* for guidance regarding activities likely to affect bog turtles and their habitat. In addition, consult with the Fish and Wildlife Service and/or appropriate State wildlife agency to definitively determine whether or not a Phase 1 survey will be necessary.

BOG TURTLE HABITAT SURVEY (= Phase 1 survey)

The purpose of this survey is to determine whether or not the wetland(s) are *potential* bog turtle habitat. These surveys are usually performed by someone who is either: (1) qualified to conduct bog turtle surveys (i.e., Phase II surveys) or (2) qualified to identify and delineate wetlands. The following conditions and information apply to habitat surveys.

- Surveys can be performed any month of the year (except when significant snow cover is present). This flexibility in conducting Phase 1 surveys allows efforts during the Phase 2 survey window to be spent on wetlands most likely to support bog turtles (i.e., those that meet the criteria below).

- Potential bog turtle habitat is recognized by three criteria *(not all of which may occur in the same portion of a particular wetland)*:

  1. **Suitable hydrology**. Bog turtle wetlands are typically spring-fed with shallow surface water or saturated soils present year-round, although in summer the wet area(s) may be restricted to near spring head(s). Typically these wetlands are interspersed with dry and wet pockets. There is often subsurface flow. In addition, shallow rivulets (less than 10 cm deep) or pseudo-rivulets are often present.

  2. **Suitable soils.** Usually - a bottom substrate of soft muck or mucky-like soils (this does not refer to a technical soil type); you will usually sink to your ankles or deeper in muck, although in summers of dry years this may be limited to areas near spring heads. In some portions of the species' range, the soft substrate consists of scattered pockets of peat (6+ inches deep) instead of muck. Suitable soils are the critical criterion.

  3. **Suitable vegetation**. Dominant vegetation of low grasses and sedges (emergent wetland), often with a scrub-shrub wetland component. Common emergent vegetation includes: tussock sedge (*Carex stricta*), soft rush (*Juncus effusus*), rice cut grass (*Leersia oryzoides*), sensitive fern (*Onoclea sensibilis*), tearthumbs (*Polygonum spp.*), jewelweeds (*Impatiens spp.*), arrowheads (*Saggittaria spp.*), skunk cabbage (*Symplocarpus foetidus*), Panic grasses (*Panicum spp.*), other sedges (*Carex spp.*), spike rushes (*Eleocharis* sp.), grass-of-Parnassus (*Parnassia glauca*), shrubby cinquefoil (*Potentilla fruticosa*), sweet-flag (*Acorus calamus*), and in disturbed sites, reed canary grass (*Phalaris arundinacea*) or purple loosestrife (*Lythrum salicaria*). Common scrub-shrub species include alder (*Alnus spp.*), red maple (*Acer rubrum*), willow (*Salix spp.*), tamarack (*Larix laricina*), and in disturbed sites, multiflora rose (*Rosa multiflora*).

- Suitable hydrology, soils and vegetation are necessary to provide the critical wintering sites (soft muck, peat, burrows, root systems of woody vegetation) and nesting habitats (open areas with tussocky or hummocky vegetation) for this species. It is very important to note, however, that one or more of these criteria may be absent from portions of a wetland or wetland complex supporting bog turtles. Absence of one or more criteria does not preclude bog turtle use of these areas to meet important life functions, including foraging, shelter and dispersal.

- If these criteria (suitable soils, vegetation and hydrology) are present in the *wetland*, then the *wetland* is considered to be potential bog turtle habitat, regardless of whether or not that portion of the wetland occurring within the project boundaries contains all three criteria. If the *wetland* is determined to be potential habitat and the project will directly or indirectly impact *any portion* of the wetland, then either:

    - Completely avoid all direct and indirect effects to the wetland, in consultation with the Service and appropriate State wildlife agency, *OR*

    - Conduct a Phase 2 survey to determine the presence of bog turtles.

- The Service and appropriate State agency (see list) should be sent a copy of survey results for review and comment including: a USGS topographic map indicating location of site; project design map, including location of wetlands and streams; color photographs of the site; surveyor's name; date of visit; opinion on potential/not potential habitat; a description of the hydrology, soils, and vegetation.

