To: Salisbury Inland Wetlands and Watercourses Commission
Cc: Abby Conroy

Fr: Michael W. Klemens, PhD, June 3rd 2021/Revised July 12th 2021

I would offer the following concepts for you to consider as you deliberate on how best to re-write your regulations. I understand that there is considerable public interest around Lakeville Lake and the Twin Lakes concerning what additional layers of review and regulation may do (or not do) to the ability of homeowners to maintain and enjoy their property. In all due respect to these stakeholders, this is but a small piece of a much larger set of issues that confront you in your role as stewards of Salisbury's wetlands. I am offering these comments as an ecologist with extensive experience in studying wetlands in Connecticut to try and frame what I hope will be a productive discussion about all of Salisbury's wetlands.

The lakes represent some of the most valuable real estate in Salisbury, but from a wetlands perspective they pale in ecological significance to many other wetlands in the Town. Lakeville Lake is a natural deep oligotrophic lake, the Twin Lakes are modified by human manipulation of water levels, eutrophication is a problem in all three lakes. East Twin has some features of an oligotrophic lake, West Twin does not. There are important habitats in and adjacent to these waterbodies (notably the Twin Lakes) because of their extensive shallow areas which support the formation of unique vegetational and biological communities.

I would direct your attention to a number of extremely fragile wetland habitats where science has demonstrated that larger wetland review areas (and buffers) are essential to long-term ecological resiliency. All these wetlands fall under your purview, <u>should be defined in your regulations</u>, and be part of your consideration of the types of buffers and review areas that are needed to maintain their integrity. I have used the term interchangeably, but a review area is just that—an area where the IWWC reviews potential impacts to a wetland resource. A buffer is land that is required to maintain the ecological integrity of the receiving waters. I know that you are all aware that an IWWC can extend its review of activities beyond its proscribed review area if it can demonstrate that these activities are reasonably likely to impair the receiving waters.

I am encouraging consideration of larger review areas around certain specific types of wetlands and watercourses—it's really quite practical—having larger review areas around certain types of wetlands will eliminate the significant burden placed upon the IWWC in arguing to extend their regulatory reach on an application that is adjacent to these valuable resources.

<u>Calcareous Fens</u> These occur on gently sloping area of glacial till above larger wetland complexes. While the underlying soils are nutrient rich—the continuous seepage of

water results in the creation of a system of rivulets, that weave between hummocks, which contain plants more commonly associated with nutrient poor bogs including sundews and pitcher plants. Fens are characterized by many rare plants that have evolved in the unique hydrological conditions created within the fen ecosystem. Fens are also the habitat of the State-endangered (CESA) and Federally-threatened (ESA) bog turtle. Salisbury is one of three towns in Connecticut that still has appropriate habitat for this species. The USFWS (2001) recommends a 300-foot buffer around fen habitats that are inhabited or potentially inhabited by bog turtles. They also recommend that activities that result in ground water withdrawals beyond the 300-foot buffer zone be evaluated. Salisbury has mapped most, if not all, of our fen habitats, and it would be appropriate to propose that a 300-foot review area <u>at minimum</u> surrounding these fragile ecosystems. Wetlands associated with Schenob Brook contain important fen habitats, as do sites along Moore Brook and Beeslick Pond.

<u>Vernal Pools.</u> Not all vernal pools in Salisbury have been mapped, but many have. Because vernal pool breeding amphibian species have extensive use of upland habitat, a 750-foot review area around high-quality vernal pools would be appropriate. This mirrors the regulatory hard look taken by agencies such as the ACOE and CT-DEEP, which follow the guidance document prepared by Calhoun and Klemens (2002) which remains the industry standard for evaluating the quality of a specific pool, and contains many mitigation strategies. It is not a prohibition against development, but rather a pathway to have an informed conversation about how to develop. The importance of vernal pool amphibians in maintaining the nutrient cycling within these wetlands was affirmed by the Connecticut courts in the River Sound decision (2010). The court concurred that the loss of vernal pool amphibians had quantifiable effects on the water quality of those wetlands. Reduction in wood frogs resulted in the eutrophication of vernal pools. Functional vernal pools also filter out methyl-mercury from acid precipitation.

<u>High Gradient Cold Water Streams:</u> These are generally associated with the Taconic Uplift in the northwestern corner of town. Klemens et al (2021: 174-178) discuss the ecological requirements of these streams, the need to protect the forest around the streams to maintain the cold waters that characterize these watercourses. Many of these streams originate from perched wooded wetlands atop the Taconic Uplift—Sages Ravine may be the most familiar of these, including the Joyceville plunge pool just east of Rte. 41. Rare and threatened species including the spring salamander, slimy sculpin, and native brook trout, all require clean, cold, well-oxygenated waters to survive. All of these species are at risk from climate change, most critically the projected retraction of hemlock forests. It has been modelled (Dukes et al 2009) that within the next half century the only town in the State that will contain this unique biological assemblage will be this portion of Salisbury, which will be climate change refugia for these species. As a general principle, the higher the gradient of a stream, the greater the need for a

broader buffer. Klemens et al (2021: 175) recommend a 300-foot buffer area around such waters, and I would recommend that the IWWC review area be <u>at minimum</u> 300 feet around these resources, including the perched wetlands and semi-boreal ponds atop the Taconic Uplift.

In conclusion, I have defined three critical wetland resources that need to be seriously considered in your regulation re-write. These unique wetland resources require at <u>minimum</u> 300-foot review areas, and certain high quality vernal pools require a 750-foot review area. Salisbury has some of the most critical wetland resources in the State, in part because of its geographical and geological location, but also because it is one of few places in the State where significant tracts of forest and open space remain. Wetlands are a critical component of the ecosystem that supports this open space and forest. I would urge you to think beyond a narrowly proscribed view of wetlands and consider what truly is at stake here. I can provide copies of any of these published documents if there is interest in delving into the scientific details of these issues.

Finally, wetlands do not exist as isolated occurrences from uplands or other wetlands. Careful consideration should be given as to how best to maintain the integrity of diverse interconnected systems, an excellent example is Moore Brook, which links a large diversity of wetland types, including fens and vernal pools. Each individual development along Moore Brook may appear minimal, but the cumulative impacts are significant. Cumulative impact analyses are critical functions of an IWWC. I would encourage you to seek legal counsel as to how to embed enabling language in your regulations to allow you, when warranted, to require an Applicant to address not only proximal impacts but cumulative impacts too.

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
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Hadley, Massachusetts

Acting Dr. Richard O. Bennett

Approved:

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

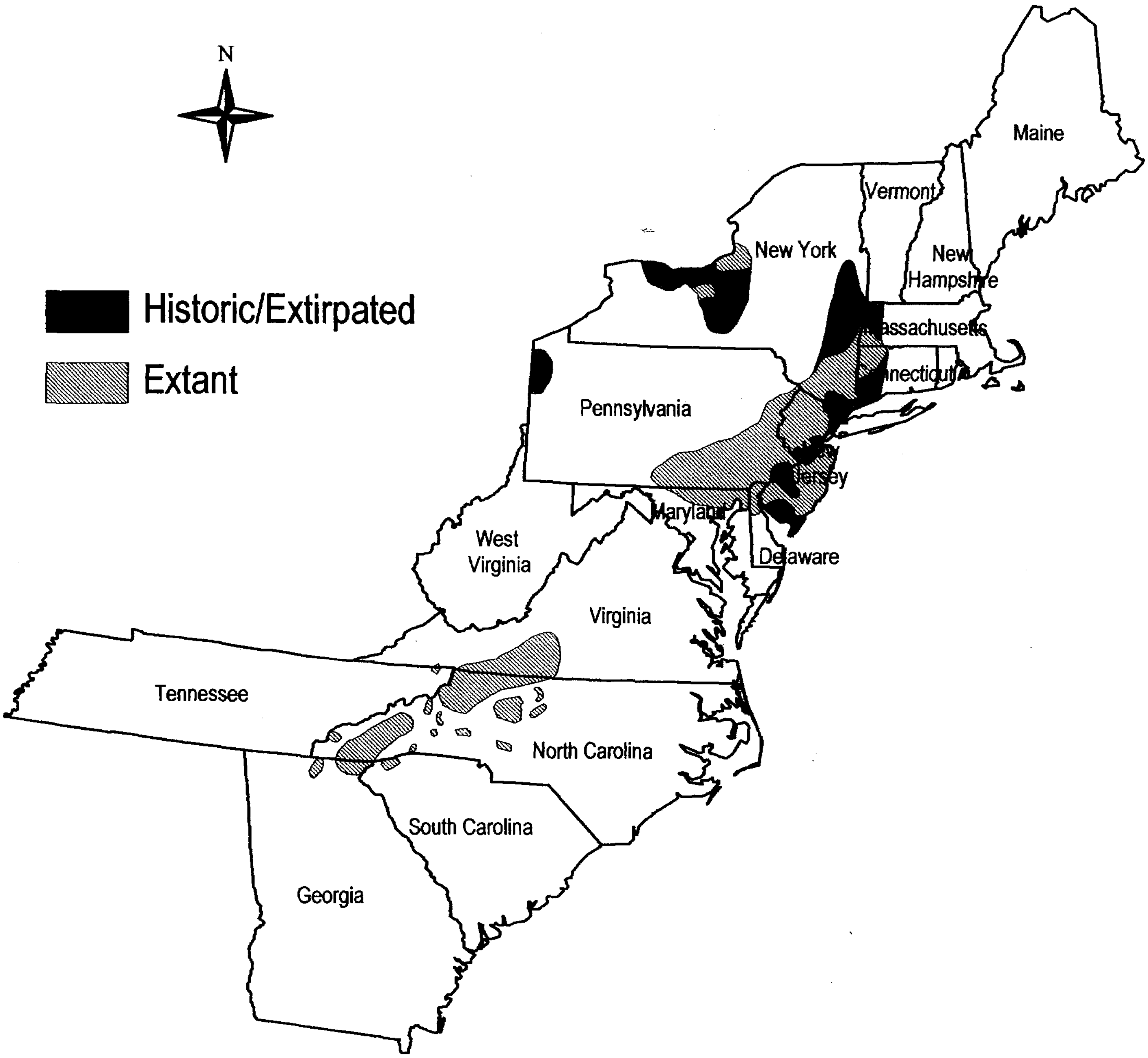

Figure 1. Bog Turtle Range Map

Delaware Bay Estuary Project
May 2001

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

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

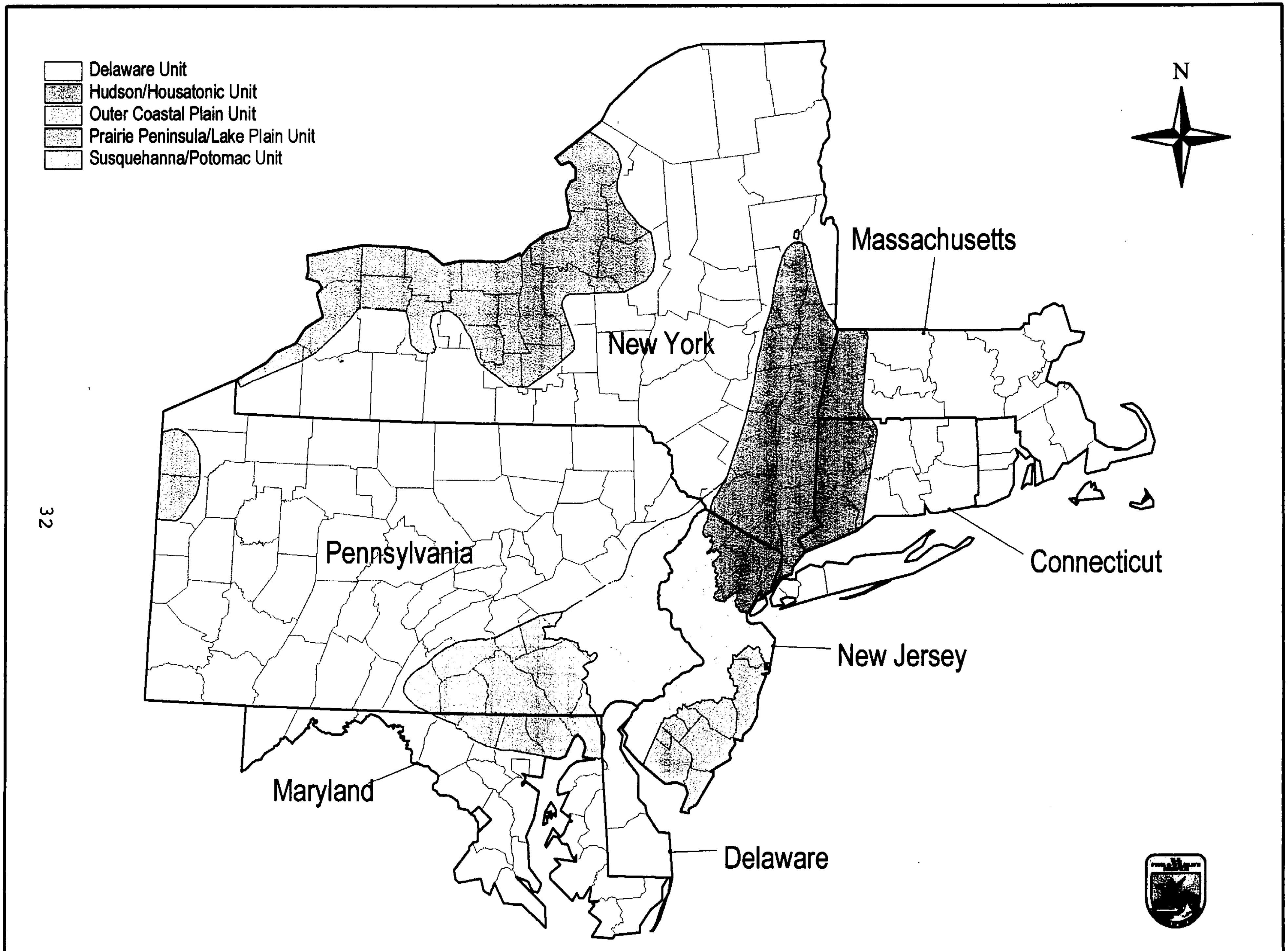

Figure 3. Bog Turtle Recovery Units (Northern Range)