BOG TURTLE SURVEY (= Phase 2 survey)

If the wetland(s) are identified as potential bog turtle habitat (see Phase 1 survey), and direct and indirect adverse effects cannot be avoided, conduct a bog turtle survey in accordance with the specifications below. Note that this is *not* a survey to estimate population size or structure; a long-term mark/recapture study would be required for that.

Prior to conducting the survey, contact the appropriate State agency (see attached list) to determine whether or not a scientific collector's permit valid for the location and period of the survey will be required.

1. Surveys should only be performed during the period from April 15-June 15. This coincides with the period of greatest annual turtle activity (spring emergence and breeding) and before vegetation gets too dense to accurately survey. While turtles may be found outside of these dates, a result of no turtles would be considered inconclusive. Surveys beyond June also have a higher likelihood of disruption or destruction of nests or newly hatched young.

2. Air and water temperatures should be a minimum of 55° F.

3. Surveys should be conducted during the day, at least one hour after sunrise and no later than one hour before sunset.

4. Cloud cover should be <50 percent, and surveys should not be conducted during or immediately following rain events, unless it clears rapidly and is sunny.

5. One (1) to three (3) people should survey each wetland together. At least one (1) of these must be a recognized qualified bog turtle surveyor[2], and the others should have at least some previous experience conducting bog turtle surveys. To maintain survey effort consistency and increase the probability of encountering turtles, it is recommended that the same surveyors be used for each wetland.

6. A minimum of four (4) surveys per wetland site are needed to adequately assess the site for presence of bog turtles. At least two of these surveys must be performed in May. From mid-April to mid-May, surveys should be separated by six or more days. From mid-May to mid-June, surveys should be separated by three or more days. The shorter period between surveys during late May and June is needed to ensure that surveys are carried out during the optimum window of time (i.e., before wetland vegetation becomes too thick).

   Note that bog turtles are more likely to be encountered by spreading the surveys out over a longer period. For example, erroneous survey results could be obtained if surveys were conducted on four successive days in late April due to possible late spring emergence, or during periods of extreme weather because turtles may be buried in mud and difficult to find.

   If bog turtles are found on the first, second or third visit, the site does not need to be revisited. Because this is solely a presence/absence survey, survey efforts at a particular wetland may cease once a bog turtle has been found.

7. Survey time should be three (3) to six (6) person-hours per acre of wetland per visit. Both random opportunistic searching and transect surveys should be used at each wetland.

8. Walk quietly through the wetland. Bog turtles will bask on sedge tussocks and mossy hummocks, or be half-buried in shallow water or rivulets. Walking noisily through the wetland will often cause the turtles to submerge before they can be observed. Be sure to search areas where turtles may not be visible, including shallow pools, underground springs, open mud areas, vole runways and under tussocks. Do not step on the tops of tussocks or hummocks because turtle nests, eggs and nesting microhabitat may be destroyed.

9. Photo-documentation of each bog turtle located will be required; a macro lens is highly recommended. The photos should be in color and of sufficient detail and clarity to identify the bog turtle to species and individual. Therefore, photographs of the carapace, plastron, and face/neck markings should be taken of each individual turtle. Do not harass the turtle in an attempt to get photos of the face/neck markings; if gently placed on the ground, most turtles will slowly extend their necks if not harassed. If shell notching is conducted, do the photo-documentation after the notching is done.

10. The following information should be collected for each bog turtle: sex, carapace length -straight line, carapace width, weight, and details about scars/injuries. Plastron length-straight line information should also be collected to differentiate juveniles from adults (> 70 mm; Ernst 1977) as well as to obtain additional information on recruitment, growth, and demography.

11. Each bog turtle should be marked (e.g., notched, PIT tagged) in a manner consistent with the requirements of the appropriate State agency and/or Service. Contact the appropriate State agency prior to conducting the survey to determine what type of marking system, if any, should be used.

12. All bog turtles must be returned to the point of capture as soon as possible on the same day as capture. They should only be held long enough to identify, measure, weigh, and photograph them, during which time their exposure to high temperatures must be avoided. No bog turtles may be removed from the wetland without permission from the Service and appropriate State agency.