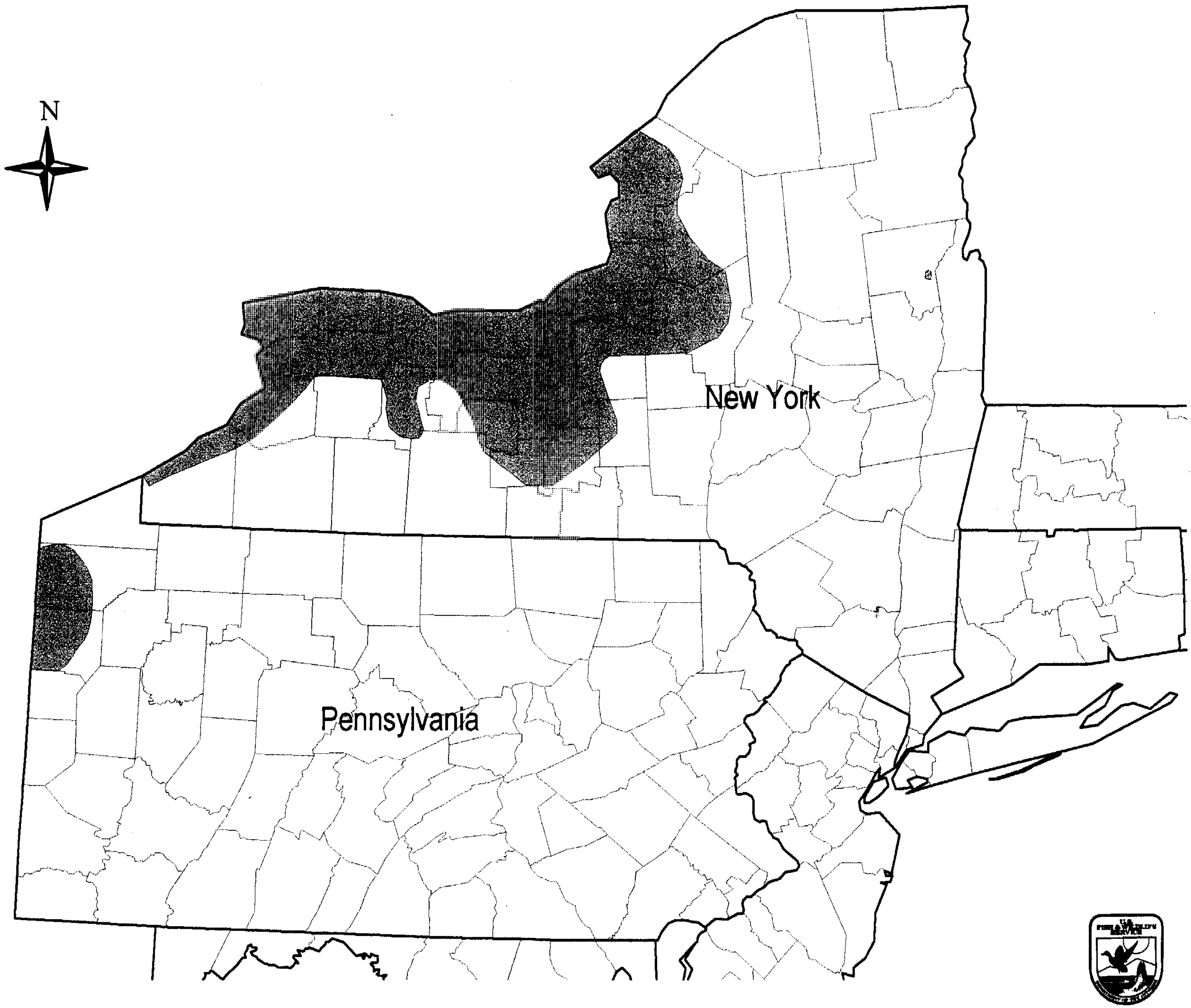

Figure 4. Prairie Peninsula/Lake Plain Recovery Unit

Delaware Bay Estuary Project
May 2001

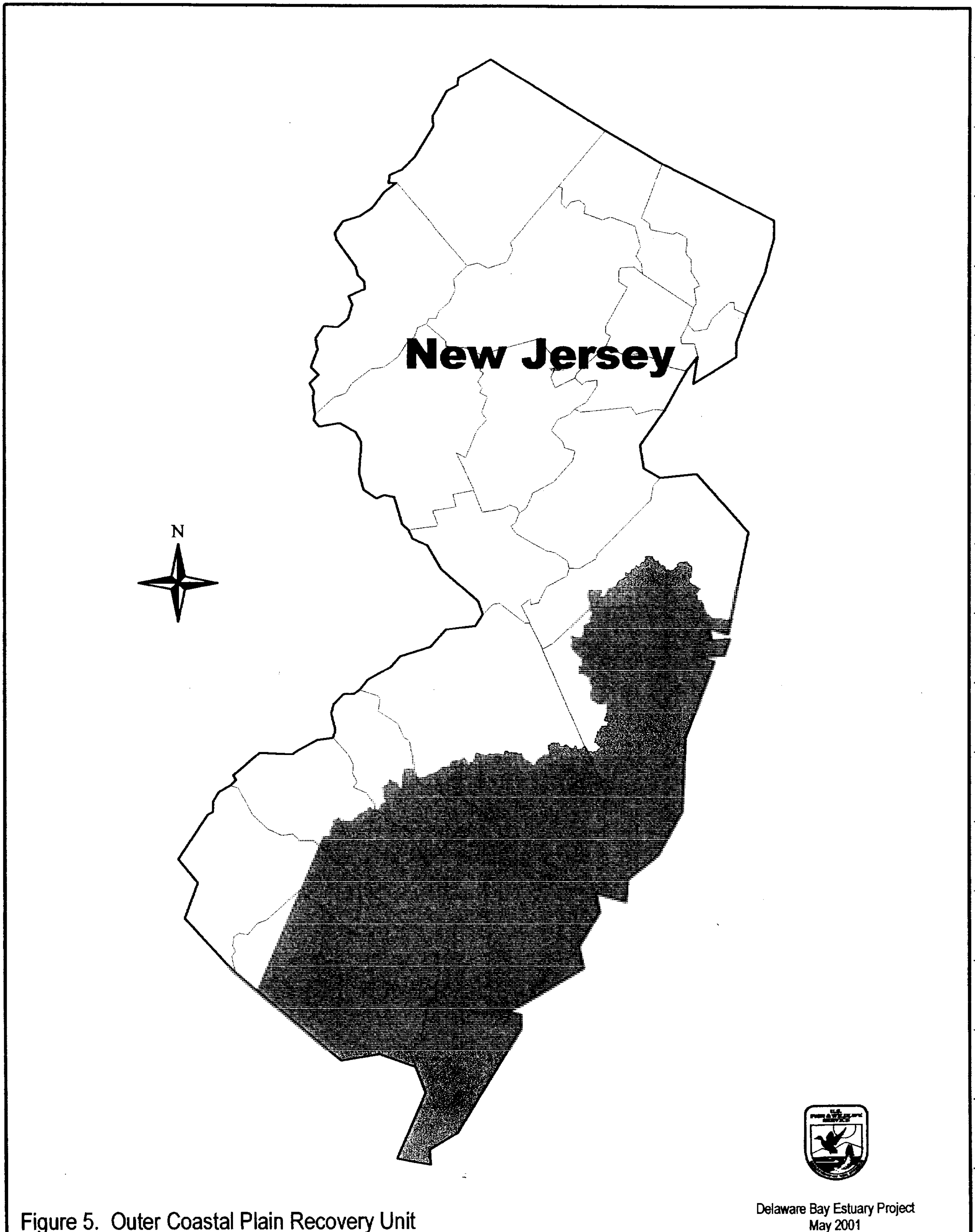

Figure 5. Outer Coastal Plain Recovery Unit

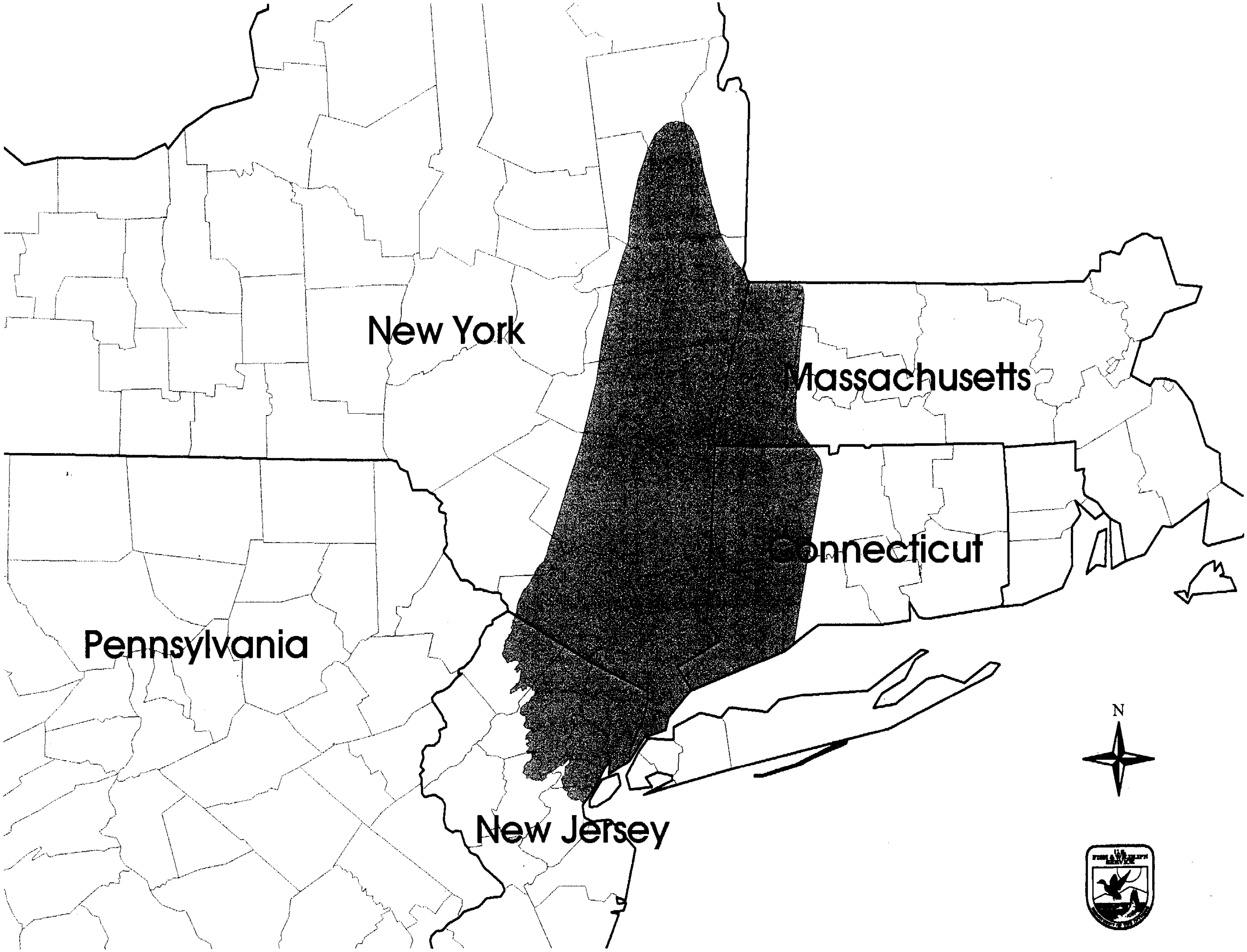

Figure 6. Hudson/Housatonic Recovery Unit

Delaware Bay Estuary Project
May 2001

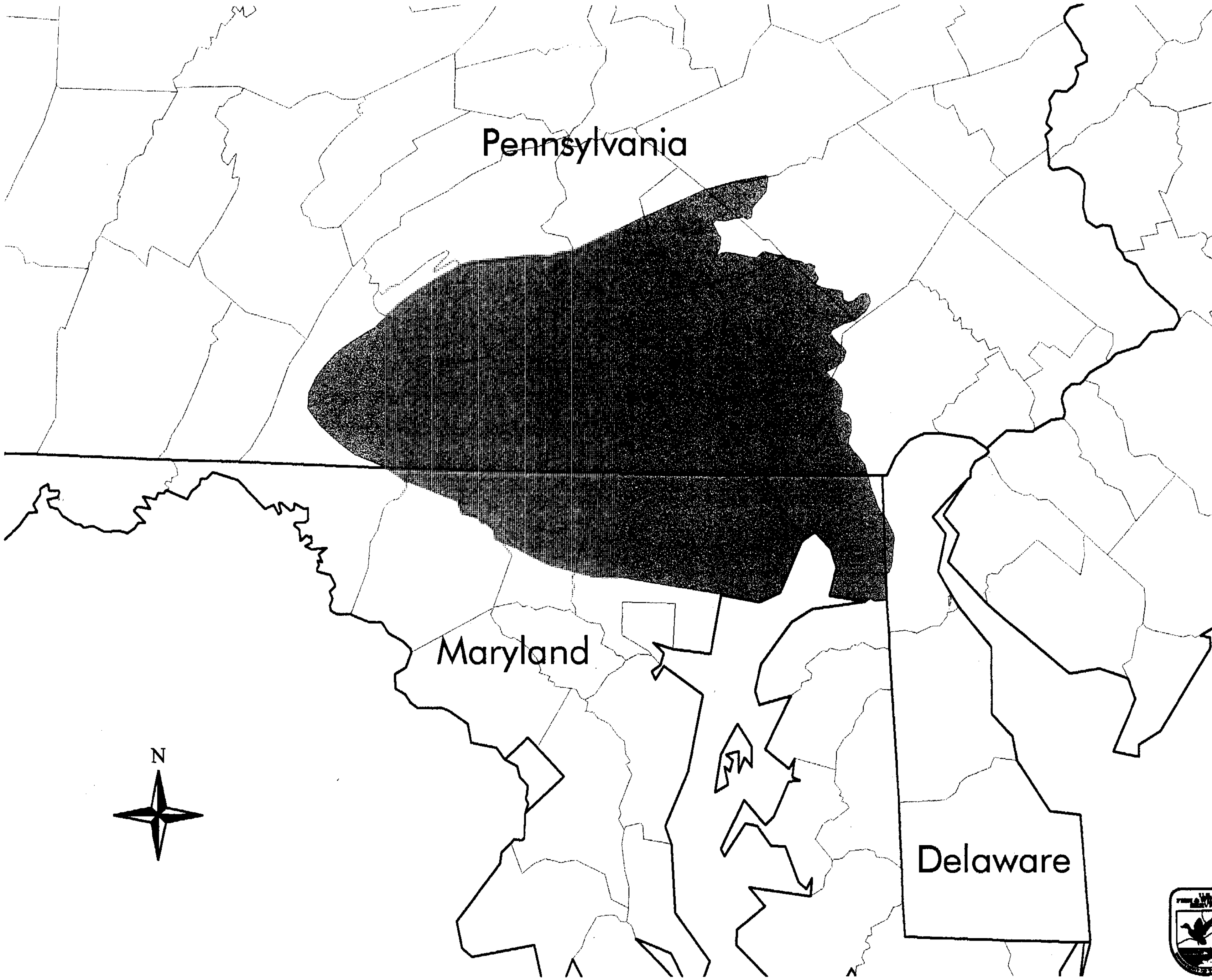

Figure 7. Susquehanna/Potomac Recovery Unit

Delaware Bay Estuary Project
May 2001

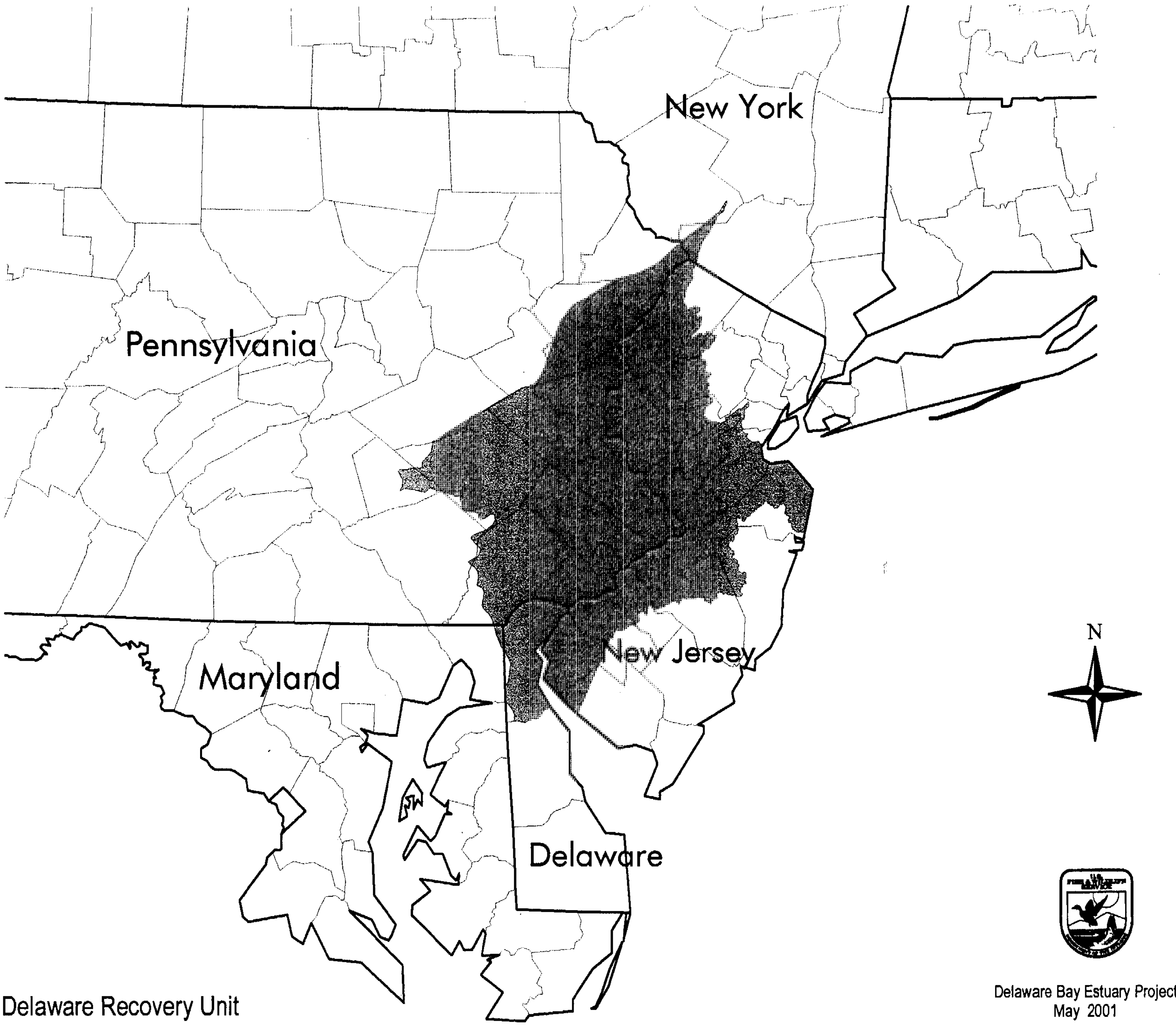

Figure 8. Delaware Recovery Unit

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.

   <u>Prairie Peninsula/Lake Plain Recovery Unit</u>. 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 be made available to the transportation agency in compliance with established confidentiality procedures in the infancy of planning phases for proposed new and existing improvement projects.

In addition, an adequate and standardized screening procedure that is similar among the various agencies and ensures that the state and federal regulatory agencies have the same species occurrence data and use similar evaluation methods should be implemented. The screening tools developed in Tasks 1.1.1-1.1.3 should be used by state wildlife agencies, natural heritage programs and the U.S. Fish and Wildlife Service to screen proposed projects/permits for potential impacts to bog turtles and their habitat.

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.** Partnering and gaining trust among organizations will be extremely important to ensure a successful recovery program. However, agencies at various levels of government often have competing purposes. Although some of these issues may be addressed at the local level, there needs to be better interagency coordination at the higher tiers of government, especially between those federal and state agencies that affect wetlands through project implementation (e.g., state departments of transportation, water allocation authorities, sewer system permitting authorities), those that permit wetland encroachments (e.g., Army Corps of Engineers, state wetland regulatory agencies), those that work with agricultural interests (e.g., Farm Bureau, NRCS), and those charged with resource protection (e.g., Environmental Protection Agency, U.S. Fish and Wildlife Service, state wildlife agencies).

1.2.1 **Identify project/permit categories that may adversely affect bog turtles and their habitat.** To improve the effectiveness and efficiency of project/permit reviews using the limited agency staff available, it is important for agencies to identify, in cooperation with the U.S. Fish and Wildlife Service, those types of permits/projects that have the potential to adversely affect bog turtles. Further review for bog turtles would only be conducted for projects/permits falling into these categories.

Agreement on this approach between Federal and State agencies could result in identification of approved activities with best management practices that create no anticipated impacts versus those potentially affecting bog turtle habitat for existing and proposed projects. The level of additional reviews and consultation would be determined based upon the type of project and relationship to a conservation zone. In addition, implementation of an early coordination process for projects that are not in development but are expected to become projects in the future would be useful in project planning and allocations of time and resources.

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.** For example, staff from federal and state wetland regulatory agencies (working within the range of the bog turtle) should be trained to identify potential bog turtle habitat and know what steps to follow when such habitat is identified. They should be alert to the potential presence of bog turtle habitat during both desktop and field reviews of projects.

Also, some federal and state habitat restoration programs, including the Fish and Wildlife Service's Partners for Fish and Wildlife Program and the Natural Resources Conservation Service's Wetland Reserve Program, restore wetlands for willing landowners. Under these programs, there may be times when landowners would like to convert wet meadows into open water habitats and inadvertently destroy bog turtle habitat. In addition, pursuant to its Conservation Reserve Enhancement Program (CREP), the USDA funds tree-planting projects, sometimes adjacent to bog turtle habitat (which could accelerate succession). Therefore, it is imperative that agency field personnel be trained in the identification of potential bog turtle habitat and the use of restoration and enhancement techniques that are compatible with bog turtle recovery.

1.3 **Avoid and minimize direct and indirect adverse effects to bog turtles and their habitat.** Projects both within 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 projects proposed to occur in wetlands and/or in upland areas adjacent to bog turtle habitat. The recommended conservation zones described in Appendix A are based on the best scientific information available and will be used as a template throughout the northern range of the bog turtle to ensure consistent and vigorous protection of extant bog turtle sites. Using the conservation zone guidelines, Federal project and permit reviews will continue to be conducted on a case-by-case basis, recognizing the distinct characteristics of each site and unique conditions of each project.

1.4 **Consider amending and/or clarifying the scope of state and municipal regulatory protections afforded to bog turtles and their habitat.** The protection of bog turtle habitat could be enhanced through expanded use (e.g., via amendment or clarification) of many existing laws and regulations, including, but not limited to those associated with: state threatened and endangered species, wetlands, storm water management, sewage systems, and green space conservation.

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

In order to achieve recovery, viable bog turtle populations in all five recovery units must be permanently protected from foreseeable threats.

2.1 **In each recovery unit, identify and prioritize sites for appropriate conservation efforts.** Conservation needs will vary tremendously by site, therefore, site-specific threats and needs assessments should be conducted. For example, while some sites are in need of management to control succession, others are in need of increased law enforcement surveillance, protection via binding conservation agreements, protection of groundwater recharge areas, conservation of upland buffers, restoration of travel routes between sites, or a combination of several conservation efforts. In addition, conservation efforts will be influenced by several factors, including site quality, population viability, severity of threats, land ownership, and resources available to implement protection. In order to achieve recovery, conservation needs must be prioritized to take advantage of the limited resources available.

In most recovery units, some very high quality bog turtle sites exist, evidenced by the quality of the habitat and the status of the population. These sites may form the starting point for meeting the recovery objectives for each unit. Other sites may be found, or may improve in quality (e.g., via management), and merit addition to this list. Although conservation of all bog turtle sites is important to stem the dramatic decline of the species, some sites are of such exceptional importance that their protection is necessary to ensure the long-term survival and recovery of the bog turtle. Identification of these sites (by state nongame programs, state heritage programs, and the U.S. Fish and Wildlife Service) is a high priority.

In general, interagency coordination regarding the priority areas will help project managers to avoid impacts during routine maintenance activities, repairs and replacement of existing structures on existing roadway networks that are within priority areas. In addition, knowledge of these sites and conservation efforts will allow project planners to integrate avoidance and minimization measures early in the project development phase as well as to manage project scheduling efficiently. Knowledge of the sites would be in compliance with established confidentiality procedures.

2.2 **Develop voluntary, cooperative stewardship programs to conserve the bog turtle and its habitat on private property.** The pattern of ownership of bog turtle habitat (i.e., primarily private, often with multiple landowners/site) provides both challenges and opportunities to develop cooperative stewardship programs that will provide incentives to landowners to enter into cooperative agreements to conserve bog turtles as a part of the working agricultural landscape. A concerted outreach to rural landowners is already underway in Maryland, and in the southern Appalachians, Project Bog Turtle has provided a template for management of wetlands for bog turtles by paying the taxes on the land on an annual basis. The Project Bog Turtle program allows farmers the use of their property, while assisting them in maintaining their family farms in the face of rising property taxes, in exchange for the rights to manage wetlands for bog turtles.

2.3 **Protect bog turtle sites through purchase and conservation easements.** Purchase of bog turtle sites by agencies and organizations dedicated to the species' conservation is encouraged to achieve long-term protection. Conservation easements may also accomplish long-term protection. Ownership alone, however, will not suffice to ensure long-term protection of these sites if management issues are not addressed (e.g., management of succession and invasive exotic plants, implementation of measures to minimize collection of turtles). Due to the risk of collection, care should be taken not to reveal bog turtle site locations when the protection of sites is planned or promoted.

Land acquisition, acquisition of partial interests in land, conservation easements, and voluntary agreements are also tools that should be considered when trying to secure long-term protection of upland buffers surrounding bog turtle wetlands, and the groundwater recharge areas supporting those wetlands.

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

The purpose of these surveys is to effectively monitor the status of the bog turtle at known sites, re-evaluate its presence at historical locations, and locate additional sites for conservation and recovery.

3.1 **Increase the effectiveness of surveys to determine the presence/absence of bog turtles within specific wetland sites.** The majority of bog turtle surveys fail to document the presence of turtles. This is due to two factors. Bog turtles do not occur in all appropriate habitats -- many seemingly suitable sites are devoid of bog turtles. However, many cursory surveys fail to detect bog turtles because of the searcher's lack of effort and skill, or the difficulty of locating bog turtles from mid-June through late March.

3.1.1 **Develop a model to identify potential bog turtle habitat and locate additional bog turtle sites.** Using information about known bog turtle habitat (wetland size, wetland classification, soils, elevation, watershed information, vegetation, depth of "muck", etc.), develop a model and/or set of identifying characteristics to assist in locating potential bog turtle habitat. Test and refine this model as additional information becomes available. More than one model or set of characteristics may be necessary due to geographical variations in habitat.

3.1.2 **Develop and use a standardized bog turtle survey protocol.** Several states have attempted to address these issues by devising a standardized protocol that requires a certain number of visits to the site at the optimal time of year and specifies person-hours of search effort per acre of wetland. A northern range bog turtle survey protocol, based in large part on the state protocols, is appended to this plan (see Appendix B). It is recommended that this protocol be used throughout the northern range of the bog turtle, especially when evaluating potential bog turtle habitat that may be affected by various land-use activities.

3.1.3 **Ensure that qualified searchers conduct bog turtle surveys.** Searching for bog turtles and recognizing their habitat is a skill that can take many months or years of fieldwork to develop and perfect. This level of expertise is necessary when conducting searches in order to ensure that potential habitat is recognized, surveys are effective, and turtles are not harmed during the survey (e.g., by stepping on nests). Many individuals considered qualified to conduct bog turtle surveys obtained their experience through graduate degree research or employment by a state wildlife agency, during which time they spent at least two field seasons surveying for bog turtles.

Nevertheless, the number of wetland habitats that may now be required for evaluation has increased significantly based upon the development of potential occurrence zones. Availability of qualified searchers and the survey time period are key factors in coordinating project reviews and project time schedules. This task will thus include the development of a protocol for designating qualified surveyors to conduct bog turtle surveys.

3.2 **Investigate the effectiveness, risks, and benefits of additional survey techniques to determine bog turtle presence.** These techniques may including trapping, remote sensing, and other experimental techniques. The survey protocol in Appendix B incorporates the most effective techniques currently known. Use of additional techniques should be as part of carefully designed experiments, with results being incorporated into the development of a protocol for using these techniques to conduct surveys.

3.3 **Conduct surveys to re-evaluate the presence of bog turtles at historical sites.**

3.3.1 **Prairie Peninsula/Lake Plain Recovery Unit.** Conduct intensive surveys to determine the presence of any remnant bog turtle populations at historical sites and in suitable wetland habitats within watersheds of historical occurrence. This task is a very high priority in this recovery unit due to the small number of known extant sites remaining in the unit and because any reintroduction efforts in this unit will be predicated upon these survey results.

3.3.2 **Other recovery units.** Additional surveys are needed at many of the historical sites within the range of the bog turtle, focusing on those sites where some suitable habitat still remains. This is a lower priority task than in the Prairie Peninsula/Lake Plain Unit, however. The priority of survey efforts needs to be balanced with the acute need to stabilize bog turtle declines at extant sites.

3.4 **Conduct surveys to locate additional populations of bog turtles.** The need for surveys to reevaluate the presence of bog turtles at historical sites and to locate additional populations varies considerably across the range and among recovery units. *De novo* survey efforts by conservation agencies and organizations (which should be focused on areas identified as most likely to yield positive results) are critically important in some areas, but they must not detract from the acute need to stabilize bog turtle declines at known extant sites. Therefore, while additional survey work should be a part of recovery efforts, it should not eclipse the needs of deploying financial and human resources to address the more difficult, longer-term recovery tasks.

Locating potential new populations is of highest priority when land-use activities are proposed which may adversely affect potential bog turtle habitat. In these cases, the survey protocol in Appendix B should be used to assess the site for the presence of bog turtles and their habitat. It should be noted, however, that reliance on development projects to locate additional populations by examining potential bog turtle habitats and conducting bog turtle surveys within the project study area should not preclude active searches by Federal or State wildlife agencies or conservation groups.

3.5 **Monitor the status of and threats to extant populations.** Known sites in all recovery units should be periodically (at least once every five years) monitored/ surveyed to determine the status of and threats to populations. This monitoring should be detailed enough to determine population trends and detect signs of recruitment/reproduction.

Site maps and survey notes/reports should be detailed enough to detect changes in and threats to habitat, including changes in hydrology, encroachment of development, successional changes, and the introduction and spread of invasive native and exotic plant species. It is recommended that this monitoring be conducted in conjunction with Task 6.1.

Agencies such as PennDOT have participated, and may continue to, in the monitoring of bog turtle populations as part of mitigation requirements through the environmental impact study process (Ryan *in litt.* 2001). Their monitoring results should be useful in determining measures to further minimize impacts of development projects and contribute to the conservation of the bog turtle.

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

Investigate potential genetic differentiation within and between bog turtle populations in the northern and southern portions of the species' range. These data will be useful to determine the degree of genetic exchange between and within populations, effective population size, the genetic impacts of reintroduction (where stock is of unknown origin or from a different population), and will aid in law enforcement activities if genetic markers can be found that can trace turtles back to particular regions or sites. As noted in Conservation Measures, Dr. Tim King of USGS-BRD has developed genetic markers that will allow marked turtles to be traced to their state, county, and watershed origins (Smith *in litt.* 2001).

4.1 **Determine family size.** Investigate family size and variance among populations. Preliminary data suggest that individual populations may be extended families, which would reduce effective population sizes; however, further investigation is needed.

4.2 **Determine effective population size.** Identify the criteria most important in determining effective population size. These may include, but are not limited to, family size and intra- and inter-population genetic relationships. Use this information to determine effective population size.

4.3 **Re-evaluate recovery criteria.** Use information obtained from other Task 4 subtasks to determine whether or not the recovery criteria will ensure long-term sustainability of the species.

4.4 **Use available genetic data to assist conservation efforts.** Genetic data may help to identify or prioritize populations (PAS) for maximum conservation effort.

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

Because the effectiveness of bog turtle reintroduction has not been demonstrated, it should only be used as a last resort when other efforts to establish a healthy population have failed. Further, reintroduction should only be considered for those sites that have high quality habitat and are protected by conservation easement or ownership by an agency or environmental organization willing to take stewardship responsibility for the turtles and their habitat. A careful evaluation of the risks and benefits of any proposed reintroduction should precede its implementation.

5.1 **Develop a protocol to assess the health of bog turtles prior to release or reintroduction.** Develop a veterinary protocol to be used prior to repatriation of bog turtles. This protocol should be used to test bog turtles for pathogens, parasites, and condition (general health) before they are released into the wild after being held in captivity or when headstarted.

5.2 **Ensure that only healthy bog turtles are released into the wild during reintroduction or repatriation efforts.** Use the protocol developed in Task 5.1 to ensure that only healthy bog turtles are released into the wild. Failure to do so could pose a substantial risk to wild bog turtle populations due to disease introduction and transmission. For example, this protocol will be used if bog turtles are to be: (a) reintroduced into areas from which they have been extirpated, or (b) repatriated to sites from which they have been removed, either as part of a captive breeding program where adult seed stock is being repatriated, or as a result of law enforcement interdiction where the origin of the seized turtles has been determined.

5.3 **Develop a strategy for reintroducing bog turtles into areas from which they have been extirpated.** This may be an important tool in recovering disjunct and peripheral populations, many of which are extirpated (specifically the Prairie Peninsula/Lake Plain Recovery unit). The focus of reintroduction is to stem erosion of the range boundaries of this species, as opposed to recovering populations in the continuous parts of the range.

This strategy should address the various options for source stock to be reintroduced, including adults of both unknown and known geographic origins, as well as captive-bred individuals from parents of known or unknown geographic origin. In addition, genetic compatibility must be considered.

5.4 **Restore bog turtle populations within the Prairie Peninsula/Lake Plain Recovery Unit through reintroductions.** If an insufficient number of extant sites occur to meet recovery objectives for this unit (based upon intensive surveys of historical and potentially suitable habitat within the Prairie Peninsula/Lake Plain Recovery Unit, in accordance with Task 3.3.1), reintroduce bog turtles into suitable, protected habitats in accordance with the reintroduction strategy developed in Task 5.3.

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

Bog turtle habitat is in an intermediate stage of succession, and in some cases is threatened by invasive exotic plants. Unless succession is set back by natural processes (flooding by beaver, fire, grazing by wildlife, etc.) and exotic plants are controlled, the habitat may become less suitable, and eventually unsuitable, for bog turtles. Active management and maintenance may be required at some sites to replace the natural processes that have been lost and to control exotic plants in order to restore or maintain habitat quality.

6.1 **Monitor the status of and threats to habitat at known bog turtle sites.** Bog turtle sites should be periodically monitored/surveyed (at least once every five years) to determine habitat conditions, and to identify the nature, magnitude and immediacy of threats to the site. Threats include, but are not limited to: succession, eutrophication, changes in hydrology, invasive plants, over-grazing, and inadequate upland buffers surrounding bog turtle wetlands. It is recommended that this monitoring be conducted in conjunction with Task 3.5 and be detailed enough to detect changes in habitat conditions over time.

6.1.1 **Use a standardized protocol to evaluate bog turtle sites.** To allow between-site comparisons, as well as same-site comparisons over time, a standardized site evaluation protocol should be used, such as Klemens' PAS protocol (Appendix C). As additional information about bog turtles and their habitat becomes available, this protocol should be re-evaluated to ensure its adequacy in reflecting site condition and quality. Site maps, survey notes/reports, and site photographs should be detailed enough to detect changes in and threats to habitat, including changes in hydrology, encroachment of development, successional changes, and the introduction and spread of invasive native and exotic plant species.

6.1.2 **Identify and map the groundwater recharge and supply zones associated with bog turtle sites.** Protection of bog turtle habitat cannot be accomplished unless the groundwater recharge and supply areas that support the habitat are protected. Identification and mapping of these areas is necessary since one of the primary indirect threats to bog turtles and their habitat is upland land use activities which alter groundwater recharge and supply (e.g., storm water detention basins, increases in impervious surfaces, road construction, groundwater withdrawal via wells).

6.2 **Conduct research/studies to understand and identify the degree to which land-use activities alter bog turtle habitat.** These studies could be based on information available about the effects of various past and ongoing land-use activities on bog turtle sites. Of particular importance is understanding the effects of succession, exotic plants, grazing, upland buffer size, and activities that alter hydrology (e.g., roads, wells, detention basins, mining, development).

6.3 **Identify the safest and most effective methods to manage, maintain and restore bog turtle habitat.** This includes restoration techniques such as plugging ditches and crushing drain tiles (Smith *in litt.* 2001) as well as implementing best management practices for bog turtle wetlands and watersheds for bog turtle populations that may be affected by routine maintenance, vegetation control, repairs, or new projects. These practices include grazing regimes, stream corridor management, buffer maintenance/ management, and control/reversal of succession. In addition, other measures that may protect the turtle, such as minimizing of road kills, reducing barrier effects, and promoting habitat connectivity, should be considered (Ryan, *in litt.* 2001).

All of these practices should emphasize a cooperative stewardship approach to engage the interests (e.g., agricultural, development) representing the dominant land-use activity on and near active bog turtle sites. Prior to use of any of these methods, the U.S. Fish and Wildlife Service and appropriate State wildlife agency should be consulted to ensure that these methods will not adversely affect bog turtles.

6.3.1 **Identify the safest and most effective methods for controlling invasive native and exotic plants, and setting back succession.** An overabundance of certain plants, including purple loosestrife, multiflora rose, reed canary grass, Phragmites, and red maple, can reduce the quality of bog turtle habitat. The method(s) of controlling each of these species needs to be identified and evaluated for potential adverse effects to bog turtles. Methods of control vary depending upon the target plant species, and may include chemical control, biological control (e.g., introduction of insects, beaver, grazers), burning, cutting, manual removal, or inundation with water. The rate, intensity, season of implementation, and effectiveness of each control method needs to be carefully evaluated to determine the potential for direct and indirect adverse effects to bog turtles and other sensitive species in the wetland (e.g., rare plants).

6.3.2 **Determine the safest and most effective methods for using grazing to restore and maintain bog turtle habitat.** In some cases, it appears that light to moderate grazing has functioned to impede succession and control invasive plants at bog turtle sites. Determine which grazers (e.g., dairy cattle, beef cattle, goats, sheep, horses, deer, buffalo) at which densities and rotations best restore and maintain bog turtle habitat. Evaluate the risks of grazing to bog turtles (e.g., risk of crushing turtles and eggs) and their habitat (eutrophication, accelerated succession if grazing is discontinued, soil compaction) against the potential benefits over both the short and long term.

Studies of the effects of grazing on bog turtles and their habitat should especially be conducted in the species' southern range due to the prevalence of grazing at numerous bog turtle sites in the south. The apparent long-term compatibility of bog turtles with grazers in the south should yield valuable information about optimal grazers, grazing density and rotations. Grazing regimes used to maintain bog turtle habitat (as observed at currently grazed southern and northern sites), however, may differ substantially from those needed to restore habitat. This is an important consideration, particularly since grazing at many northern sites has been discontinued in the past 20 years as the rural landscape has become increasingly suburban.

6.3.3 **Identify methods to prevent adverse hydrological changes to bog turtle habitat, and restore hydrology at altered sites.** The hydrology of many wetlands occupied by bog turtles has been altered or is vulnerable to alteration by roads, wells, development, detention basins, subsurface drilling, mining, etc. Identify engineering techniques to prevent the adverse effects of these land-use activities. Also, identify restoration techniques such as plugging ditches and crushing drainage tiles to restore the hydrology of altered sites.

Also worthy of investigation are storm water management practices that would minimize direct ("point-source") discharge to wetlands and maximize site recharge and pre-development runoff patterns.

Additional approaches that should be considered to prevent adverse hydrological changes include, but are not limited to: public/private partnerships to protect buffer and groundwater recharge/supply areas (see Task 6.1.2), public infrastructure planning (particularly sewers and water supplies), and zoning/local ordinances to protect these areas.

6.3.4 **Identify methods to reconnect fragmented habitat.** Throughout the species range, populations have been isolated from one another and cut off from suitable and potentially suitable habitat, primarily due to roads and associated development. Research should focus on identifying safe and effective methods to allow turtle movement between wetlands, including properly designed culverts, bridges and roads. The design should consider not only the reconnection of habitat, but also minimize the risk of turtle road-kills, and avoid adverse hydrological changes to the habitat.

6.4 **Manage, restore and maintain bog turtle habitat, as appropriate.** Prior to conducting any management activities, a site-specific threat assessment and management plan should be done. This is necessary because threats, and therefore the management technique(s) needed to minimize those threats, differ substantially between sites. If at all possible, the nesting and hibernation areas should be identified (at extant sites) so that management techniques can be designed to ensure the protection of these critical areas.

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.** Using information obtained from implementation of Tasks 6.3.1 and 6.3.2, manage bog turtle sites as appropriate. Management should only be conducted when succession and/or exotic plants threaten to degrade the habitat and it is determined that the control method(s) will not adversely affect bog turtles.

6.4.2 **Restore hydrology to altered bog turtle sites.** At sites where ditching, draining, culverts, detention basins, development, and other activities have negatively affected bog turtle habitat, restore site hydrology using methods (Task 6.3.3) that will not adversely affect bog turtles.

6.4.3 **Reconnect fragmented habitats (using methods identified in Task 6.3.4).**

6.4.4 **Ensure that agency expertise is available to assist in the management, restoration and maintenance of bog turtle habitat.** Every U.S. Fish and Wildlife Service office and/or state wildlife agency in those states where bog turtles occur should have at least 1-2 employees available to assist in the implementation of Task 6.4. These individuals would provide technical assistance, conduct on-site threat assessments, develop site-specific management/restoration plans, and in some cases implement site-specific management/restoration plans.

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).** Surveys to date have focused primarily on determining bog turtle presence/absence; therefore, data regarding the status and health of known bog turtle populations is scant. Cursory survey information at some sites, and in-depth studies at a few sites, however, indicates that many populations may suffer from small size, limited or no recruitment, and/or skewed sex ratios.

7.1.1 **Determine what constitutes a "viable" bog turtle population.** Using information obtained through implementation of Task 4, along with other appropriate information (e.g., about population size, structure and health), define "viable population."

In order to achieve recovery, another important consideration is the ability of available and/or restorable habitat to support a viable population.

7.1.2 **Develop a survey protocol to evaluate the population status of bog turtle sites.** A survey protocol more intensive than presence/absence surveys but less intensive than multi-year mark recapture or radio telemetry studies needs to be developed to quickly and accurately depict the status of the many bog turtle populations within the northern range.

In the meantime, as a possible rule of thumb, S. Smith (*in litt.* 2001) suggests that if turtles are found after a very short amount of survey time (10 minutes or less) on the initial visit, they later prove to have moderate to large populations (> 25 individuals), although they may still have demographic and recruitment problems. Conversely, there are some sites that have what Smith (*in litt.* 2001) has characterized as "subterranean" populations, where the animals spend an inordinate amount of time down in a well-defined tunnel system, making them very hard to find; these sites may also be frequently visited by researchers, suggesting that the turtles have developed an avoidance behavior.

7.1.3 **Determine the baseline health parameters of free-ranging bog turtles.** Once determined, this information can be used to assess the health of wild bog turtles and to assist in fulfillment of Tasks 5.1 and 7.1.3.

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 population size, structure and recruitment.** This may vary substantially depending upon the type and density of predators in a particular area. Animals of particular interest include rodents and raccoons. Some populations appear to have suffered from lack of or diminished recruitment and a skewed population structure due to increased predation from predators considered to be human commensals.

7.1.6 **Identify appropriate population management techniques.** The effectiveness, risks, and benefits of potential population management techniques should be evaluated. Particular emphasis should be placed on evaluating nest protection (using exclosures of various designs), nest site protection (using fencing), predator control (trapping, exclusionary fencing), and headstarting.

7.2 **Using techniques identified in Task 7.1, manage bog turtle populations to improve their health and status, as appropriate.** Where surveys have identified a need to improve the status of a bog turtle population, management techniques should be implemented if the site has sufficient suitable habitat, and can be adequately protected from collection. Attempts should also be made to identify the underlying cause of the problem (e.g., nest site predation, collection, unavailability of suitable nesting habitat, contaminants) before intervention techniques are implemented.

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.** These protocols (*sensu* Klemens 1995) should include a decision-making tree to identify instances in which seized turtles could be repatriated to known sites, used as source stock for reintroduction or captive breeding programs, or transferred (via a chain of custody) to an appropriate educational facility (e.g., zoo or museum).

8.2 **Train law enforcement personnel.** Familiarize law enforcement personnel with the bog turtle's habitat, distribution, and vulnerability to collection (e.g., through training and informal contacts).

8.3 **Create a centralized repository of information that could assist law enforcement personnel in identifying the areas from which turtles have been taken.** This information would include the names of researchers that have marked turtles and a description of the marking system(s) used. It would also include any other types of information (e.g., genetic) that may identify the species point of origin.

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.** If this is determined to be an effective strategy for protecting bog turtles, provide neighborhood watches with the training and tools necessary to implement this task.

8.6 **Seek maximum penalties for offenses relating to the illegal collection, trade, and possession of bog turtles.** Considering the high monetary value of individual bog turtles, maximum penalties must be sought and imposed under both federal and state wildlife laws in order to send a strong message to the public about the species' vulnerability, and a strong message to collectors about the high cost of conducting of illegal activities.

8.7 **Promote the development and implementation of laws regulating intra- and interstate commerce in state and federally listed species.** These should be a CITES-type laws placing strict limits on the trade of state and federally listed threatened and endangered species (particularly reptiles and amphibians), treating them similar to Appendix I species under CITES for the purposes of both intra- and interstate commerce.

8.8 **Develop and use genetic markers to identify the origin of seized turtles.** This will help enforcement officials to assess Lacey Act and other violations. With the advent of genetic markers developed by Dr. Tim King of USGS-BRD, this is a near-term possibility.

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

The purpose of these outreach and education efforts is to foster knowledge of, appreciation of, and concern for the bog turtle, and thereby support of federal and state protection and recovery efforts on behalf of this species. While the distribution of information about the bog turtle is certainly encouraged, site-specific location information should not be distributed due to the threat of collection and trade.

9.1 **Develop and implement public awareness programs.** The bog turtle is an attractive, diminutive turtle. Turtles as a group are well received by the general public. Given these factors, it should be possible to develop awareness and information campaigns that engender popular concern for this turtle and recovery efforts on its behalf. A secondary level of awareness could focus on its unique and specialized habitats, which are home to a variety of charismatic botanical species such as pitcher plants, orchids, and sundews.

9.1.1 **Develop and distribute educational materials about the bog turtle.** Many states have state-specific educational materials (e.g., brochures, websites) about the bog turtle. These should be more actively distributed to appropriate target audiences. In addition, regional educational materials (e.g., a brochure, general distribution maps, law enforcement contact information) should be developed.

9.1.2 **Make effective use of the media in conducting outreach efforts.** The plight and conservation status of the bog turtle should be emphasized, along with efforts to conserve the species. The importance of site confidentiality to minimize collection threats, however, must also be considered. For example, researchers, biologists, managers and zoo personnel should not disclose the exact areas (i.e., bog turtle sites) where research is taking place, where management efforts are taking place, or where bog turtles originated.

9.2 **Develop and implement programs targeted specifically at local decision makers (municipal, county, and state).** In addition to the critical role county and state decision makers play in bog turtle conservation, municipal home rule is a key feature of the governing structure of the northeastern United States; varying from state to state, the basic premise is that much of the authority over land-use decisions has been assumed by municipal governments (e.g., townships, boroughs, towns). As bog turtles are widely distributed within their geographic range, case-by-case decisions made by state and local governments have the potential to either positively or negatively affect recovery efforts. The objective of education/outreach programs is to provide guidance and tools so that local decision-makers can better protect bog turtles as part of their statutory land-use planning and environmental review processes.

9.2.1 **Provide local decision makers with information about the general location of bog turtles/bog turtle habitat.** Local decision makers are hampered by a lack of information about the location of bog turtles and bog turtle habitats within their jurisdictions. The majority of decisions that adversely affect bog turtles and their habitats have been made in complete ignorance of the presence or potential presence of bog turtles. If decision makers are provided with the names of watersheds of importance to bog turtles, they will be able to use this information when screening development projects and then contact the appropriate agency when projects fall into these areas.

9.2.2 Provide local decision makers with guidance about avoiding adverse effects to bog turtles. Even where the presence of bog turtles and their habitat is known and acknowledged by local decision-makers, guidelines are lacking as to how to manage development and infrastructure improvements in a way so as to not adversely affect the turtle and its habitat.

Develop specific guidance to address the following topics: how much upland buffer is required, how to engineer road crossings (or when to deny road crossings), how to manage storm water runoff and impervious surfaces (Task 6.3.3), and what types of land uses may be more compatible with the survival of the turtle and its habitat. Such information needs to be developed in a best-management-practices type formula, so as to technically empower local decision makers to make better choices, i.e., choices that foster economic development within their communities while promoting the conservation of the bog turtle and its habitat.

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. Due to the important role private landowners can play in the recovery of this species, they should be informed about bog turtle occurrences on their property and site-specific threats to turtles and their habitat. Failure to do so could: (1) place turtles and their habitat at increased risk due to implementation of various land use practices by the landowner (e.g., herbicide application, mowing, land subdivision for development), and (2) result in missed opportunities for cooperative habitat conservation efforts.

To assist in stemming illegal collection of bog turtles, landowners and managers should be encouraged to report suspicious activities to state wildlife conservation officers, and be provided with the appropriate contact information (e.g., hot-line telephone numbers) to do so.

9.3.2 Prepare bog turtle habitat management guidelines for landowners and land managers. These guidelines should incorporate information about the safest ways to effectively manage bog turtle habitat (Task 6.3). Landowners should receive some assurance that they will not be penalized for conducting management activities conducted in strict compliance with the guidance, even if take of bog turtles incidentally occurs. This could be accomplished via a federal enhancement of survival permit. These management guidelines should be published and distributed, along with appropriate agency contact information.

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

The designation of five recovery units in this plan was governed primarily by biogeographic and ecological distinctions, as well as the distinctiveness of certain threats. Therefore, although the overall goals and tasks are applicable across the bog turtle's northern range, there are distinct unit differences requiring that priorities and efforts may vary between these recovery units.

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PART 3: IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the bog turtle recovery program over the next three years. It is a guide for meeting the recovery objectives discussed in Part 2 of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. The schedule will be updated as recovery tasks are accomplished.

Key to Implementation Schedule Priorities (column 1)

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Responsible Agencies (column 5)

USFWS	=	U.S. Fish and Wildlife Service
ES	=	USFWS, Ecological Services
RW	=	USFWS, Refuges and Wildlife
PF&W	=	USFWS, Partners for Fish and Wildlife
LE	=	USFWS, Law Enforcement
USGS	=	U.S. Geological
COE	=	U.S. Army Corps of Engineers
EPA	=	U.S. Environmental Protection Agency
DOT	=	Federal or State departments of transportation
SWA	=	State wildlife agencies
LG	=	Local and municipal governments
NGO	=	Nongovernmental organizations
AI	=	Academic institutions
PL	=	Private landowners

IMPLEMENTATION SCHEDULE
Bog Turtle Recovery Plan, May 2001

Priority	Task Description	Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
1	Map/identify watersheds or wetland systems of occurrence.	1.1.2	3 years	ES	SWA		25	25	
1	Protect bog turtle sites through purchase and conservation easements.	2.3	ongoing	ES, RW	SWA, NGOs				TBD
1	Monitor the status of and threats to extant populations.	3.5	ongoing	ES, RW	SWA, AI	25	25	25	Continue until delisted. Implementation includes tasks 1.3 & 7.1.1
1	Identify methods to prevent adverse hydrological changes to bog turtle habitat, and restore hydrology at altered sites.	6.3.3	2 years	ES	USGS	5	5		
1	Control succession and invasive exotic plants	6.3.1	ongoing	ES, RW, PF&W	NGOs, SWA, PL	150	150	150	future $ depends on success of initial treatments
1	Determine and implement effective strategies for preventing and prosecuting offenses relating to the illegal collection, trade, and possession of bog turtles.	8.6	ongoing	ES	SWA				no additional costs
2	Map contiguous wetland habitat	1.1.1	3 years	ES	SWA, NGOs	25	15	10	Continue as needed. Note, tasks 1.1.1 - 1.1.3 will be implemented as per task 1.1.4.
2	Include all extant bog turtle sites on the state freshwater wetlands maps, as appropriate.	1.1.3	5 years		SWA	5	5	5	5K additional in FY 4-5; some costs included under tasks 1.1.1 & 1.1.2.
2	Ensure that adequate screening tools for early identification of projects that may affect bog turtles are used.	1.1.4	ongoing	ES	SWA				no separate cost
2	Identify project/permit categories that may adversely affect bog turtles and their habitat.	1.2.1	1 year	ES	SWA, COE, DOT, EPA	5			
2	Train appropriate federal, state, and local agency staff in the recognition of bog turtle habitat, and threats to habitat and species.	1.2.2	ongoing	ES	SWA, AI	5	3	2	continue at 2K level indefinitely
2	Avoid and minimize direct and indirect adverse effects to bog turtles and their habitat.	1.3	ongoing	ES	SWA, COE, DOT, EPA				no separate cost
2	In each RU, identify and priority sites for appropriate conservation efforts.	2.1	2 years	ES	SWA	15	19	18	pending survey results in 3.1.2
2	Develop voluntary, cooperative stewardship programs to conserve the bog turtle and its habitat on private property.	2.2	ongoing	ES, PF&W	NGOs, SWA	50		50	intermittent there after as needed
2	Develop a model to identify potential bog turtle habitat and locate additional bug turtle sites.	3.1.1	3 years	ES	SWA, AI	5	2	2	funding after year 1 is for model refinement
2	Develop and use a standardized bog turtle survey protocol.	3.1.2	ongoing	ES	SWA, AI	20	20	20	additional as needed; see Appendix B in this plan

IMPLEMENTATION SCHEDULE
Bog Turtle Recovery Plan, May 2001

Priority	Task Description	Task Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	Ensure that qualified searchers conduct bog turtle surveys.	3.1.3	ongoing	ES	SWA	7	3	3	additional 3K intermittently as needed
2	Investigate the effectiveness, risks and benefits of conducting trapping surveys to determine bog turtle presence.	3.2	3 years	ES	SWA, AI	3	3	3	
2	Conduct surveys to re-evaluate the presence of bog turtles at historical sites in the Prairie Peninsula/Lake Plain RU.	3.3.1	3 years	ES	SWA	4	2	1	
2	Determine effective population size	4.2	2 years	ES	USGS, SWA		5	5	
2	Use available genetic data to assist conservation efforts	4.4	ongoing	ES	SWA, AI				no separate cost; planning task
2	Restore bog turtle populations within Prairie Peninsula / Lake Plain RU through reintroductions	5.3	ongoing	ES	SWA				to be initiated after year 3 as needed
2	Use a standardized protocol to evaluate bog turtle sites.	6.1.1	ongoing	ES	SWA	10	10	10	additional 7K per year as needed
2	Conduct research/studies to understand and ID the degree to which land-use activities alter bog turtle habitat	6.2	ongoing	ES	SWA, AI				TBD
2	Identify the safest and most effective methods for controlling invasive native and exotic plants, and setting back succession.	6.3.1	2 years	ES	SWA	1		1	
2	Determine the safest and most effective methods for using grazing to restore and maintain bog turtle habitat.	6.3.2	ongoing	ES	SWA, PL	2		2	intermittent - 2K approx. every 3 years
2	Identify methods to reconnect fragmented habitat.	6.3.5	3+ years	ES	SWA, AI	5	5	5	subsequently as needed, cost TBD
2	Restore hydrology to altered bog turtle sites	6.4.2	ongoing	ES	DOD, COE, SWA, DOT, USGS, PL	150	150	150	future $ depends on success of initial treatments
2	Reconnect fragmented habitats using methods identified in Task 6.3.4.	6.4.3	ongoing	ES	SWA				cost TBD
2	Develop a survey protocol to evaluate the population status of bog turtle sites.	7.1.2	1 year	ES	SWA, AI	2			
2	Implement strategies developed in task 7.1	7.2	ongoing	ES	SWA, AI				TBD - includes task 7.1.5
2	Train law enforcement personnel.	8.2	ongoing	ES, LE	SWA	5	3	2	
2	Create a repository of information that could assist LE personnel in identifying areas from which turtles have been taken.	8.3	ongoing	ES, LE	SWA	5	2	2	continue with 2K per year as needed