13. The Fish and Wildlife Service and appropriate State agency should be sent a copy of survey results for review and concurrence, including the following: dates of site visits; time spent per wetland per visit; names of surveyors; a site map; a description of the wetlands within the project area (e.g., acreage, vegetation, soils, hydrology); an explanation of which wetlands or portions of wetlands were or were not surveyed, and why; survey methodology; weather per visit at beginning and end of survey (air temperature, water temperature, percent cloud cover, wind, and precipitation); presence or absence of bog turtles, including number of turtles found and date, and age/sex of turtles found; and other reptile and amphibian species found and date.

ADDITIONAL SURVEYS / STUDIES

Proper implementation of the Phase 2 survey protocol is usually adequate to determine species presence or probable absence. Additional surveys, however, may be necessary to determine whether or not bog turtles are using a particular wetland, especially if the Phase 2 survey results are negative but the quality and quantity of habitat are good and in a watershed of known occurrence. In this case, additional surveys (Phase 2 and/or trapping surveys), possibly extending into the following field season, may be recommended by the Service or appropriate State agency.

If bog turtles are documented to occur at a site, additional surveys/studies may be necessary to characterize the population (e.g., number, density, population structure, recruitment), identify nesting and hibernating areas, and/or identify and assess adverse impacts to the species and its habitat, particularly if project activities are proposed to occur in, or within 300 feet of, wetlands occupied by the species.

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[1] As additional information becomes available regarding survey techniques and effectiveness, these survey guidelines may be updated and revised. Contact the Fish and Wildlife Service or one of the state agencies listed below for the most recent version of these guidelines.

[2] Searching for bog turtles and recognizing their habitat is a skill that can take many months or years of field work to develop. This level of expertise is necessary when conducting searches in order to ensure that surveys are effective and turtles are not harmed during the survey (e.g., by stepping on nests). Many individuals that have been recognized as qualified to conduct bog turtle surveys obtained their experience through graduate degree research or employment by a state wildlife agency.

CONTACT AGENCIES - BY STATE

(Revised May 2001)

STATE	FISH AND WILDLIFE SERVICE	STATE AGENCY
Connecticut	U.S. Fish and Wildlife Service New England Field Office 22 Bridge Street, Unit #1 Concord, NH 03301	Department of Environmental Protection Env. & Geographic Information Center 79 Elm Street, Store Floor Hartford, CT 06106 *(info about presence of bog turtles in or near a project area)* Department of Environmental Protection Wildlife Division, Sixth Floor 79 Elm Street, Store Floor, Hartford, CT 06106 *(to get a Scientific Collectors Permit or determine what type of marking system to use)*
Delaware	U.S. Fish and Wildlife Service Chesapeake Bay Field Office 177 Admiral Cochrane Drive Annapolis, MD 21401	Nongame & Endangered Species Program Delaware Division of Fish and Wildlife 4876 Hay Point Landing Road Smyrna, DE 19977
Maryland	U.S. Fish and Wildlife Service Chesapeake Bay Field Office 177 Admiral Cochrane Drive Annapolis, MD 21401	Maryland Department of Natural Resources Wildlife & Heritage Division PO Box 68, Main Street Wye Mills, MD 21679
Massachusetts	U.S. Fish and Wildlife Service New England Field Office 22 Bridge Street, Unit #1 Concord, NH 03301	Division of Fisheries and Wildlife Dept. Fisheries, Wildlife and Env Law Enforcement Rt. 135 Westboro, MA 01581
New Jersey	U.S. Fish and Wildlife Service New Jersey Field Office 927 North Main Street, Bldg. D-1 Pleasantville, NJ 08232	Endangered & Nongame Species Program Division of Fish, Game & Wildlife Northern Region Office 26 Route 173W Hampton, NJ 08827
New York	U.S. Fish and Wildlife Service 3817 Luker Road Cortland, NY 13045	New York Natural Heritage Program Department of Environmental Conservation 700 Troy-Schenectady Road Latham, NY 12110-2400 *(info about presence of bog turtles in or near a project area)* NY Department of Environmental Conservation Special Licenses Unit 50 Wolf Road Albany, NY 12233 *(for endangered species permit applications)*
Pennsylvania	U.S. Fish and Wildlife Service Pennsylvania Field Office 315 South Allen Street, Suite 322 State College, PA 16801	Endangered Species & Herpetology Coordinator Pennsylvania Fish and Boat Commission Bureau of Fisheries and Engineering 450 Robinson Lane Bellefonte, PA 16823