IMPLEMENTATION SCHEDULE

Bog Turtle Recovery Plan, May 2001

Priority	Task Description	Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	Investigate the effectiveness, risks, and benefits of PIT tagging wild and captive bog turtles as a research tool and deterrent to collection/trade.	8.4	ongoing	ES, LE		5	1	1	ongoing coordination
2	Develop and use genetic markers to identify the origin of seized turtles.	8.8	ongoing	ES, LE	USGS, SWA	1	1	1	markers developed; 1K annually through recovery period
2	Inform and educate individuals/entities who own or manage bog turtle habitat about the species and threats to its existence	9.3	2 years	ES	SWA	5	2.5		
3	Amend and/or clarify the scope of state and municipal regulatory protections afforded to bog turtles and their habitat.	1.4	ongoing	ES	SWA, LG				no separate cost
3	Conduct surveys to re-evaluate the presence of bog turtles at historical sites in other recovery units	3.3.2	4 years	ES	SWA	2	2	2	additional 2K in year four
3	Conduct surveys to locate additional populations of bog turtles.	3.4	ongoing	ES, RW	DOD, COE, SWA, DOT				10K total after year 3 - does not include surveys pursuant to project planning
3	Determine family size.	4.1	2 years	ES	USGS, SWA		10	10	
3	Re-evaluate recovery criteria.	4.3	1 year	ES	SWA, AI				initiate after year 3, no separate costs
3	Develop a protocol to assess the health of bog turtles prior to reintroduction.	5.1	2 years		AI			1	additional 1K in year four
3	Develop a strategy for reintroducing bog turtles into areas form which they had been extirpated.	5.2	1 year	ES	SWA, AI			1.5	
3	Restore bog turtle populations within the Prairie Peninsula/Lake Plain RU through reintroductions.	5.4	10 years	ES	SWA				to be initiated after year 3 as needed; funding TBD
3	Identify and map the groundwater recharge and supply zones associated with bog turtle sites.	6.1.2	3 years	ES	USGS		20	20	additional 20K in year four
3	Ensure that agency expertise is available to assist in the management, restoration and maintenance of bog turtle habitat.	6.4.4	ongoing	ES	SWA				cost will be part of operating budgets of agencies
3	Determine what constitutes a "viable" bog turtle population.	7.1.1	1 year	ES	SWA, AI			10	
3	Determine the baseline health parameters of free-ranging bog turtles	7.1.3	3 years	ES	SWA, AI	7	5	5	
3	Develop a protocol to assess the role of disease in wild bog turtle populations.	7.1.4	1 year		AI			2.5	
3	Determine the effects of predation on population size, structure, and recruitment.	7.1.5	ongoing	ES	SWA, NGOs	1.5		1.5	intermittently, some costs incorporated into monitoring tasks

IMPLEMENTATION SCHEDULE
Bog Turtle Recovery Plan, May 2001

Priority	Task Description	Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
3	Identify appropriate population management techniques.	7.1.6	ongoing	ES	SWA	3	3	3	additional 3K per year as needed
3	Identify protocols to be followed as to the disposition of confiscated turtles.	8.1	1 year	ES, LE	AI	2.5			
3	Investigate the potential for using neighborhood watches to monitor bog turtle sites for illegal collecting activity.	8.5	2 years	ES, LE	SWA	1	1		if deemed beneficial, coordinate an ongoing program
3	Promote the development and implementation of laws regulating intra- and inter-state commerce in state and federally species.	8.7	3 years	ES*, LE	SWA				*ES also includes Division of Endangered Species in Washington, D.C.
3	Develop and distribute education materials about the bog turtle.	9.1.1	ongoing	ES, RW	USDA, NGOs, SWA	5	5	5	as needed including 9.2.2
3	Make effective use of the media in conducting outreach efforts.	9.1.2	ongoing	ES	SWA				will involve staff time, no additional costs
3	Develop and implement programs targeted specifically at local decision makers.	9.2	ongoing	ES	SWA	2	0.5	0.5	materials development and refinement
3	Develop RU specific recovery tasks recognizing that each RU will require a different prioritization of approaches.	10	1 year	ES	SWA, AI				priority setting complete by FY 3 - no separate costs; implementation TBD

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. <u>At least two of these surveys must be performed in May</u>. 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

BOG TURTLE COUNTIES OF OCCURRENCE OR LIKELY OCCURRENCE[1]

(Revised May 2001)

STATE	COUNTY	
Connecticut	Fairfield	Litchfield
Delaware	New Castle	
Maryland	Baltimore	Cecil
	Carroll	Harford
Massachusetts	Berkshire	
New Jersey	Atlantic	Morris
	Burlington	Ocean
	Camden	Passaic
	Gloucester	Salem
	Hunterdon	Somerset
	Mercer	Sussex
	Middlesex	Union
	Monmouth	Warren
New York	Albany	Seneca
	Columbia	Sullivan
	Dutchess	Ulster
	Genesee	Warren
	Orange	Wayne
	Oswego	Westchester
	Putnam	
Pennsylvania	Adams	Lancaster
	Berks	Lebanon
	Bucks	Lehigh
	Chester	Monroe
	Cumberland	Montgomery
	Delaware	Northampton
	Franklin	York

[1] *This list is valid for one year from the date indicated. It may, however, be revised more frequently if new counties of occurrence are documented. Updates to this list are available from the Service upon request.*

APPENDIX C.
STANDARDIZED BOG TURTLE SITE-QUALITY ANALYSIS

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The first step in to set up "population analysis sites." Occurrences are combined to form "population analysis sites" using a drainage basin approach with the following caveats:

Combined occurrences must be part of a wetland system/drainage basin with:

1. no major impediments[1] to turtle movements between the combined occurrences, and

2. a continuous corridor of stream/wetland habitat connecting the sites.

[1] A major impediment is a condition that significantly reduces the chance of a turtle successfully moving between wetland sites. For example, a stream that moves through open fields, from bog to bog, is connected as turtles can move from point to point. What constitutes a major impediment requires some judgement. The following are good examples of major impediments:

- Steeply graded, rocky streams.

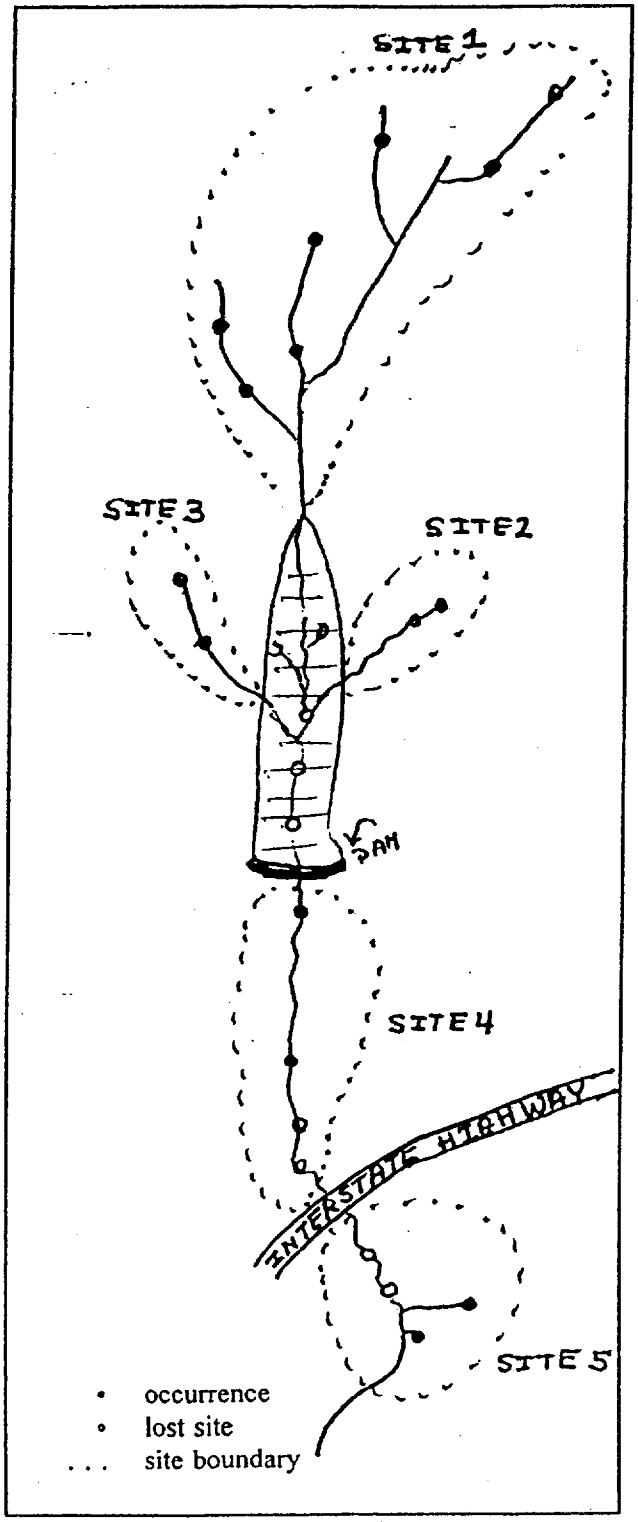
- Multiple-lane paved roads (i.e., highways).

- Two-lane paved roads crossing wetland at grade with moderate-heavy traffic, during peak hours (ca. 8AM-5PM) averaging 1 car per minute or greater. Note: Roads that are located above a wetland, i.e. not intersecting with the wetland at grade, are generally not a major impediment nor are dirt and lightly travelled roads. In general, road crossings appear to be a greater fragmentation problem in large valleys with extensive wetlands, i.e. many areas of the Northeast or the French Broad River valley in North Carolina, than in the hilly topography of Allegheny Co. (North Carolina) or Floyd Co. (Virginia).

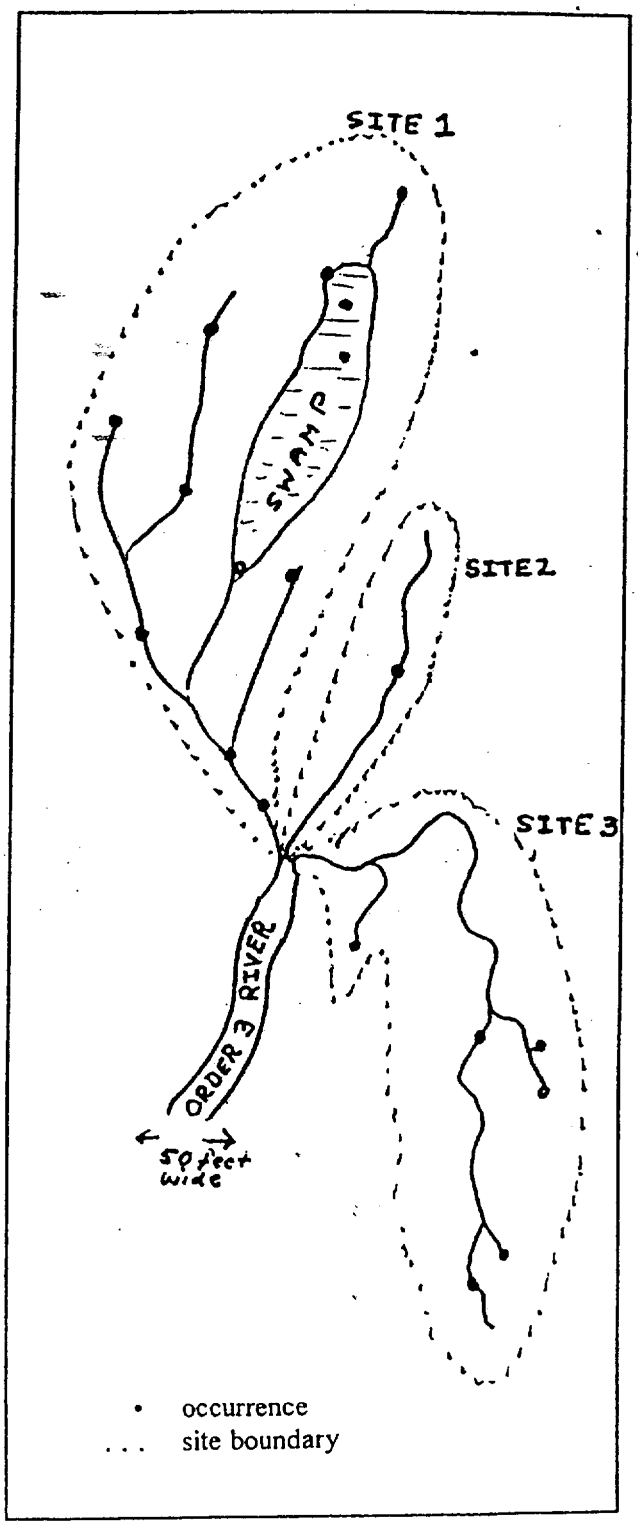
- Large rivers (often order 3 or higher). While first and second order streams are dispersal corridors, large rivers (greater than 20 feet wide and at least two feet deep) are a barrier. Therefore, theoretically one could combine an entire continuous unfragmented habitat covering a first/second order stream drainage basin downstream to the confluence of a third order stream.

- Large impoundments and reservoirs, especially if bare-edged or surrounded by inhospitable habitat. A small pond is not an impediment, especially if shallow and weedy-edged. The key here is to think—could a bog turtle move easily around this pond, either along the pond edge or amongst the edging vegetation to reach areas up or downstream?

Population Analysis Sites in Fragmented Habitat



Population Analysis Sitesin Unfragmented Habitat



MATRIX ONE
POSSIBLE SCORE RANGE 4–20

These categories deal with the quality of the population analysis sites. When unsure between two categories, round to the next number down, i.e. assume the condition is worsening rather than improving.

Site Size/Fragmentation

1. Disjunct[2] and/or isolated by fragmentation, very small (the area of primary bog turtle use, i.e., open canopy fen/bog/mixed alder-meadow complex is less than 2 acres).

2. Disjunct and/or isolated by fragmentation, small (the area of primary bog turtle use, i.e., open canopy fen/bog/mixed alder-meadow complex is 2–5 acres).

3. Disjunct and/or isolated by fragmentation, large (the area of primary bog turtle use, i.e., open canopy fen/bog/mixed alder-meadow complex is greater than 5 acres).

4. Interconnected[3] wetland system, no other occurrences reported (recent or historical) within the drainage basin.

5. Interconnected wetland system, with other occurrences reported (recent or historical) within the drainage basin.

[2] Disjunct is defined as not being able to move up or downstream because of either habitat limitations and/or fragmentation by impediments.

[3] Interconnected wetland systems have no major impediments to movement and are greater than or equal to one mile in length. Fragmentation could divide a large system into several disjunct sections, which should each be treated as a single interconnected wetland system, if greater than or equal to one mile in length (see rationale for lumping occurrences). Wetland systems less than one mile in length should be categorized as disjunct and ranked as 1, 2, or 3 (see above).

Invasive Plants and Successional Species

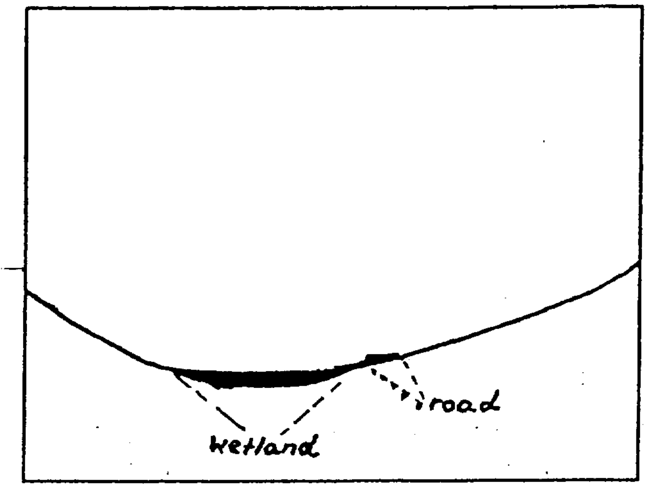
As % of core bog turtle habitat. Invasive species include purple loosestrife, giant reed, multiflora rose, reed canary grass, mint, watercress, dog fennel. Successional species include red maples and alders.

1. Dominates (essentially a monoculture).
2. Thick (75% coverage).
3. Moderate(50% coverage).
4. Light (25% coverage).
5. Insignificant (less than 25%)

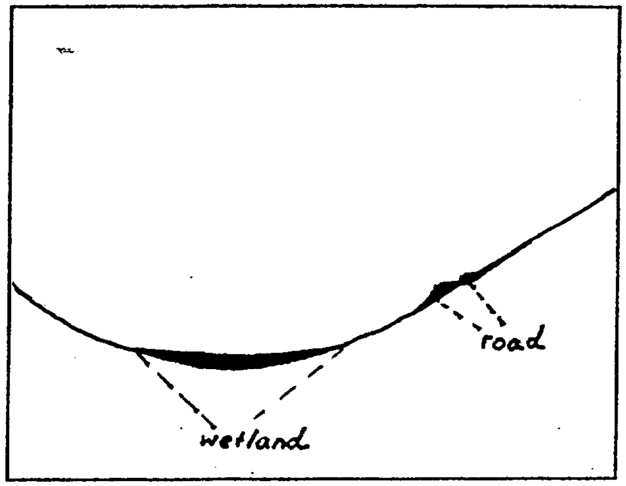
Proximal Threats

Note the proximity of major threats, such as a road crossing ***at grade***, housing development, or other equivalent threat, in relationship to the core-habitat. ***Core-habitat*** is the area (core zone) of the wetland or wetland complex utilized or likely to be utilized by bog turtles. Examples of core-habitat include open-canopy fen, bog, tussock sedge meadow, mixed alder-meadow complex. Forested wetlands surrounding these areas are not considered core-habitat.

Cross-section of Valley Showing Paved Road at Wetland Grade = Proximal Threat



Cross-section of Valley Showing Paved Road above Wetland Grade ≠ Proximal Threat.



1. Active pernicious intrusion into the wetland habitat including ditching, draining, diversion, or construction in wetland. (Note: Many wetlands have been ditched and diverted in the past. This is only to current activities that are disrupting the wetland soils/vegetation, or recent activities that are continuing to alter the hydrology of the site.)

   OR

   Threat(s) within 50 feet of the core-habitat.

2. Threat(s) within 200 feet of the core-habitat.

3. Threat(s) within 400 feet of the core-habitat.

4. Threat(s) within 660 (⅛ mile) feet of the core-habitat.

5. All proximal threats more than 660 feet (⅛ mile) from the core-habitat.

General Habitat Conditions

Obtain ***most recent*** 7.5 minute USGS topographic maps and plot 1.0 mile radius of "population analysis site," in case of elongated sites, such as along stream corridors, focus on land within one mile of population analysis site boundary. Characterize the dominant land use[4] as:

1. Urban, fragmented, areas of pink on topographic map instead of individual house icons. Dense network of roads.

2. Suburban, fragmented. More green areas, but roads are laid down in characteristic pattern of subdivisions as opposed to roads for travel. Houses are depicted by icons, limited pink urban areas.

3. Rural, some residential, intense land use. Roads run from point to point as opposed to sub-division feeder configuration. Some main roads show heavier development, but the overlying pattern is rural use, with over 50% of the land in fields and agriculture. Small areas of high disturbance may be scattered in this matrix, including factories and quarries. Many areas in the central portion of the bog turtle's range fit this description.

4. This is essentially similar to 3, but with much lighter use. Less than 50% of the land is given over to agriculture and pasture, with large areas of woods and undeveloped areas.

5. This is essentially similar to 4, but with much lighter use. Less than 25% of the land is given over to agriculture and pasture, with large areas of woods and undeveloped areas.

[4] Ideally, topographic maps should not form the sole basis for assigned values for "general habitat conditions." These maps are out-of-date from the moment of printing and it is essential to use the most up-to-date revision available from the USGS. However, in order to evaluate conditions and trends over the entire range of the bog turtle, it would be impossible to recheck every site. The score on the above variable should be adjusted, whenever possible to accommodate more recent, field-checked site information.

MATRIX TWO
POSSIBLE SCORE RANGE 2–10

The next step is to score "population analysis sites" as follows, using data that are no more than ten years old. ***The data collected here will be compared against scores on Matrix One to determine consistency of habitat quality and population health. For Matrix Two score only populations where sufficient field work[5] has been conducted to answer both questions accurately.***

Population Size

1. Up to 5 individuals.
2. 6–10 individuals.
3. 11-15 individuals.
4. 16-24 individuals.
5. 25 or more individuals.

Recruitment

1. Only aged adults (plastron devoid of growth lines or showing areas of wear).
2. Younger adults (all growth lines visible). Aged adults may also be present.
3. Hatchlings present/or nests found. Adults are considered present by default.
4. Adults and one age class of juveniles present. (Juvenile is any turtle that has completed one full season of growth)
5. Adults and two or more age classes of juveniles present.

[5] The question of sufficient field work to determine population health and structure is problematic. Certainly in terms of recruitment, there are sites where, under exceptionally fortuitous circumstances, one may obtain a score of 5 on a single visit . In terms of population size, repeated visitations are necessary to gather data. It is strongly recommended that the only sites evaluated using Matrix Two be those where there have been ongoing mark-recapture studies. ***Do not use Matrix Two if you have only good recruitment data and inadequate population size data.*** It is estimated that the number of sites where sufficient Matrix Two data exists is considerably less than 10 percent of all known bog turtle sites.

BOG TURTLE SITE CLASSIFICATIONS[1]

HABITAT MATRIX (MATRIX 1)	
TOTAL SCORE	HABITAT RANK
16-20	good
13-15	fair
4-12	poor

POPULATION MATRIX (MATRIX 2)	
TOTAL SCORE	POPULATION RANK
8-10	good
5-7	fair
2-4	poor

OVERALL SITE RANKING (for sites analyzed using both matrices)		
MATRIX 1 RANK	MATRIX 2 RANK	COMBINED SITE RANK[2]
good	good	good
good	fair	good or fair
good	poor	fair
fair	good	good
fair	fair	fair
fair	poor	poor or fair
poor	good	fair
poor	fair	poor
poor	poor	poor

[1] Compiled by U.S. Fish and Wildlife Service (Pennsylvania Field Office), based on scores obtained via implementation of Matrix 1 and Matrix 2 of Klemens' *Standardized Bog Turtle Site-Quality Analysis*

[2] Additional surveys may be needed to more accurately determine population and site status.

APPENDIX D.

LIST OF REVIEWERS

In accordance with USFWS policy (USFWS and NOAA 1994), requests for peer review of the agency draft plan were sent to independent scientific experts. These reviewers were asked to pay particular attention to: (1) issues and assumptions relating to the biological and ecological information of the plan, and (2) scientific data related to the tasks in the proposed recovery program. Requests for peer review were sent to the following individuals:

Timothy L. King
U.S. Geological Survey – Biological Resources Division
Leetown Science Center
Kearneysville, West Virginia

Larry Master
The Nature Conservancy
Eastern Regional Office
Boston, Massachusetts

Scott A. Smith
Maryland Department of Natural Resources
Wye Mills, Maryland

Detailed comments regarding biological information and recovery priorities in the plan were received from Scott Smith, most of which have been incorporated into this final plan. The focus of these comments was on recovery unit and status information, concerns about continued illegal collection, and refinement of the survey guidelines.

Comments were also offered by the following individuals and agency representatives on the technical and/or agency drafts of the Bog Turtle (*Clemmys muhlenbergii*) Recovery Plan. These comments have been incorporated as appropriate into the final plan. All comment letters are on file in the Pennsylvania Field Office of the U.S. Fish and Wildlife Service, 315 So. Allen St., State College, PA, 16801.

Rudolf G. Arndt
The Richard Stockton College of New Jersey
Pomona, New Jersey

Gerald A. Barnhart
NYS Dept. of Environmental Conservation
Division of Fish, Wildlife & Marine Resources,
Albany, New York

Kathelene M. Bisko
Rouse/Chamberlin Homes
Exton, Pennsylvania

Alvin Breisch
NYS Dept. Environmental Conservation
Division of Fish and Wildlife
Albany, New York

Mark Clough
U.S. Fish and Wildlife Service
New York Field Office
Cortland, New York

Clifford Day
New Jersey Field Office
U.S. Fish and Wildlife Service
Pleasantville, New Jersey

Carl H. Ernst
George Mason University
Fairfax, Virginia

William Galli
16 Parker Street
North Adams, Massachusetts

Richard P Gamble
Toll Brothers , Inc.
Huntingdon Valley, Pennsylvania

Robert J. Gross
The Vanguard Group
Valley Forge, Pennsylvania

Richard B. Hamilton
NC Wildlife Resources Commission
Raleigh, North Carolina

Geoffrey Hammerson
The Nature Conservancy
Higganum, Connecticut

Nancy Heaslip
NYS Dept. of Environmental Conservation
Division of Fish and Wildlife
Albany, New York

Dennis W. Herman
North Carolina Museum of Natural Sciences
Raleigh, North Carolina

Dennis W. Herman, Tom J. Thorp
Project Bog Turtle
c/o NC Museum of Natural Sciences
Raleigh, North Carolina

James H. Howard
Frostburg State University
Frostburg, Maryland

Christy Johnson-Hughes
U.S. Fish and Wildlife Service
Pennsylvania Field Office
State College, Pennsylvania

Ted Kerpez
NYS Dept. of Environmental Conservation
Division of Fish and Wildlife
Albany, New York

Frank Lowenstein
The Nature Conservancy
Berkshire Taconic Landscape Program
Sheffield, Massachusetts

Michael Luzier
National Association of Home Builders
Washington, D.C.

Karen L. Mayne
U.S. Fish and Wildlife Service
Virginia Field Office
Gloucester, Virginia

James McDougal
Wildlife Conservation Society
Rye, New York

Joseph C. Mitchell
Department of Biology
University of Richmond
Richmond, Virginia

Paul Novak
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Lantham, New York

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Baltimore District
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John Jake Ryan
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Michael M. Ryan
PA Department of Transportation
Harrisburg, Pennsylvania

Duane L. Searles
Home Builders Association of
Bucks/Montgomery Counties
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Scott A. Smith
MD Department of Natural Resources
Wye Mills, Maryland

David Stilwell
U.S. Fish and Wildlife Service
New York Field Office
Cortland, New York

Jason Tesauro
NJ Department of Environmental Conservation
Division of Fish, Game, and Wildlife
Trenton, New Jersey

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Best Development Practices

Conserving Pool-Breeding Amphibians in Residential and Commercial Developments in the Northeastern United States

Metropolitan Conservation Alliance

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Wildlife Conservation Society

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Best Development Practices

Conserving Pool-Breeding Amphibians in Residential and Commercial Developments in the Northeastern United States

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PREFACE

Vernal pools and adjacent upland habitats contribute a vast amount of biodiversity to landscapes of the northeastern United States. However, due to their small size, and a variety of other issues, these habitats are disproportionately impacted by development trends associated with regional urban and economic growth. As a result, vernal pools—and the species that depend on them—are disappearing at a rapid rate. We must come to terms with the complexities that surround the protection of vernal pools. The Best Development Practices (BDPs) in this publication present a new approach to accomplish this goal. This document also outlines steps to identify those vernal pools worthy of protection. These BDPs are not, and we repeat ***not***, new layers of regulation. They provide a decision-making pathway that builds upon the strong tradition of home rule within our region; they add value to that home rule by enabling municipalities to become more effective stewards of their natural resources. We consider this a win-win solution—one that should eliminate costly delays in project approval by giving local decision-makers the ability to reliably identify wetlands worthy of protection and, by default, other areas where a community can plan for additional growth and development.

As conservationists with real-world experience working in communities throughout New England and New York, we realize our dual obligation. We need to help those communities plan for their conservation needs. However, for conservation planning to be truly effective, we must also provide information to help those communities plan for their infrastructure and development needs. Ultimately, we view these BDPs as an exercise in empowering local decision-makers to make better, scientifically credible, and consistent decisions. In short, we seek to replace site-by-site reactive decision-making with a framework for making multiple decisions. This is, in essence, planning. We are thankful to the many people who contributed their time and efforts in the development of these guidelines, including our colleagues in academia, resource management, municipal government, and the development community. This is a work in progress. We look forward to receiving feedback from users of these BDPs as to their effectiveness, and we welcome suggestions for improvement.

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I. INTRODUCTION

Vernal pools, and the adjacent critical terrestrial habitat used by vernal pool amphibians during the non-breeding season, often overlap with land slated for residential or commercial development. These Best Development Practices (BDPs) provide a pragmatic approach to stewardship that encourages communities to attain a more complete knowledge of their vernal pool resources, gather the information that enables them to designate pools that are exemplary and worthy of protection, and then develop strategies to protect them. Implementing these BDPs will better balance the needs of vernal pool wildlife with human activities.

Best Development Practices for vernal pools are recommended conservation strategies for residential and commercial development that minimize disturbance to vernal pools and the surrounding critical terrestrial habitat. These BDPs:

- provide a framework for decision makers to assess the quality of individual pool habitats;
- have positive effects, or minimize negative effects, of development on natural resources;
- provide standards based on the best available science;
- were developed with the participation of state agencies, scientists, resource managers, and developers in the New York-New England region (the Region); and
- are offered under the premise that voluntary compliance, reinforced with education, is an effective strategy for protecting natural resources.

CAUTION! This document addresses only one element of the vernal pool conservation equation. Specifically, it targets pools located on privately owned, relatively small parcels of land (usually less than several hundred acres) at the suburban-rural frontier, which have been slated for development. We recognize that a comprehensive protection strategy for vernal pools must also include large tracts of unfragmented habitat (thousands of acres) with multiple pools. In New England and New York, these lands are primarily held by Federal and state government, and by the timber industry. To address management of these large habitat blocks in a working forest landscape, see *Forest habitat management guidelines for vernal pool wildlife in Maine* (Calhoun and deMaynadier 2001). Owners of small woodlots may also apply the harvest principles outlined in that document.

What is a Vernal Pool?

Vernal pools are wetlands of great interest to ecologists because, despite their small size, they are characterized by high productivity and a unique assemblage of species adapted to breeding in seasonally flooded wetlands (Skelly et al. 1999, Semlitsch 2000). Within the last decade, interest in vernal pools has increased dramatically because of well-publicized declines of amphibians, many of which breed in vernal pools and other small wetlands (Pechmann et al. 1991, Lannoo 1998).

Plants and animals dependent upon vernal pools vary from state to state, as does the definition of a vernal pool. The following is an operational definition based on those common ecological functions identified by all states in the Region:

> *Vernal pools are seasonal bodies of water that attain maximum depths in spring or fall, and lack permanent surface water connections with other wetlands or water bodies. Pools fill with snowmelt or runoff in the spring, although some may be fed primarily by groundwater sources. The duration of surface flooding, known as hydroperiod, varies depending upon the pool and the year; vernal pool hydroperiods range along a continuum from less than 30 days to more than one year (Semlitsch 2000). Pools are generally small in size (< 2 acres), with the extent of vegetation varying widely. They lack established fish populations, usually as a result of periodic drying, and support communities dominated by animals adapted to living in temporary, fishless pools. In the Region, they provide essential breeding habitat for one or more wildlife species including Ambystomatid salamanders* (Ambystoma *spp., called "mole salamanders" because they live in burrows), wood frogs* (Rana sylvatica), *and fairy shrimp* (Eubranchipus *spp.*).

A review of vernal pool definitions either adopted or developed by each state in the Region is provided in *Appendix 1*; despite varying definitions, all pools share a unique ecology. Where available, vernal pool-associated amphibian species are listed for each state. Some states have not yet developed a definition for vernal pools, while others have extremely specific definitions. Some definitions focus on physical characteristics of pools while others are defined by the species of amphibians and invertebrates breeding in the pools. Vernal pool identification guides are available to help citizens recognize these habitats. Information about these guides is provided in *Appendix 3*. See Figures 1, 2, and 3 for images of vernal pools and associated amphibian breeding habitats.

What is Critical Terrestrial Habitat?

Pool-breeding amphibians depend upon both aquatic *and* terrestrial habitats for survival. Most adult vernal pool amphibians in the Region spend less than one month in breeding pools; the rest of their annual cycle is spent in adjacent uplands and wetlands (Semlitsch 1981, 2000). The surrounding forest provides critical terrestrial habitat for adult amphibians and newly emerged juveniles throughout the year (Semlitsch 1998). In their upland habitats, both young and adults need areas of uncompacted, deep organic litter; coarse woody debris; and shade. These elements provide a suitable forest floor environment for amphibians as they move through the forest, feed, and hibernate (deMaynadier and Hunter 1995, DiMauro 1998). This dependence on the surrounding landscape for survival has prompted one researcher (Semlitsch 1998) to refer to this critical terrestrial habitat around pools as a "life zone," instead of a "buffer zone." Conservation strategies that focus only on protecting breeding pools and associated wetlands will most likely fail to maintain healthy amphibian populations. Protection of critical terrestrial habitat must also be a priority (Marsh and Trenham 2001).

SIX REASONS TO CONSERVE VERNAL POOL LANDSCAPES

(1) UNIQUENESS

Fish-free pools provide optimal breeding habitat for a specialized group of amphibians that have evolved to use these wetlands. Vernal pool amphibian eggs and larvae are extremely vulnerable to fish predation. Even though vernal pool amphibians may breed in wetlands where fish are present, survival of eggs and larvae in such environments is limited (Petranka 1998).

Many vernal pool amphibians return to breed in the pools where they developed (Duellman and Trueb 1986, Berven and Grudzin 1990, Sinsch 1990) and show little tendency to relocate if their breeding habitat is disturbed (Petranka et al. 1994). Protecting vernal pools is a critical first step in conserving vernal pool amphibians.

(2) HABITAT

Small wetlands and vernal pools contribute significantly to local biodiversity by supporting an abundance of plants, invertebrates, and vertebrates that would otherwise not occur in the landscape (Semlitsch and Brodie 1998, Gibbs 2000). Many small mammals, birds, amphibians, and reptiles use these wetlands for resting and feeding. The average travel distance for frogs, salamanders, and small mammals is less than 0.3 km (Gibbs 1993, Semlitsch 1998, Semlitsch and Bodie 1998). The destruction of small wetlands in the landscape increases the distances between remaining wetlands. Often, these distances are greater than these animals can travel. Large mammals (e.g., bear, moose) use these small wetlands as a food source. Rare wildlife, including state-listed species, may use pools (see Tables 1 and 2).

(3) WEB OF LIFE

Vernal pools contribute a significant amount of food (e.g. amphibians and insects) to adjacent habitats (Semlitsch et al. 1996, Skelly et al. 1999). This food production is fueled by decaying leaves (organic matter) that are deposited in these pools each fall. After emerging from the vernal pool, wood frogs and salamanders may be eaten by a wide variety of forest animals including snakes, turtles, birds, and small mammals (Wilbur 1980, Pough 1983, Ernst and Barbour 1989). For example, in one Massachusetts vernal pool, Windmiller (1990) found that the weight of all the vernal-pool breeding amphibians exceeded the weight of all breeding birds and small mammals in the 50-acre upland forest surrounding his study pool. He concluded that vernal pool amphibians exert a powerful influence on the ecology of surrounding forests, up to 0.25 miles from the edge of the pool.

(4) SAFETY NET

Vernal pools are so small that they frequently fall through the regulatory cracks. Because vernal pools are often small in size and hard to identify, they are inadequately protected by state or local wetland regulations. An overview of state regulations for vernal pools is presented in *Appendix 1*.

(5) EDUCATIONAL RESOURCE

A vernal pool is a small ecosystem, easy to “wrap your arms around.” As such, it makes an ideal outdoor laboratory for school children and adults. Often, a local pool can be visited or people discover that they have a vernal pool on their own property. These pools are often rich with life and easier to become intimate with than lakes or rivers.

(6) AESTHETICS

The rich array of moss-covered logs, delicate shades of greens and browns through dappled sunlight, and the beauty of the vividly marked or masked amphibians that breed in these sylvan gems, are all inspirations.

Amphibians, reptiles, and small mammals also need suitable upland habitat *connecting* wetlands. These animals live in small populations or small units that, together, make a larger population. These small populations often mix through dispersal of juveniles. For example, small populations may replenish one another with new breeding stock when natural catastrophes (e.g., drought or freezing) eliminate breeding adults or cause larval failures in certain pools.

The average distance that a spotted salamander moves from a pool into the surrounding forest is 386 feet; Jefferson salamanders may travel 477 feet (see Figure 4; Windmiller 1996; Semlitsch 1998; Faccio, *in prep.*) with as much as half the population, in some instances, travelling even greater distances. Wood frog juveniles, on average, disperse approximately 1,550 feet from a breeding pool (Berven and Grudzien 1990). *Therefore, long-term persistence of vernal pool amphibian populations depends on the availability of habitat that connects local populations and enables dispersal among them* (Semlitsch and Bodie 1998).

Other animals (including reptiles, birds, and small mammals) also depend on these small wetlands. Beetles and water bugs, for example, that overwinter in permanent water migrate to vernal pools to breed and feed during the spring and summer. Medium- to large-sized mammals, including raccoon, skunk, fox, deer, moose, and bear, visit pools to feed on amphibian eggs and fresh green shoots emerging in spring or, later in the season, on amphibians and insects. Therefore, the loss of individual vernal pools may weaken the health of entire wildlife communities.

The bottom line: Connections between pools, through the upland landscape, must be maintained to accommodate population movements—dispersal to and from pools for breeding, foraging (feeding), resting, and replenishing locally extinct populations.

Vernal Pool Animals

Many definitions of vernal pools contain language referring to “obligate” or “indicator” species. Obligate species depend upon vernal pools for successful breeding. However, many so-called obligate species, such as wood frogs and spotted salamanders, breed in other wetlands, including roadside ditches, artificial wetlands, and small ponds. However, in many of these breeding sites, the survival of the eggs and production of juveniles may be greatly diminished. We suggest using the term “indicator” species as a more ecologically accurate term. A list of vernal pool indicator species of the Region, with state conservation status information, is provided in Table 1; images of representative indicator species are provided in Figure 5.

The term “facultative” species commonly refers to animals that use the pools for resting and foraging; they might reproduce in vernal pools, but use other habitats for reproduction as well. A list of vernal pool facultative species in the Region, with state conservation status information, is provided in Table 2; images of representative facultative species are provided in Figure 6.

Table 1. Vernal pool indicator species and state conservation status
(E = endangered, T = threatened, SC = special concern, P = present, A = absent).

INDICATOR SPECIES	RI	CT	MA	NH	VT	ME	NY
Blue-spotted salamander	A[1]	T/SC[2]	SC	P	SC	P	SC
Jefferson salamander	A	SC	SC	SC	SC	A	SC
Spotted salamander	P	P	P	P	P	P	P
Marbled salamander	P	P	T	SC	A[3]	A	SC
Tiger salamander	A	A	A	A	A	A	E
Wood frog	P	P	P	P	P	P	P
Spadefoot toad	T	E	T	A	A	A	SC
Fairy shrimp[4]	P	P	SC[5]	P	P	P	P
Featherfoil	SC	SC	P	P	A	T	T

[1]The blue-spotted salamander is extirpated in Rhode Island.
[2]Blue-spotted pure diploid populations are listed as Threatened; the blue-spotted hybrid complex is listed as Special Concern.
[3]Unsubstantiated historic records; no populations have been located (Andrews 2001).
[4]Fairy shrimp comprise a group of several related crustaceans throughout the region; "P" indicates presence of one or more species.
[5]In Massachusetts, the Intricate Fairy Shrimp is listed as Special Concern.

Table 2. Vernal pool facultative species and state conservation status[1]
(E = endangered, T = threatened, SC = special concern, P = present, H = historical record only, A = absent).

FACULTATIVE SPECIES	RI[1]	CT	MA	NH	VT	ME	NY
Northern cricket frog	A	A	A	A	A	A	E
Western chorus frog	A	A	A	A	E	A	P
Four-toed salamander	P	P	SC	P	SC	SC	P
Spotted turtle	P	P	SC	SC	E	T	SC
Wood turtle	SC	SC	SC	P	SC	SC	SC
Blanding's turtle	A	A	T	SC	A	E	T
Eastern box turtle	P	SC	SC	A	A	E	SC
Eastern ribbon snake	SC	SC	P	P	SC	SC	P
Eastern hognose snake	SC	SC	P	P	A	H	SC
Ringed boghaunter dragonfly	SC	E	E	E	A	E	H

[1]For the purposes of this table, we have combined RI's categories of SI (State Interest) and C (Concern) to equal Special Concern (SC).

In-depth natural history accounts of pool-breeding amphibians and other species can be found in *Amphibians and Reptiles of Connecticut and Adjacent Regions* (Klemens 1993), *Amphibians and Reptiles in Connecticut: A Checklist with Notes on Conservation Status and Distribution* (Klemens 2000), *Maine Amphibians and Reptiles* (Hunter et al. 1999), *A Field Guide to the Animals of Vernal Pools* (Kenney and Burne 2000), *A Guide to Amphibians and Reptiles* (Tyning 1990), and *Salamanders of the United States and Canada* (Petranka 1998). See Figure 7 for examples of various stages within a mole salamander (*Ambystoma*) life cycle.

II. PLANNING AND ASSESSMENT

This section complements Section III; Management Goals and Recommendations, by providing step-by-step guidelines to develop a locally based conservation plan for vernal pools. Conservation of vernal pool-breeding amphibian habitat is often most effective at the local level where neighbors, planners, and other concerned citizens play an active stewardship role. The planning process will take time and many hands to develop and implement, and should not take the place of, or delay, the application of management recommendations to individual projects as they arise.

Effective planning for vernal pool conservation at the municipal level requires long-term vision instead of short-term crisis reaction. This enables communities to plan for the protection of vernal pool resources as a subset of their overall master planning process. Therefore, it is not viewed as inconsistent or discretionary, but rather as a legitimate part of the jurisdiction's accepted and approved development goals. Three sequential steps for local conservation are presented: (1) vernal pool mapping and inventory, (2) vernal pool ecological assessment, and (3) developing conservation actions.

> **NOTE:** Clustering development away from vernal pools and other key resources is an important planning tool. It not only conserves open space, but also reduces impervious surfaces and accessory infrastructures.

> **CAUTION!** The absence of a local vernal pool inventory and assessment should ***not*** forestall implementation of Management Recommendations for individual projects and small scale conservation initiatives. To address development and conservation concerns at individual vernal pools, proceed to Section III: Management Goals and Recommendations.

The goal of municipal-wide inventory and mapping exercises is to identify exemplary pools or pool clusters in each community. This enables decision-makers, developers, and citizens to understand which sites are considered to be of special significance as a community resource.

Step 1. Vernal Pool Mapping and Inventory

Identifying vernal pools in your town might at first seem like a daunting task. In this section we present some simple steps to get you started. Further tips and details for identifying and mapping vernal pools are provided in *Appendices 2* and *3*.

Some vernal pools can be located by using aerial photography and National Wetland Inventory (NWI) maps (see *Appendix 2* for details). Inventory methods will vary according to the availability of resources, the region of interest, and level of expertise. A primer on identifying and mapping vernal pools using aerial photography and Geographic

Information Systems is available in the publication *Massachusetts Aerial Photo Survey of Potential Vernal Pools* (Burne 2001).

Pre-inventory checklist:

Towns should consider the following issues *before* beginning the inventory process:

- Assess the status of wetland and vernal pool mapping in your town. It is possible that outside contractors or researchers have already located vernal pools for various projects.
- Is aerial photography available for your town? Is it appropriate for the mapping project? (See *Appendix 3* for aerial photo resources.)
- Do you have skilled volunteers for photo-interpretation and field identification of vernal pools (using whatever criteria are applicable to your State or town)?
- What is the availability of funding (Federal or State) for conducting an inventory or for contracting professionals to photo-interpret vernal pool resources?
- Is there a local university, land trust, or non-profit environmental organization willing to offer guidance or other support?

Conducting the inventory:

1. Locate vernal pools through mapping, ground surveys, or a combination of both. If possible, use a Geographic Positioning System (GPS) to obtain coordinates, so that a vernal pool data layer can be created in a Geographic Information System (GIS).
2. Mark locations of pools on tax maps, topographic maps, and, if available, in GIS.
3. Identify clusters of pools.
4. Conduct a biological inventory/field verification of as many pools as possible (see Ecological Assessment steps, below).
5. Identify pools or pool complexes of conservation interest and work to develop a protection strategy (see details provided later in this document).

Step 2. Ecological Assessment: Prioritizing Conservation Targets

Towns will not be able to protect every vernal pool. Therefore, it is important to know which pools have the greatest ecological significance, and thus merit greater protection. This can be accomplished by examining pools in the field and collecting biological data to determine each pool's relative local importance. The following “Vernal Pool Assessment Sheet” provides a means for doing this. Issues associated with such assessments are described in the text below.

Vernal pools, or clusters of pools within a town, may vary tremendously in quality or ecological significance. In general, towns should focus their conservation efforts on:

1. ecologically significant pools along size and hydroperiod (length of time the pool holds water) gradients in order to protect a wide diversity of pool-breeding invertebrates and amphibians;
2. pools with intact critical terrestrial habitat;
3. pools with long-term conservation opportunities (e.g., pools on public land, not-for-profit lands, or in large tracts of relatively undisturbed private ownership); and
4. maintaining or restoring the adjacent terrestrial habitat for pools in agricultural or suburban lawn/landscaped settings where the amount of forest cover is limited. (Note: Although forested landscapes are preferred habitat, unfragmented agricultural lands support dispersal of many amphibians and have the potential to become even more valuable following old field succession or reforestation.)

Rating the ecological significance of an individual vernal pool is not a simple process. For this reason, we provide general guidance for assessment of vernal pool ecological significance based on two parameters: (1) biological value of the vernal pool, and (2) condition of the critical terrestrial habitat. Assessment of a pool's biological value factors in species abundance, species diversity, and pool vulnerability. Assessment of the critical terrestrial habitat includes the integrity of the vernal pool's envelope (land within 100 feet from the pool's edge) and critical terrestrial habitat (land from 100 to 750 feet from the pool's edge).

Note: The egg mass thresholds and critical thresholds of development around the pool are based on current available science. Egg mass numbers may vary regionally (Calhoun et al., unpub. data). We urge you to complete your own biological inventory and assess egg mass densities that indicate important breeding pools in your area. These numbers may be influenced by whether pools occur in clusters or are isolated. Low numbers in clustered pools do not make the pool less valuable; instead, they may indicate that the population has dispersed its breeding among all the pools.

We identify pools with 25% or less developed area in the critical terrestrial habitat as having high priority. The few studies that have been conducted on this topic suggest that development pressures (buildings, impermeable surfaces, roads, lawns) higher than 25-30% cause declines in breeding populations (see "Translating Science into Conservation," below). See Figure 8 for examples of vernal pools and critical terrestrial habitats under varying development scenarios.

VERNAL POOL ASSESSMENT SHEET

A. Biological Value of the Vernal Pool

(1) Are there *any* state-listed species (Endangered, Threatened, or Special Concern) present or breeding in the pool?
Yes______ No__________

(2) Are there two or more vernal pool indicator species breeding (i.e., evidence of egg masses, spermatophores [sperm packets], mating, larvae) in the pool?
Yes______ No__________

(3) Are there 25 or more egg masses (regardless of species) present in the pool by the conclusion of the breeding season?
Yes______ No__________

B. Condition of the Critical Terrestrial Habitat

(1) Is at least 75% of the vernal pool envelope (100 feet from pool) undeveloped?
Yes______ No__________

(2) Is at least 50% of the critical terrestrial habitat (100-750 feet) undeveloped?
Yes______ No________

NOTE: For these purposes, "undeveloped" means open land largely free of roads, structures, and other infrastructure. It can be forested, partially forested, or open agricultural land.

Cumulative Assessment

Number of questions answered YES in category A	Number of questions answered YES in category B	Tier Rating
1-3	2	Tier I
1-3	1	Tier II
0	1-2	Tier III
1-3	0	Tier III

CAUTION! *This rating system is designed strictly as a planning tool, not as an official assessment tool.* It will enable you to determine the relative ecological value of pools within your community. A Tier I rating—which will most likely apply to only a minority of sites—denotes exemplary pools; Management Recommendations should be applied at these sites. For pools rated as Tier II, proceed with care; you need more information! Tier II pools will probably constitute the majority of your vernal pool resources; Management Recommendations should be applied at these sites to the maximum extent practicable. Tier II pools might also be likely candidates for restoration efforts (e.g., reforestation of the critical terrestrial habitat).

TRANSLATING SCIENCE INTO CONSERVATION

Very little published research has addressed conservation concerns as they relate to vernal pool habitats and wildlife. Therefore, the recommendations made in this document are based primarily upon decades of field observations made by the authors. Those observations have repeatedly demonstrated that pool-breeding wildlife populations experience precipitous declines in response to developments within vernal pool envelopes and critical terrestrial habitats.

Vernal pool research conducted in Massachusetts by Bryan Windmiller (unpub. data) corroborates the authors' conclusions. In one study, 25 acres (10 hectares) of upland forest adjacent to a vernal pool in an urban setting was almost completely cleared. Within two years, the pool's wood frog population was extirpated (i.e., wood frogs became locally extinct). This occurred despite the maintenance of an untouched 150-foot wide buffer of forested upland around the pool and a forested wetland corridor adjacent to the pool. These findings underscore the fact that narrow buffers alone—which are usually less than 150 feet—are insufficient to protect wildlife populations.

In a second study, Windmiller tracked large populations of spotted salamanders, blue-spotted salamanders, and wood frogs over a five-year period at two vernal pool breeding sites located in close proximity. The land surrounding one of the pools remained largely intact throughout the five years. At the second pool, approximately 25% of the existing forested upland within about 1,000 feet (300 meters) was cleared for residential development after the first year of the study. That development also greatly fragmented the remaining forested upland, although a 100-foot wide buffer was left untouched.

Within four years of the beginning of construction, spotted salamander numbers declined by 53%; the wood frog population was reduced by 40%. Blue-spotted salamander numbers also declined over a two-year period following initial construction but subsequently recovered to pre-development levels. In contrast, there was no reduction in amphibian breeding population sizes at the undeveloped pool.

This study demonstrated that even a relatively small degree of development—covering approximately 25% of the surrounding critical terrestrial habitat—can negatively impact vernal pool wildlife. As in the first study, these impacts occurred despite the maintenance of a forested buffer.

The recommendations in this document would limit the footprint of development to <25% of the area surrounding productive vernal pools. This is a relatively conservative recommendation, given the results of the second study. However, this threshold may be less detrimental to resident amphibians if impacts are further reduced by following site-specific recommendations made in Section III of this document.

Step 3. Putting a Conservation Plan into Action

From Awareness to Action

Informed with the results of a town-wide vernal pool survey and assessment, local decision-makers can begin targeting for protection those significant vernal pools and vernal pool clusters identified by their inventory and assessment. The advantage of such a proactive planning exercise is that it replaces the site-by-site debate, which is focused on individual pools, with an objective, scientifically informed process that can be applied to all of a town's vernal pool resources. From a developer’s perspective, it provides certainty as to where locally important or significant resources are located. This should replace the *status quo* of vocal opposition to almost every development near a vernal pool, regardless of the relative ecological viability of the pool.

Why is it important to simplify the presently confused process? Concern for vernal pools has risen dramatically over the last decade. However, unless clarity and fairness become integral parts of the decision-making process, we risk creating a backlash that could undo all that has been achieved in heightening public awareness of these vital resources. With increased knowledge and authority comes a responsibility to act in a consistent and fair manner.

The most difficult task will be to determine from the Assessment and Mapping Exercise where a community should focus their efforts. We recognize that it is impossible to protect every vernal pool and its critical terrestrial habitat. Therefore, each community should prioritize its efforts based on the results of its inventory and assessment. The driving impetus for this priority-setting exercise is that a smaller number of well-protected vernal pools (ideally those with intact envelopes and 75% undeveloped critical terrestrial habitat) is far preferable, from a conservation standpoint, to a greater number of pools “protected” in name only but lacking a sufficient envelope and critical terrestrial habitat to sustain populations of vernal pool species. Once conservation priorities are established, there are a variety of mechanisms local jurisdictions can employ to achieve these goals.

CAUTION! The priority-setting exercise will focus conservation efforts on certain parcels of property, and de-emphasize the importance of others. Because of the political and emotional nature of such decisions, this priority-setting should be conducted with maximum public input, so that the community understands the reasoning behind this exercise. Priorities set by a small group, in the absence of broader public involvement and understanding, are likely to be challenged, and will ultimately be ineffective.

Incorporation into Comprehensive, Development, or Master Plans

Community Master Plans should incorporate the goals of these vernal pool protection strategies, justification for those goals, and locations of exemplary pools that have been targeted for stewardship. There are two primary reasons for doing this.

- Clarity: It is very important that all stakeholders (property owners, citizens, developers, and local decision-makers) are aware of the goals of vernal pool protection and which properties are considered essential to achieving those goals. This provides some level of certainty in what is now a chaotic case-by-case debate.
- Security: If a community clearly articulates its goals and objectives in a written, publicly adopted document, and then consistently follows those guidelines, it is less susceptible to legal challenges. Legal challenges against municipal decisions are most successful if it can be demonstrated that those decisions are capricious, without reasoned basis, and therefore inconsistent with a community's articulated goals and policies.

Acquisition

Acquisition is expensive and therefore not often feasible for communities. It is important to spend limited acquisition dollars wisely. However, under certain circumstances it might be possible for a community or land trust to acquire key properties. We recommend acquisition measures for individual vernal pools only if they receive a Tier I rating during the Vernal Pool Assessment Exercise; this acquisition should include at least 750 feet of land from the vernal pool depression in all directions. In addition, acquisition efforts are appropriate for large blocks of open space with clusters of pools of any Tier.

Easements

Easements provide another mechanism to protect pools and their contiguous critical terrestrial critical habitat. On subdivision projects where open space with vernal pools is reserved we recommend that the developer convey a conservation easement to a local land trust, the municipality, or a conservation or scientific not-for-profit organization. In our experience this conservation strategy is far superior to reliance on a homeowner's association to protect these resources. The holder of the easement would be responsible for ensuring that the terms of the easement are being met, and for informing the neighbors about the stewardship needs of the property.

Overlay Zones

A resource overlay zone specifically designed to protect vernal pools can be adopted by the town. This would be particularly effective where clusters of Tier I and Tier II pools occur. While leaving town zoning in place, additional standards, requirements, and incentives are applied in the overlay zone. It is recommended that a town adopt a resource overlay zone to encompass those vernal pools and critical terrestrial habitats that have been designated as protection priorities. The zone could provide a mix of regulations and incentives to conserve vernal pools and preserve economic equity including (but no limited to):

- minimal lot-clearing restrictions within the zone, allowing for more dense clustering of development;
- density bonuses for tightly clustered, conservation-oriented subdivisions;
- reductions in road width standards including cul-de-sac radii, and prohibiting hard 90 degree, vertical curbing;
- establishment of a transfer of development rights (TDR) program where a landowner gets credits in a developable portion of town in exchange for giving up development credits in the overlay zone. TDRs are complicated to set up, because one needs a sending district (the overlay zone) as well as a receiving district (an area where development can be intensified). Therefore, this may not be an appropriate strategy for many towns. However, towns could incorporate some, if not all, of the practices recommended in this document as standards to guide development in an overlay zone.

Vernal Pool Ordinances

Some municipalities have developed ordinances specifically to protect vernal pools and their associated terrestrial habitat. Some of these use rating systems that place undue emphasis on number of species present or on larger vernal pools. A better approach would be to develop a local ordinance that incorporates ***both*** the assessment and best development practices presented herein.

Recognition and Voluntary Stewardship Programs

Programs that encourage vernal pool stewardship could be set up to provide technical advice and recognition to landowners who voluntarily protect and manage these resources. Similar programs to register natural areas on private property have been successful both as conservation strategies and in raising public awareness. Another approach would be to publicly recognize those developments that incorporate vernal pool Best Development Practices. Apart from demonstrating that it is possible to develop responsibly, such recognition may be an important marketing tool. In Farmington, Connecticut, a small development has been created that has turned a vernal pool and its resources into the centerpiece of the development and its marketing (see Case Study: Jefferson Crossing—Innovative Conservation Design for a Subdivision, page 14).

For other ideas for forming local partnerships for vernal pool conservation, see *Vernal Pool Conservation in Connecticut: An Assessment and Recommendations* (Pressier et al. 2001).

CASE STUDY

Jefferson Crossing

Innovative Conservation Design for a Subdivision

On Talcott Mountain—a trap-rock ridge lying west of Hartford, Connecticut—a unique conservation subdivision was created, incorporating many of the design principles contained in this manual. Unlike most subdivisions, where natural resources are expected to "fit" around a pre-conceived development pattern, Jefferson Crossing was designed with great sensitivity to the site's natural features. The subdivision is named for the rarest vernal pool breeding amphibian found on the site, the state-listed Jefferson salamander, *and* for the fact that the salamanders will be able to cross freely through the site to their breeding pool. To accomplish this, all structures and infrastructure were placed outside of the vernal pool envelope. In addition, the design of the site maximized protection of the critical upland habitat zone through a combination of conservation easements and lot-clearing restrictions. Finally, the design allows for unimpeded movement of amphibians and other wildlife throughout the forested site.

The execution of this novel design required a commitment from the developer to engage a team of professionals to simultaneously integrate design, engineering, and natural resource protection. For example, the proposed entrance road (using an existing access from a demolished single family house) was determined to be too close to the vernal pool. The developer acquired an additional lot of land specifically to enable relocation of the entrance road well beyond the vernal pool envelope. The houses were clustered several hundred feet away from the vernal pool; this, combined with lot clearing restrictions (no more than 50% per lot) and conservation easements, resulted in 75% of the site being protected in its natural state.

The roadways internal to the site have "Cape Cod curbing" to allow salamanders to move freely. Stormwater is handled through swales and a single catch basin. To minimize mortality of amphibians and other wildlife caught in the catch basin system, the water moves through a grassy swale and into an open, biofiltration wetland. By using low gradient curbing and eliminating the need for hydrodynamic separators, amphibian mortality is minimized. Additional restrictions govern the design of individual driveways; the use of pesticides, herbicides, and salts; and exterior lighting.

Jefferson Crossing will incorporate its unique conservation design as part of its marketing strategy. The location of the homes tucked amongst the hemlock trees and nestled between trap rock outcrops will attract a distinctive type of buyer, one that is looking to live in greater harmony with the natural world. Ms. Anitra Powers, who developed this property on the site of her family homestead, rejected conventional development patterns. Her vision has turned what many would consider a liability into an asset.

III. MANAGEMENT GOALS AND RECOMMENDATIONS

Management goals are described below for each of three vernal pool management areas: the vernal pool depression, the vernal pool envelope (100 ft. from spring high water), and the critical terrestrial habitat (100 to 750 ft from spring high water). See Figures 8 and 9 for schematics of vernal pool management areas and recommendations.

Management Areas and General Recommendations

Vernal Pool Depression

Description and Function:
This area includes the entire vernal pool depression up to the spring high water mark. Due to seasonal fluctuations in water levels, the vernal pool depression may or may not be wet during the period when a development review is initiated. During the dry season, the high-water mark generally can be determined by the presence of blackened leaves stained by water or silt, aquatic debris along pool edges, water marks on surrounding trees or rocks, or a clear change in topography from the pool depression to the adjacent upland. The pool basin is the breeding habitat and nursery for pool-dependent amphibians and invertebrates.

Desired Management:
For all Tiers, maintain the pool basin, associated vegetation and the pool water quality in an undisturbed state.

Rationale:
Creating ruts or otherwise compacting substrates in and around the pool can alter the pool’s water-holding capacity, disturb eggs or larvae buried in the organic layer, and alter the aquatic environment. Excess slash, construction debris, or channeled stormwater in the pool basin can hinder amphibian movement and alter water quality. Removal of pool vegetation reduces the availability of egg-attachment sites.

Vernal Pool Envelope

(area within 100 feet of the pool's edge)

Description and Function:
The envelope consists of a 100-foot area around the pool, measured from the spring high water mark. In the spring, high densities of adult salamanders and frogs occupy the habitat immediately surrounding the pool. Similarly, in early summer and early fall, large numbers of recently emerged salamanders and frogs occupy this same habitat. This zone also maintains the water quality of the pool depression and provides a source of leaves, which constitute the base of the pool food web.

Desired Management:

- Maintain an undeveloped forested habitat around the pool, including both canopy and understory (e.g., shrubs and herbaceous vegetation).
- Avoid barriers to amphibian dispersal (emigration, immigration).
- Protect and maintain pool hydrology and water quality.
- Maintain a pesticide-free environment.

Rationale:
The integrity of the forest immediately surrounding the pool depression is critical for maintaining water quality, providing shade and litter for the pool ecosystem, and providing suitable terrestrial habitat for pool-breeding amphibian populations. Juvenile salamanders are especially vulnerable to drying during the first months after emergence (Semlitsch 1981). Such desiccation is much more likely where habitat elements described above (e.g., leaf litter, shade) are lacking.

Critical Terrestrial Habitat

(area within 100-750 feet of the pool's edge)

Description and Function:
The critical terrestrial habitat extends 650 feet beyond the upland edge of the vernal pool envelope (i.e., 750 feet beyond the edge of the pool). This area provides habitat for amphibians during the non-breeding season for foraging, dispersing, and hibernating. During the breeding season, adults migrate to pools through this zone.

Desired Management:

- Maintain or restore a minimum of 75% of the zone in contiguous (i.e., unfragmented) forest with undisturbed ground cover.
- Maintain or restore forested corridors connecting wetlands or vernal pools.
- Provide suitable terrestrial habitat for pool-breeding amphibian populations by maintaining or encouraging at least a partially closed-canopy stand that will provide shade, deep litter, and woody debris.
- Minimize disturbance to the forest floor.
- Where possible, maintain native understory vegetation (e.g., shrubs and herbs).

Rationale:
This area is needed to support upland populations of amphibians that breed in vernal pools. Juvenile and adult wood frogs and mole salamanders select closed-canopy forests during emigration and dispersal in managed forest landscapes (deMaynadier and Hunter 1998, 1999). Spotted salamanders often occur under, or closely associated with, woody debris on the forest floor (Windmiller 1996). Other mole salamanders in the Region have similar habitat needs. Rutting and scarification of the forest floor may prevent

salamanders from traveling to breeding pools by creating barriers along travel routes (Means et al. 1996). Furthermore, if shallow ruts fill with water, vernal pool amphibians may deposit eggs in ruts that do not hold water long enough to produce juveniles. Created treatment wetlands (e.g., detention ponds) that are located near to vernal pools often cause similar problems.

Roads (and associated development) within this zone limit the amount of terrestrial habitat available to amphibian populations, fragment and isolate remaining pieces of habitat, facilitate further development, and directly result in mortality of individuals. Recent research conducted within Rhode Island has demonstrated that vernal pool-breeding amphibians may be extremely sensitive to roads constructed within 0.62 miles (1 km) of the vernal pools in which they breed (Egan 2001; Egan and Paton, *in prep*.). Within this area, a mere 16 linear feet of road per acre (12 m/ha) was linked to significant declines in numbers of wood frog egg masses; only 25 feet of road per acre (19 m/ha) appeared to cause significant declines in numbers of spotted salamander egg masses. Beyond these thresholds, even slight increases in road density severely limited the potential of the areas surrounding pools to serve as nonbreeding habitat. Research by Klemens (1990) has suggested that actual road configuration and pattern (i.e., “roads to nowhere” and cul-de-sacs servicing subdivisions vs. linear roads connecting urban centers), as well as road density, likely factors into amphibian population declines.

Although much of amphibian terrestrial life history is still unknown, researchers have documented travel distances from breeding pools of juvenile wood frogs and adult mole salamanders (see Figure 4 and reviews by Windmiller 1996, Semlitsch 1998). These distances, along with all of the other factors discussed above, demonstrate that pond-breeding amphibians require significant habitat surrounding pools.

Summary of Management Areas

To ensure successful breeding, vernal pool depressions must be left intact and undisturbed. Excluding development and minimizing disturbances to the area immediately surrounding the vernal pool (i.e., the pool’s envelope) will provide breeding amphibians with a staging ground and will also help to maintain pool water quality. Additional upland habitats are required during the nonbreeding season; such “critical terrestrial habitats” can be maintained by limiting development and by applying Management Recommendations (discussed in the following section). By carefully considering the recommendations made for each of these three management areas, viable populations of pool-breeding amphibians may be maintained. A summary of management areas and desired outcomes is presented in Table 3.

Table 3. Recommended guidelines for vernal pools and surrounding management areas in developing landscapes

Management Area (distance from pool edge)	**Area of Managed Zone** (acres)[1]	**Primary Wildlife Habitat Values**	**Desired Management**	**Recommended Guidelines**
Vernal Pool Depression (0 ft)	0.2	Breeding pool; egg attachment sites.	Good water quality and water-holding capacity; undisturbed basin with native vegetation along the margin.	No disturbance.
Vernal Pool Envelope (100 ft)	1.4	Shade and organic inputs to pool; upland staging habitat for juvenile amphibians.	Maintain forested envelope around pool; avoid barriers to amphibian movement; prevent alteration of water quality or pool hydrology.	No development and implementation of Management Recommendations for this zone.
Critical Terrestrial Habitat (750 ft)	40	Upland habitat for pool-breeding adult amphibians (for foraging, dispersing, and hibernation).	Partially shaded forest floor with deep, moist uncompacted litter and abundant coarse woody debris.	Less than 25% developed area; implementation of Management Recommendations for this zone.

[1] Approximate area, based on a 100-ft. diameter pool.

Specific Issues and Recommendations

In the following section management recommendations and standards for specific development issues (e.g., road construction, stormwater management, and locations of outbuildings) are provided. We encourage application of relevant recommendations.

Roads and Driveways

Conservation Issues:

- Road mortality is a major contributing factor in amphibian declines. This occurs by direct mortality from vehicular traffic as well as increased vulnerability to depredation and desiccation when amphibians cross roads.

- A number of studies have shown that roads (and urbanization) limit amphibian dispersal and abundance (Gibbs 1998; Lehtinen et al. 1999; deMaynadier and Hunter 2000; Egan and Paton, *in prep*.). Certain species are reluctant to cross open, unvegetated areas, including roads. Roads create barriers to amphibian dispersal. Curbs and catch basins act as traps that funnel and collect amphibians and other small animals as they attempt to cross roads.
- Roads are sources of chemicals and pollutants that degrade adjacent aquatic and terrestrial habitats. These pollutants include, but are not limited to, salts, particulate matter, and heavy metals. Eggs and larval amphibians are especially sensitive to changes in water quality. Influxes of sediment can smother eggs, while salts and heavy metals are toxic to larvae (Turtle 2000).
- Roads create zones of disturbance characterized by noise and light pollution. Both of these pollutants interfere with the ability of amphibians to disperse across the landscape. Noise pollution can also interfere with frog calling activity, which is an essential part of their reproductive ecology.
- Roads can change hydrology (thus changing vernal pool quality and hydroperiod).

Management Recommendations:

- Roads and driveways should be excluded from the vernal pool depression and vernal pool envelope.
- Roads and driveways with projected traffic volumes in excess of 5-10 cars per hour should not be sited within 750 feet of a vernal pool (Windmiller 1996). Regardless of traffic volumes, the total length of roads within the critical terrestrial habitat should be limited to the greatest extent possible (Egan and Paton, *in prep*.).
- Use Cape Cod-style curbing (see Figure 10) or no-curb alternatives on low capacity roads.
- Use oversize square box culverts (2 feet wide x 3 feet high) near wetlands and known amphibian migration routes to facilitate amphibian movement under roads. These should be spaced at 20-foot intervals *and* use curbing to deflect amphibians toward the box culverts.
- Use cantilevered roadways (i.e., elevated roads that maximize light and space underneath) to cross low areas, streams, and ravines that may be important amphibian migratory routes.
- Cluster development to reduce the amount of roadway needed and place housing as far from vernal pools as possible.

Site Clearing, Grading, and Construction Activities

Conservation Issues:

- Site clearing may result in crushing large numbers of amphibians and other animals.
- Site clearing and subsequent construction activities reduce terrestrial habitat available to amphibians by decreasing the extent of the habitat, compacting soil, removing downed woody debris, diminishing invertebrate food supplies, and decreasing the number of small mammal burrows used for refuge by salamanders.
- Site clearing removes shade trees, which alters local climate, resulting in elevated vernal pool water temperatures and increased drying of the forest floor. Amphibians are sensitive to alterations in temperature and are highly subject to desiccation. Elevated temperatures in vernal pools can increase algal productivity, thereby reducing oxygen available to developing amphibian larvae and increasing the likelihood of larval die-offs.
- Site clearing and grading increase erosion rates, which may result in sedimentation of vernal pools. Increased sediment loads stress and kill both amphibian eggs and developing larvae and can alter the structure and composition of in-pool vegetation
- Site clearing and grading create barriers to amphibian dispersal by stockpiling mounds of soil, altering topographic contours, and creating open areas which amphibians may be reluctant to cross because of increased vulnerability to predation and desiccation.
- Use of silt fencing to control erosion creates major obstacles to movement of amphibians and other small animals. Removal of silt fencing is rarely addressed, or often overlooked in sedimentation and erosion control plans. The prevailing belief is that more fencing, for longer periods, provides better environmental protection. Therefore, fences are often left in place indefinitely, impeding the migratory patterns of tens of thousands of animals. Erosion control structures should be removed within 30 days of final site stabilization. Erosion control berms—a sediment control measure accepted in some states—are effective sediment barriers when properly installed and provide less of an obstacle for amphibians and reptiles. Installation of sediment control barriers to control erosion and sedimentation should be limited to the down-gradient edge of any disturbed area and adjacent to any drainage channels within the disturbed area.
- Site clearing and grading can de-water vernal pools by altering surface-water drainage patterns associated with the pool.
- Site clearing can create water-filled ruts. These ruts intercept amphibians moving toward the vernal pool and may induce egg deposition. Often the ruts do not hold water long enough to allow development of the amphibians and therefore act as "sinks" that result in population declines.
- Perc test holes act as pitfall traps, collecting large numbers of amphibians, turtles, and other animals. Unable to climb the vertical walls of the perc scrape, these animals perish.

- Site clearing and grading creates habitat for the establishment of invasive plants and facilitates the movement of amphibian predators (edge species) into the forest interior.

Management Recommendations:

- Minimize disturbed areas and protect down-gradient buffer areas to the extent practicable.
- Site clearing, grading, and construction activities should be excluded from the vernal pool depression *and* the vernal pool envelope.
- Site clearing, grading, and construction activities should be limited to less than 25% of the entire vernal pool habitat (i.e., the pool depression, envelope, and critical terrestrial habitat).
- Limit the area of clearing, grading, and construction by clustering development.
- Minimize erosion by maintaining vegetation cover on steep slopes.
- Avoid creating ruts and other artificial depressions that hold water. If ruts are created, refill to grade before leaving the site.
- Refill perc test holes to grade.
- Use erosion and sediment control best management practices to reduce erosion. Stagger silt fencing with 20 foot breaks to avoid disrupting amphibian movements or consider using erosion control berms. Use combinations of silt fencing and hay bales to reduce barrier effects. Re-seed and stabilize disturbed areas immediately; permanent stabilization for revegetated areas means that each area maintains at least 85% cover. Remove silt fencing as quickly as possible and no later than 30 days following final stabilization. Minimize use of silt fencing within 750 feet of vernal pools. Erosion control berms can be leveled and used as mulch or removed upon final stabilization.
- Limit forest clearing on individual house lots within the developed sections of the vernal pool management zones to no more than 50% of lots that are two or more acres in size. Encourage landscaping with natural woodland, containing native understory and groundlayer vegetation, as opposed to lawn.
- Silt fencing *should* be used to exclude amphibians from active construction areas. At Jefferson Crossing (see Case Study), each house construction site was encircled by a silt fence barrier to keep salamanders away from heavy machinery, excavation, and stockpiling. However, construction activities should, ideally, occur outside of peak amphibian movement periods (which include early spring breeding and late summer dispersal).

Stormwater Management

Stormwater management provides an excellent example of how addressing one set of environmental issues can result in creation of other environmental impacts, as follows.

Conservation Issues:

- Systems of curbs, catch basins, and hydrodynamic separators—designed to capture and treat road runoff—intercept, trap, and kill amphibians and other small animals crossing roads. These systems can also de-water vernal pools by releasing water into another watershed, or downslope of a vernal pool. Hydrodynamic separators are especially problematic because they remove particulate matter from stormwater via swirl chambers. These devices cannot distinguish between sediments and small vertebrates; thus, thousands of amphibians can be killed in one unit.
- Systems of gutters, leaders, and infiltration systems designed to capture and manage roof runoff can drain wetlands if the roof water is captured and released in another watershed, or below the vernal pool area.
- Systems designed to capture road and roof runoff can alter how long pools hold water by transporting additional water into the vernal pool watershed. This is especially critical in short hydroperiod pools that support fairy shrimp.
- Vernal pools and other small wetlands have been inappropriately used as stormwater detention pools and biofiltration basins. These practices create a degraded aquatic environment subject to sediment loading, pollutants, and rapid changes in water quantity, quality, and temperature.
- Stormwater detention basins and biofiltration ponds can serve as decoy wetlands, intercepting breeding amphibians moving toward vernal pools. If amphibians deposit their eggs in these artificial wetlands, they rarely survive due to the sediment and pollutant loads, as well as fluctuations in water quality, quantity, and temperature.

Management Recommendations:

- Vernal pool depressions should never be used, either temporarily or permanently, for stormwater detention or biofiltration.
- Detention and biofiltration ponds should be located at least 750 feet from a vernal pool; they should never be sited between vernal pools or in areas that are primary amphibian overland migration routes, if known.
- Treat stormwater runoff using grassy swales with less than 1:4 sloping edges. If curbing is required, use Cape Cod curbing. Maximize open drainage treatment of stormwater.
- Use hydrodynamic separators only in conjunction with Cape Cod curbing or swales to avoid funneling amphibians into treatment chambers, where they are killed.
- Maintain inputs to the vernal pool watershed at pre-construction levels. Avoid causing increases or decreases in water levels.

- Minimize impervious surfaces (i.e., surfaces that do not absorb water) to reduce runoff problems and resulting stormwater management needs. Use of grass pavers (concrete or stone that allows grass to grow) on emergency access roads and in low use parking areas is recommended. Use of phantom parking is also recommended. Zoning formulae often require more parking spaces than are actually needed. Under a phantom parking strategy, sufficient land is reserved for projected parking requirements, but only a portion of the parking area is constructed at the outset. Additional areas are paved on an as-needed basis.
- Examine the feasibility (which varies by location) of reducing the road width standard to achieve conservation goals (i.e., minimize the footprints of roads). This is often done in tandem with development clustering, to reduce impervious surfaces and disturbance areas.

Accessory Infrastructure

Conservation Issues:

- In many communities, a different standard is employed when evaluating impacts of accessory structures and functions (e.g., outbuildings, pools), as compared to homes and other buildings. There appears to be no legal basis for this distinction, but rather a discretionary sense that, for example, the construction of a swimming pool in a regulated area surrounding a wetland is different (i.e., less harmful) than construction of a house within the same area. For pool-breeding amphibians, there is no distinction; the siting of accessory structures near vernal pools is a major conservation issue resulting in the loss of millions of amphibians and other small creatures each year.
- Below-ground swimming pools may function as large animal traps, capturing salamanders, frogs, small mammals, snakes, and turtles. Trapped animals either drown or are killed by chlorinated water.

Management Recommendations:

- Accessory structures should be excluded from the vernal pool depression and vernal pool envelope.
- Below-ground swimming pools located within the critical terrestrial habitat of a vernal pool should be surrounded by some sort of barrier. A fine mesh wire at the base of a picket fence or a one-foot high, 90-degree, curb or barrier would deter amphibians from travelling into the pool.

Lighting

Conservation Issues:

- Light spillage in wetlands and woodlands affects a diversity of wildlife species (e.g., see www.urbanwildlands.org). Recent increases in the use of security and garden lighting have intensified problems associated with light spillage. Scientific experiments and anecdotal evidence suggest that changes in lighting may affect frog reproduction, foraging, predator avoidance, and social interactions (Buchanan 2002). Buchanan demonstrated in laboratory experiments that dark-adapted frogs exposed to rapid increases in illumination may be temporarily 'blinded', unable to see prey or predators until their eyes adapt to the new illumination. Similarly, there is evidence that salamanders are strongly attracted to light (S. Jackson, University of Massachusetts, pers. comm.). This behavioral response could divert salamanders away from breeding sites; it could also make them more vulnerable to predation or road mortality during migrations. Artificial lights that emit unusual spectra may especially disrupt these migration patterns (Wise and Buchanan 2002). Research on the effects of lighting on amphibian behavior and larval development is ongoing.

Management Recommendations:

- Exterior and road lighting within 750 feet of a vernal pool should use low spillage lights—those that reflect light directly downward onto the area to be illuminated. A variety of products to accomplish this goal are now on the market. Avoid using fluorescent and mercury vapor lighting.

Wetland Creation and Alteration

Conservation Issues:

- Extensive structural complexity (i.e., the arrangement of different layers of trees, shrubs, and plants in a small wetland) supports a diversity of small vertebrates and invertebrates. When wetlands are altered through clearing of vegetation, impoundment of water, or dredging, the microhabitats used by many species of wildlife are changed or lost. This results in unsuitable breeding habitat for many amphibians, including vernal pool species.
- Wetland creation is another byproduct of development and landscape alteration. Created wetlands are often mandated as replacement for other wetlands lost during development; sometimes, they are also incorporated as design features in a subdivision. Similar to altered wetlands, created wetlands usually lack the structural diversity, microhabitats, and hydrology to support vernal pool breeding amphibians.

- Altered and created wetlands often support highly adaptable, widespread, “weedy” species (e.g., bullfrogs or green frogs). These species prey upon, or successfully outcompete, vernal pool-breeding amphibians, which reduces or locally eliminates populations of these habitat specialists.
- Created wetlands that do not have the appropriate habitat often attract breeding amphibians. Eggs laid in these “decoy” pools often do not survive. Such pools serve to trap breeding amphibians and might result in local population declines.

Management Recommendations:

- Alteration of existing conditions within vernal pools and other small wetlands should be avoided.
- Creation of ponds and similar wetlands should be avoided within 750 feet of a vernal pool.
- Redirect efforts from *creating* low value, generalized wetlands to *enhancing* terrestrial habitat around vernal pools. These enhancements could include reforestation of post-agricultural lands within 750 feet of a vernal pool, restoration of forest, importing additional cover objects (e.g., logs, stumps), and removal of invasive plants and animals.

Post-Construction Activities

After a construction project has been completed, there are long-term development issues that continue to affect vernal pools. Even projects that are designed with ecological sensitivity can cause problems over time, due to the day-to-day activities of humans. Many of these longer-term problems can be anticipated and avoided during the overall design and approval process of the project.

Conservation Issues:

- Pest animals are those species that humans encourage by subsidizing food resources and fragmenting habitats. Raccoons, foxes, and skunks fall into this category. These artificially inflated mammal populations often prey heavily on vernal pool amphibians during the breeding season.
- Domestic animals, including pets, can threaten pool wildlife through predation or physical disturbance of habitats.
- Protected areas around wetlands, over time, are intruded upon by humans. Impacts include dumping, forest clearing, dirt biking, introduction of free-ranging dogs and cats, favoring of invasive plant species, fires, collection of native wildlife, and other activities that degrade the vernal pool and its envelope.

- Increased pesticide use is usually associated with suburban landscaping. These toxins often enter into the vernal pool watershed and compromise the pool's ability to serve as a breeding site and nursery for vernal pool species.

Management Recommendations:

- Discourage predators by making garbage and other supplemental food sources unavailable.
- *Consider keeping cats indoors at all times.* This would reduce predation on a wide variety of species, ranging from pool-breeding amphibians to ground-nesting birds. Attaching bells to cat collars does *not* significantly reduce the ability of cats to prey on small vertebrates.
- Mark the edge of a protected area (e.g. the critical terrestrial habitat) with permanent markers. Well-marked boundaries make enforcement of restricted areas clear to both homeowners and the local wetlands enforcement agency. For example, granite monuments or stone cairns could be placed every 10 feet around a protected area. In cases where intrusion is a concern, small sections of stone wall could be erected; these walls should be discontinuous, so that they do not impede amphibian dispersal.
- Use covenants or deed restrictions to assure that the vernal pool and its envelope are conserved and that pesticide use, lot clearing, and other degrading activities are kept out of associated areas. Assign the homeowner or homeowner's association with responsibility for ensuring that conditions of the covenant or deed restriction are met. Provisions should also be included to allow a third-party, such as the town or local land trust, with adequate notice, to enter the property and conduct appropriate management and remediation, charging the homeowner for these services.
- In the case of a homeowner's association or other type of multiple tenant arrangement, a stewardship manual could be prepared that would educate each purchaser, or lessee, as to the unique nature of the property they are purchasing or renting, what their collective obligations to protect the resource entail, and where to obtain additional assistance or information.
- A conservation easement, covering at minimum the vernal pool depression and vernal pool envelope (and, preferably, including land within the "critical terrestrial habitat"), could be held by a municipality, land trust, or other non-governmental organization.

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A "classic" vernal pool lying in a basin, or depression, in deciduous woodland.
Although these habitats are important for vernal pool-breeding species, only a small percentage of pools within the Region have this distinctive signature. Many cryptic (i.e., non-classic) vernal pools are found within larger wetland systems. Figure 3 provides some examples of the wide diversity of these cryptic vernal pools.

Large vernal pool.
Although vernal pools average considerably less than one acre in size, some are as large as two acres. Large vernal pools are not uncommon in the northern part of the Region.

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Small vernal pool.
*Most vernal pools are quite small, as typified by this 0.25-acre pool. This photograph depicts two important components of vernal pools**:** **microtopographic complexity** (as illustrated by a patchwork of hummocks, moss, and logs) and **vertical stratification** (which consists of a variety of layers of herbaceous plants, low shrubs, tall shrubs, and trees). Collectively, these elements provide a tremendous variety of microhabitats, which support the rich diversity of life in and around vernal pools.*

Aerial view of vernal pool.
Many pools exhibit this concentric, ring-like pattern of habitat zones.

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Figure 1. Vernal Pool Size and Structure

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Snowbound vernal pool in late March.
Vernal pool levels are generally highest during winter and spring. This pool contains breeding populations of Jefferson salamanders, spotted salamanders, and wood frogs.

Drying vernal pool in late June.
Low water levels—and resulting low oxygen levels—exclude fish from vernal pools, which would otherwise decimate larval amphibian populations. This site provides breeding habitat for Jefferson salamanders, spotted salamanders, and wood frogs. Blanding's turtles, wood turtles, and box turtles also use this pool.

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Dry vernal pool in August.
Most vernal pools will begin to refill in the autumn, when plants become dormant and use less water. Spotted salamanders and wood frogs breed at this site. The pool is also used by spotted turtles and box turtles.

Figure 2. Vernal Pool Seasonality

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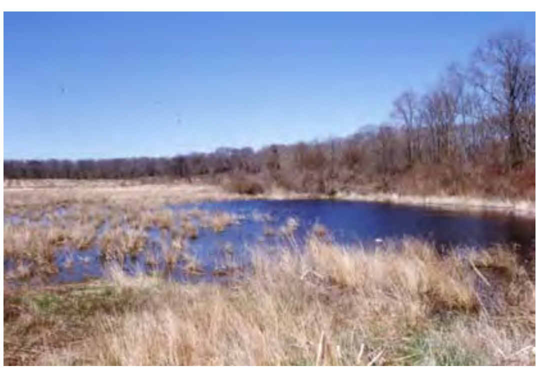
Semi-permanent pool.
Jefferson and spotted salamanders breed in this wetland. This pool rarely dries up completely, as opposed to classic vernal pools, which dry up annually.

Floodplain swamp.
Blue-spotted salamanders and wood frogs breed in depressions and oxbows within river floodplains. When floodwaters recede, these pools become isolated; therefore, they do not provide breeding habitat for fish. Four-toed salamanders, spotted salamanders, and wood turtles also use this habitat.



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Pool with seasonally flooded wet meadow.
Larval amphibians exploit the rich food resources and warmer water of the meadow. As the meadow dries, the larvae retreat into the deeper pool to complete their development. Tiger salamanders breed here; the site also provides habitat for box turtles and ribbon snakes.

Red maple swamp with carpet of *Sphagnum* moss.
Spotted and four-toed salamanders, as well as wood frogs, breed in deeper pools of forested wetlands. These water-filled pockets are often created when trees are uprooted during severe storms.

Figure 3. Cryptic Vernal Pools

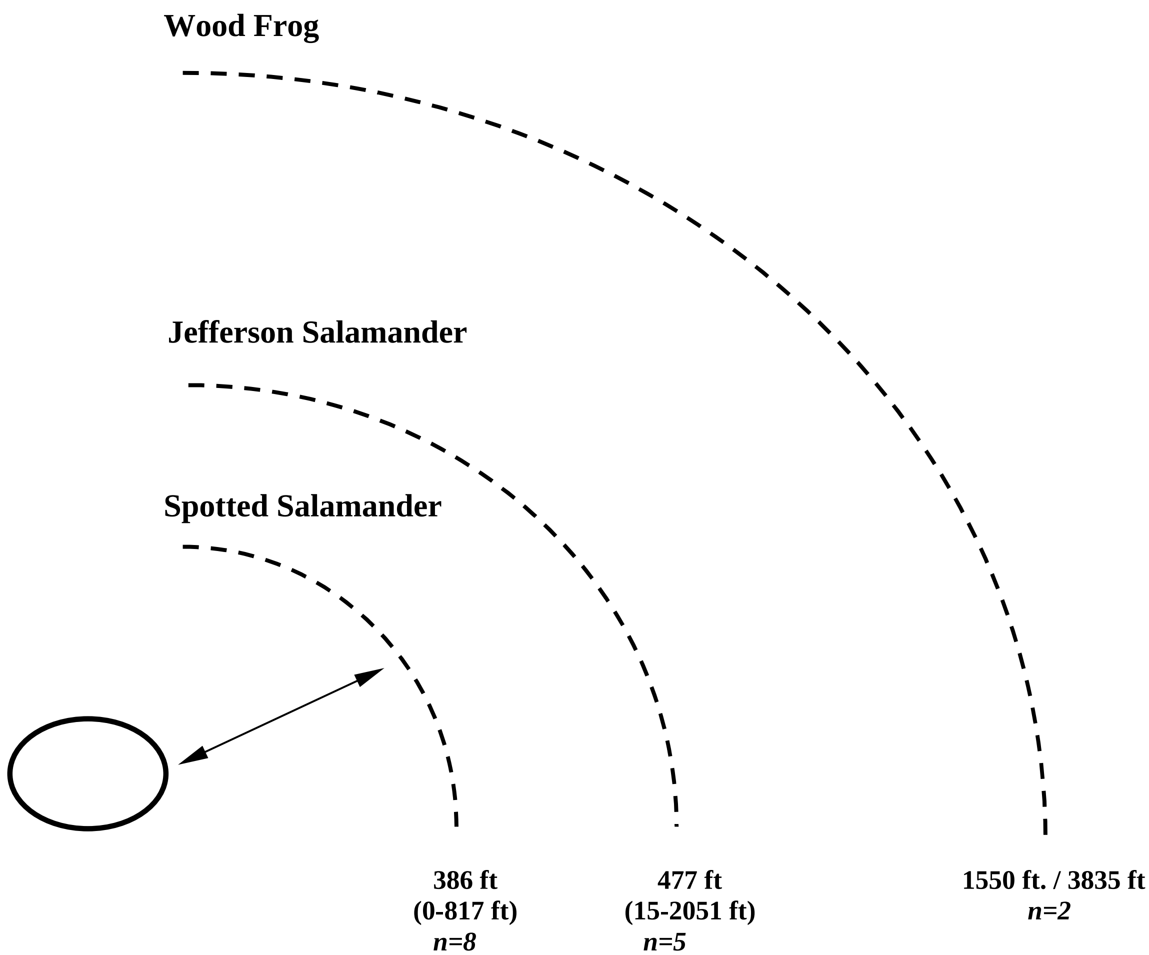

Figure 4. Migration Distances for Vernal Pool Amphibian Indicator Species*

Adult salamander migration distances are provided as means (and ranges). Two values are reported for wood frogs (*Rana sylvatica*)—mean juvenile dispersal distance and maximum adult migration distance. The number of studies contributing data *(n)* is listed for each species (sources include: Windmiller 1996; Semlitsch 1998; Berven and Grudzien 1990; Faccio, *in prep.*).

*Distances are not to scale.

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Jefferson Salamander *(Ambystoma jeffersonianum)*

© Richard G. Zweifel/AMNH

Spotted Salamander *(Ambystoma maculatum)*

© Richard G. Zweifel/AMNH

Wood Frog *(Rana sylvatica)*

© Richard G. Zweifel/AMNH

Eastern Spadefoot Toad *(Scaphiopus holbrookii)*

© Leo P. Kenney

Fairy Shrimp *(Eubranchipus* sp.)

© Maine Natural Areas Program

Featherfoil *(Huttonia inflata)*

Figure 5: Examples of Vernal Pool Indicator Species of the Region

© Don Sias

Four-toed Salamander *(Hemidactylium scutatum)*

© Geoff A. Hammerson

Spotted Turtle *(Clemmys guttata)*

© Michael W. Klemens

Blanding's Turtle *(Emydoidea blandingi)*

© Geoff A. Hammerson

Eastern Box Turtle *(Terrapene c. carolina)*

© Geoff A. Hammerson

Eastern Ribbon Snake *(Thamnophis s. sauritus)*

© Francis C. Golet/URI

Ringed Boghaunter *(Williamsonia lintneri)*

Figure 6: Examples of Vernal Pool Facultative Species of the Region

© Louis N. Sorkin

Male salamanders migrate to vernal pools under the cover of darkness and deposit spermatophores on the pool bottoms.

© Geoff A. Hammerson

Females enter the pond during nightime rains, engage in courtship, and are fertilized by picking up the spermatophores. They then deposit clumps of jelly-coated eggs.

© Geoff A. Hammerson

Bushy-gilled larvae hatch. They are voracious feeders and develop rapidly for several months.

© Geoff A. Hammerson

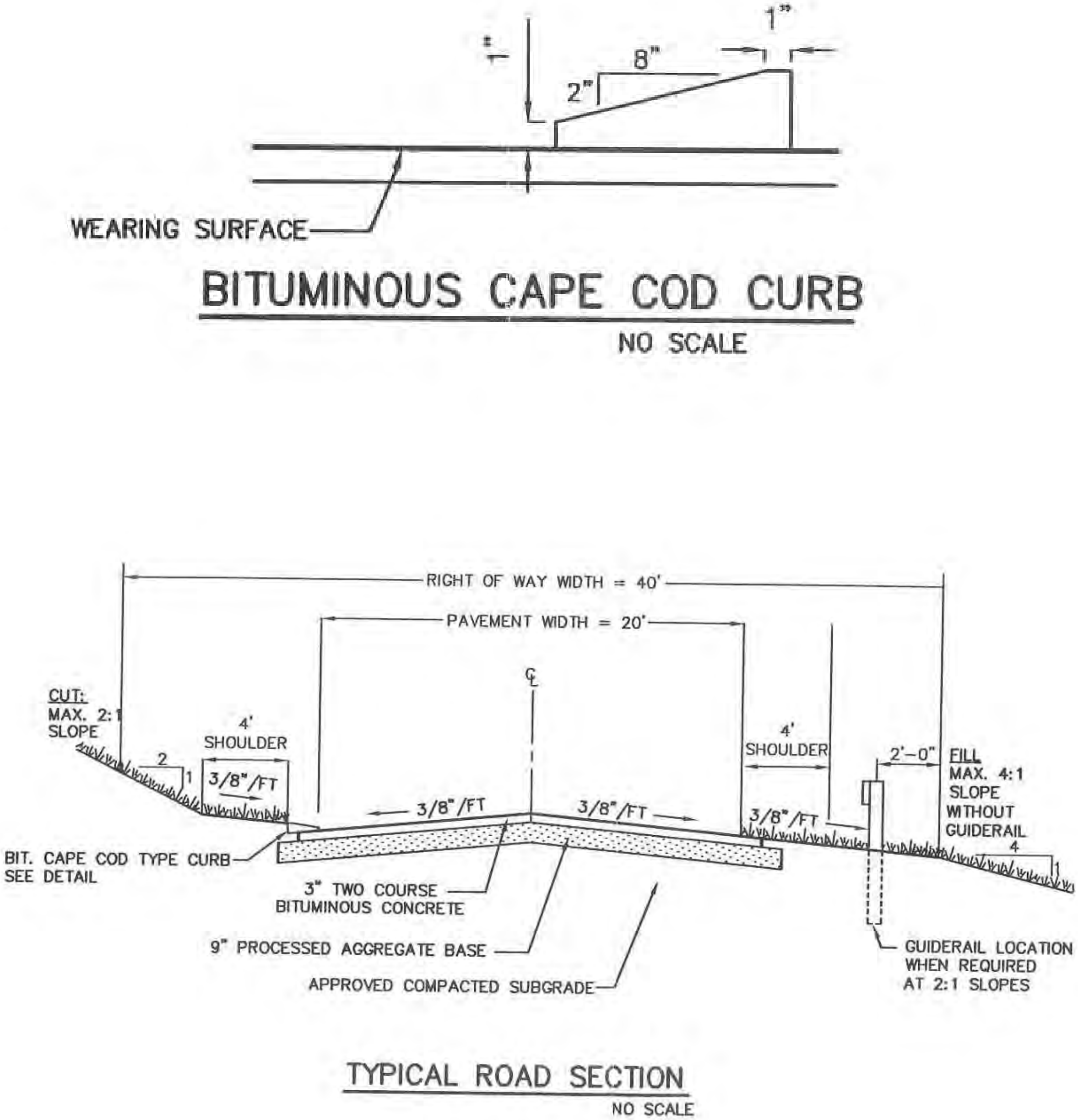
Larvae metamorphose. The pattern of this newly-transformed marbled salamander metamorph differs markedly from an adult.

© Chris Raithel

Adult patterns appear several weeks to months after metamorphosis, as seen here in the adult marbled salamander (Ambystoma opacum).

Figure 7: Mole Salamander *(Ambystoma)* Life Cycle*

*Source: Klemens 2000. Text reprinted by permission of the author and the Connecticut Department of Environmental Protection.



Source: Jefferson Crossing, Farmington, CT; Buck and Buck Engineers, Hartford, CT.

Figure 10: Design Schematics for Road and Driveway Construction to Reduce Impacts on Pool-Breeding Amphibians

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Appendix 1

Vernal Pool Regulation and Definitions

Introduction

Wetlands are more extensively regulated than any other habitat or landscape unit within our Region, due in large part to their ecological sensitivity and the number of ecological services they provide (e.g., flood abatement, water quality improvement, groundwater recharge). However, despite the vast amount of resources devoted to wetlands—at Federal, state, and local levels—regulations addressing vernal pools are, for the most part, ineffective or nonexistent. Most wetland regulations contain lower size thresholds; therefore, impacts to small wetlands such as vernal pools often "slip under the radar" of regulatory agencies. In addition, although many regulatory agencies have jurisdiction over upland "buffers" or "setbacks" surrounding wetlands, such jurisdiction rarely extends beyond 150 feet from wetland edge—a distance that is insufficient for maintaining vernal pool wildlife populations. Another hurdle lies in the establishment of a standardized definition of "vernal pool;" numerous, widely varying definitions exist within the Region. The following text discusses the details and limitations of wetland regulations within the Region, as they pertain to vernal pools.

Federal Regulation

Dredge and fill activities in freshwater wetlands are regulated at the federal level through Section 404 of the Clean Water Act (CWA). The Army Corps of Engineers (the Corps) oversees this program. However, regulation does not necessarily equal protection. Keep in mind that the CWA was created to protect water quality, not wildlife habitat. Often, permits are issued for relatively small impacts; however, vernal pools often fall within the exempted size threshold. Most states in the Region have Programmatic General Permits (PGP), which currently replace all Nationwide Permits. PGP's are intended to expedite the review of "minimal" impact work in coastal and inland waters and wetlands. General permits are also supposed to be authorized for activities that are "substantially similar in nature." Any proposed project that does not qualify for the PGP must then go through the individual permit review process. A PGP is designed to work in concert with a State's wetland regulatory program. Ideally, the Corps allows the State regulatory agency to take the lead on permitting of smaller impact projects. Any of the Federal resource agencies can "kick out" a project for screening as an individual permit if the agency can document that the wetland or water body impacts would be more than "minimal," which really isn't difficult to do. The level of scrutiny and review is generally less for a PGP project than for an individual permit project. For example, all applicants have to demonstrate that they have first avoided and then minimized the amount of wetland impact, but the amount of documentation required by a PGP application is generally quite a bit less than for an individual permit.

Maine—Maine has a "kick out" for vernal pools from Category I of the Programmatic General Permit.

Connecticut, Vermont and Massachusetts—PGPs require screening reviews for fill in vernal pools. A vernal pool is defined in the PGP as an "…often temporary body of water occurring in a shallow depression that fills during spring rains and snow melt and typically dries up during summer months. Vernal pools support populations of specialized species, which may include wood frogs, mole salamanders *(Ambystoma)*, fairy shrimp, fingernail clams and other invertebrates. A feature common to vernal pools is the lack of breeding populations of fish. Some shallow portions of permanent waterbodies also provide vernal pool function by supporting breeding populations of vernal pool species. Old, abandoned, artificial depressions may provide these necessary breeding habitats."

Another administrative tool is known as the "pre-construction notification" process; this process allows so-called minor wetland fillings to be reported to the Corps after the fact, so that the Corps can track acreage lost. The Corps is aware of the limitations of these approaches, and recently has begun to curtail the use of these programs in areas of ecological concern, such as the New York City Watershed. However, in many sections of the Northeast, filling of small wetlands continues; among the hardest hit are those wetlands supporting vernal pool-dependent species.

Because of a recent Supreme Court decision (SWANCC; January 9, 2001), the Corps no longer regulates isolated wetlands by invoking the Migratory Bird Act. This ruling puts even more pressure on individual states to take the lead in protection of these resources.

Other federal agencies involved in wetland permitting include the US Fish and Wildlife Service, which serves in an advisory capacity on projects that may affect wildlife resources, and the Environmental Protection Agency, which has veto power over Corps decisions.

State Regulation

Each state in the Region has a wetland protection statute that regulates activities in jurisdictional wetlands. The specifics of the regulatory program and permit process vary from state to state, but small wetlands, including vernal pools, receive the least protection under most state regulatory programs. For example, New York has a regulatory minimum-size threshold of 12.4 acres, considerably larger than the majority of vernal pools. The only vernal pools protected at the state level in New York are those that: 1) contain a State-listed endangered or threatened species *and* 2) have been added, through a public hearing process, to the official map of State-regulated wetlands. Even Massachusetts, which has led the region with its program of volunteer-driven vernal pool certification, is unable to protect sufficient critical terrestrial habitat to sustain the amphibians that breed within those certified pools. In fact, most states do not include the terrestrial habitat associated with isolated wetlands in their wetland regulations.

Note: Under all Federal and state regulations, even where vernal pools are regulated, the critical terrestrial habitat around them is not. Sometimes a small buffer around the wetland is maintained, but this does not provide the necessary upland habitat for pool-breeding amphibians.

Connecticut

Overview:
Legislation passed in 1995 (P.A. 95-313) and included in the Inland Wetlands and Watercourses Act (originally passed in 1972) expanded the definition of "watercourse" to include, "all other bodies of water, natural or artificial, vernal or intermittent." Regulation occurs at the municipal level via town Inland Wetlands Commissions. While not specifically defining "vernal pools" this amendment promoted their inclusion in municipal inland wetland regulations. However, no towns have developed regulations regarding vernal pools specifically. The Connecticut Department of Environmental Protection has model regulation and guidance documents.

Definition:
There is no official definition for a vernal pool. The University of Connecticut and the Forest Stewardship Program (Donahue 1995) have issued guidance for identification and protection of vernal pools. They recommend the following physical features and the presence of one or more obligate species:

a. water for approximately 2 months during the growing season,
b. a confined depression that lacks a permanent outlet stream,
c. no fish, and
d. dries out in most years.

The following definition of a vernal pool was prepared by the Connecticut Vernal Pool Working Group: "seasonal or permanent watercourse in a defined depression or basin, that lacks a fish population and in most years supports breeding and development of amphibian or invertebrate species recognized as obligate to such watercourses.

Proposed obligate species:
fairy shrimp, spotted salamander, eastern spadefoot toad, Jefferson salamander, marbled salamander, wood frog.

Maine

Overview:
In organized towns, wetlands are regulated by the Department of Environmental Protection (DEP) through the Maine Natural Resources Protection Act (NRPA

1996). Vernal pools generally meet Federal and State wetland definitions and are subject to regulation. However, the degree of environmental review in Maine depends upon the size of the *impact* to the wetland. Impacts to wetlands that are less than 4,300 ft^2 (approximately 0.1 acres) require no reporting. Impacts between 4,300 ft^2 and 15,000 ft^2 (approximately 0.3 acres) require the lowest level of review, Tier 1, and have an expedited 30-day review process with no requirement of compensation for wetland loss. Tier II (impacts >15,000 ft^2 to 1 acre) and Tier III (impacts > 1 acre) require greater documentation and require input from professional delineators.

In the unorganized towns and plantations, the Land Use Regulation Commission (LURC) regulates activities in wetlands. LURC's language on vernal pools is consistent with the statutory provisions in NRPA. However, LURC's regulatory authority over vernal pools is tied to the Maine Department of Inland Fisheries and Wildlife's (MDIFW) ability to define and identify vernal pools. In unorganized towns, MDIFW is relying on a voluntary, cooperative strategy for protecting vernal pools.

"Significant vernal pools" (SVPs) were listed as "Significant Wildlife Habitat" in Maine's 1995 revision of the NRPA. Designation of SVP's is pending formal adoption of a definition of "significant vernal pools" and development of a system to pre-identify vernal pools.

Proposed definition:
The following definition has been approved by the Maine Vernal Pool Working Group, and will be incorporated into the Natural Resources Protection Act.

"Vernal pools are naturally-occurring, temporary to permanent bodies of water occurring in shallow depressions that typically fill during the spring and fall and may dry during the summer. Vernal pools have no permanent or viable populations of predatory fish. Vernal pools provide the primary breeding habitat for wood frogs, spotted salamanders, blue-spotted salamanders and fairy shrimp, and often provide habitat for other wildlife including several endangered and threatened species. Vernal pools intentionally created for the purposes of compensatory mitigation are included in this definition."

Indicator species:
wood frog, spotted salamander, blue-spotted salamander, fairy shrimp

Massachusetts

Overview:
The Massachusetts Wetlands Protection Act Regulations (310CMR 10.00, 1996) include measures for the regulation of vernal pool habitat, as long as it is located within another category of wetland regulated by the Act, and as long as it has

been certified by the Massachusetts Division of Fisheries and Wildlife (MDFW) prior to the filing of a Notice of Intent by an applicant. A vernal pool must be certified and mapped by the Natural Heritage and Endangered Species Program (NHESP) prior to permitting of a wetland impact. Criteria are available through NHESP.

Definition:
The Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00,1996) define vernal pools as "confined basin depressions which, at least in most years, hold water for a minimum of two continuous months during the spring and/or summer, and which are free of adult fish populations, as well as the area within 100 feet of the mean annual boundaries of such depressions."

Obligate species:
fairy shrimp, spotted salamander, blue-spotted salamander, Jefferson salamander, silvery salamander, Tremblay's salamander, marbled salamander, wood frog

New Hampshire

Overview:
In New Hampshire, there is no minimum size limit to projects that require a wetland permit. Vernal pools are regulated in New Hampshire only if they are located within other regulated wetlands (Wetlands Board Code of Administrative Rules 1993); they have traditionally been assessed as low-value wetlands.

New Hampshire Fish and Game (NHFG) developed a vernal pool identification manual (Tappen 1997) to initiate local conservation efforts. Following documentation, the information is supposed to be forwarded to NHFG and the local conservation commission for informational purposes. However, there are no state or local regulations that give added protection to documented vernal pools.

Definition:
There is no official regulatory definition of a vernal pool. New Hampshire Fish and Game defines a vernal pool as "A temporary body of water providing essential breeding habitat for certain amphibians and invertebrates and does not support fish." For a pool to be documented, it must be demonstrated that:

a. the pool occupies a confined depression without a permanently flowing outlet;
b. the pool contains water for at least two months in the spring/summer;
c. the pool dries up and therefore does not support fish;
d. indicator species are present (i.e., there is evidence of amphibian breeding or the presence of certain invertebrates in a flooded pool)

Indicator species:
fairy shrimp, spotted salamander, blue-spotted salamander, Jefferson salamander, marbled salamander, wood frog

New York

Overview:
Vernal pools are not specifically recognized and would only be subject to regulation under the following conditions (NYS DEC Article 24 Freshwater Wetlands law):

1. greater than 12.4 acres,
2. demonstrating unusual local importance for one or more of the specific benefits set forth in subdivision seven of section 24-0105,
3. contain a State-listed endangered or threatened species *and* have been added, through a public hearing process, to the official map of State-regulated wetlands, or
4. located within Adirondack park (minimum regulated size 1 acre).

An act to amend the environmental conservation law was introduced in February 2000 (A9561) that specifically describes vernal pools and recommends lowering the State regulated wetland size from 12.4 acres to 3 acres.

Definition:
There is no regulatory definition of a vernal pool. Ecological Communities of New York State (Reschke 1990) describe the natural vernal pool community as follows:

"…a wetland in a small, shallow depression within an upland forest. Vernal pools are flooded in spring or after a heavy rainfall, but are usually dry during summer. Many vernal pools are filled again in autumn. This community includes a diverse group of invertebrates and amphibians that depend upon temporary pools as breeding ponds. Since vernal pools cannot support fish populations, there is no threat of fish predation on amphibian eggs or invertebrate larvae. Characteristic amphibians include wood frog (*Rana sylvatica*), mole salamanders (*Ambystoma* spp.), American toad *(Bufo americanus*), green frog (*Rana clamitans*), and red-spotted newt (*Notophthalmus viridescens*)."

Indicator species:
The New York Natural Heritage Program is reviewing the literature and will produce a list of obligate species, most likely matching those listed in Massachusetts.

Rhode Island

Overview:
The Rhode Island Fresh Water Wetlands Act (RIFWWA) does not specifically regulate vernal pools but defines *pond* as a place not less than one-quarter (1/4) of an acre in extent, natural or manmade, wholly or partly within the state of Rhode Island, where open standing or slowly moving water shall be present for at least six (6) months a year.

To ensure enhanced protection for vernal pools, the 1994 rules included a new wetland category, *special aquatic site* defined as a body of open standing water, either natural or manmade which does not meet the definition of 'pond' but which is capable of supporting and providing habitat for aquatic life forms as documented by:

a) presence of standing water during most years as documented on site or by aerial photographs; and

b) presence of habitat features necessary to support aquatic life forms of obligate wildlife species, or the presence, documented use, or evidence of aquatic life forms of obligate wildlife species (except biting flies).

There is no size minimum but, because most are smaller than 1/4 acre, they do not meet the definition of "pond"; therefore, there is no protection of the adjacent upland. DEM can regulate land use within 50 feet of the edge of ponds but not smaller water bodies. The applicant is expected to recognize special aquatic sites—based on the presence of aquatic life forms of obligate wetland species or their habitats—and to put them on plans for proposed development. DEM checks those sites, and other wetlands, in the field during the project review.

Definition:
None (but see definition of "special aquatic site," above).

Indicator species:
fairy shrimp, spotted salamander, blue-spotted salamander, Jefferson salamander, marbled salamander, wood frog

Vermont

Overview:
Vernal pools can be protected under Vermont's wetland rules only if they are part of a Class II wetland or better (i.e., show up on Vermont Significant Wetland Inventory maps derived from National Wetland Inventory maps). If a Class II wetland is protected under the wildlife habitat section or any other section, the maximum protection would be for the wetland and a 50-foot buffer. Class 1 wetlands can be protected with a 100-foot buffer, but there are few Class 1

wetlands at this time. Vernal pools are potentially protected under this rule only if they are within a mapped wetland or are contiguous to such a wetland. Again, only up to 50 feet of the adjacent land around such a pool could be protected for a Class II wetlands

Vermont Wetland Rules (Water Resources Board 1990) do not specifically address vernal pools. Under the rules, Vermont evaluates wetlands based on 10 functions and values, wildlife habitat being one of those. The likely impact of a project on those functions is then assessed. If it is determined that a pool provides significant amphibian breeding habitat, this could trigger a larger buffer requirement or a potential denial of a project.

According to Rule 5.4 c (1), the following considerations are made in designating *wetlands significant for wildlife*:

a. The wetland provides habitat that supports the reproduction of uncommon Vermont amphibian species including: Jefferson salamander, blue-spotted salamander, spotted salamander, and others found in Vermont of similar significance;

b. The wetland supports or based on its habitat, is likely to support, breeding populations of any uncommon Vermont amphibian species including: mountain dusky salamander, four-toed salamander, Fowler's toad and others found in Vermont of similar significance.

Definition:
None.

Local Regulation

Building upon a long tradition of home rule in New York and New England, towns may adopt more stringent protective wetland regulations than those mandated at the state and federal levels. There are two specific aspects of vernal pool protection where local ordinances add considerable value to conservation efforts. First, local laws are able to extend protection to very small wetlands, including vernal pools that fall beneath the regulatory threshold of state or federal governments. Second, local laws are able to protect upland habitat surrounding a vernal pool. The Connecticut towns of Guilford and Redding have proposed statutory protection of vernal pools by maintaining large areas of critical upland habitat surrounding vernal pools and the upland connections between pools.

The downside to this approach is the creation of a patchwork pattern of wetland protection, varying from town to town. It is not unusual for a wetland that spans two political jurisdictions to be conserved in one town, and be totally unprotected in the other. The level of diligence and expertise in enforcing and interpreting local wetland ordinances also varies from town to town. Even the most comprehensive wetland ordinance is vulnerable to the lack of political will and due diligence by local decision-makers in its application. Another downside to vernal pool regulation is that groups opposing development are beginning to use vernal pools indiscriminately—regardless of their relative biological value—as a tool to thwart applications in the local review process.

Appendix 2

Using Aerial Photography to Locate Vernal Pools

The practicality of using aerial photography to identify vernal pools varies with predominant forest cover-type, scale, timing, and type of photography. A primer on identifying vernal pools through aerial photography and using Geographic Information Systems to create a database is available in *Massachusetts Aerial Photo Survey of Potential Vernal Pools* (Burne 2001). Aerial photo coverage can provide a landscape overview to aid during reconnaissance-level (i.e., field) surveys. From aerial photographs one can identify areas most likely to have pools. For example, topography and breaks in the forest canopy give clues to vernal pool location.

Use of aerial photography must be followed with ground-truthing. *In fact, finding existing vernal pools in the field and then characterizing the way they appear on aerial photography (i.e., defining the* ***signature*** *of vernal pools) may help in picking out other potential pools on photography*. NOTE: Even with good aerial photography and experienced photo-interpreters, many vernal pools are easily missed; this may be due to pool size, forest cover type, the presence of tree shadows, or because the pools are embedded in other wetlands). It is critical to ground-truth!

Below are some common challenges and solutions for using photography for pre-identification of pools based on work done in Maine, Massachusetts, and Rhode Island.

What do I use?

- **Stereo coverage:** Try to obtain aerial photographs in stereo pairs and view them with a stereoscope. Subtle changes in relief can provide clues to potential vernal pool sites.
- **Season and ground conditions:** Photos taken when the leaves are off the trees, the ground is free of snow, and water levels are high provide the best opportunity for identifying vernal pools. Early spring (March-May) is generally the best period for capturing these conditions, but late fall (November-December) may also provide good visibility for aerial coverage. Identification of vernal pools is least reliable on photos taken during very dry years or in the middle of summer when tree canopies obscure ground conditions.
- **Scale and film type:**

  Scale

  The larger the scale (e.g., 1:4,800 is a larger scale than 1:12,000), the easier it is to identify small ground features. Generally, scales at least 1:4,800 to 1:12,000 should be obtained to identify small pools. However, scales as small as 1:31,680 (2 inches per mile) have been used successfully to identify vernal pools that are 0.25 acre in size (L. Alverson, Forest Resource Consultant, pers. comm.). Ultimately, the scale of photography needed to successfully pre-identify vernal pools will depend on the type of film, time of year photos were flown, forest cover type, and size of the pool.

Film Type

Color Infrared—CIR is the most reliable photography for picking out vernal pools because water absorbs color infrared light and appears black in contrast to the lighter colored (pink, magenta, orange, yellow) vegetation. A study conducted at the University of Massachusetts, Amherst (MacConnell et al. 1992) found that large-scale CIR (1:4,800 or 1:12,000) was the best tool for delineating wetlands, particularly forested wetlands. Specifically, they found that CIR is very sensitive to water and chlorophyll—key features for wetland identification. Photo interpretation was faster, more consistent, more accurate and required less corollary information and field work to maintain a high level of accuracy. CIR had much finer resolution than black and white film at the same scale, permitting the use of smaller scale photography. Tiner (1990) and Stone (1992) discuss the advantages of CIR film in photo-interpreting wetlands. The disadvantage of using CIR photography is that it is considerably more expensive than black and white photography.

Black-and-White—A pilot project in York and Penobscot counties evaluating the use of black-and-white aerial photography at 1:4,800 or 1:12,000-scale found it to be an effective pre-identification tool in deciduous forests in southern Maine. Pre-identification using 1:4,800-scale photography resulted in both a higher percentage of correct predictions and less omissions than did 1:12,000-scale photography. However, in lower Penobscot valley, pre-identification of vernal pools less than 0.5 acre was not effective in mixed and evergreen forests (both wetland and upland). In some cases, known pools could not be identified on the photography (K. Huggins, Champion International, pers. comm.).

True Color—An evaluation of true color photography and vernal pool pre-identification has not been conducted. Fall true color photography is effective in picking out red maple swamps in softwood mosaics. These forested wetlands potentially harbor vernal pools. True color photography taken under leaf-off conditions, especially in early spring, may reveal considerable detail of the forest floor. Small waterbodies such as vernal pools may appear as dark spots, or occasionally as white patches if light is reflected off the water surface. Spring leaf-off true color at 1:9000-scale is available for much of southern and central Maine at Maine Forest Service District offices and USDA Natural Resource Conservation Service offices.

What do I look for?

1. Vernal pools may appear as small openings in the forest canopy on winter or spring photos; in deciduous forests they can be detected through the canopy.
2. In forests that have not been harvested for 15-20 years, look for a hole or gap in the canopy that seems larger than the typical shadows caused by individual trees. If the gap is black with no visible vegetation, it may be a vernal pool.
3. Use signature color and relief when attempting to distinguish vegetated vernal pools dominated by ferns, sedges, or grasses. Vegetation growing in water or in very wet soils

imparts gray shades to black and white photos, grayish green tones in color photographs, and grayish pink colors in color infrared photos (CIR).

4. Identifying subtle pockets of variation in relief can be especially helpful when distinguishing vegetated vernal pools in larger wetland complexes. Uneven ground and shallow depressions can be seen through a stereoscope on aerial photographs.
5. Vernal pools might occur in clusters due to uneven topography and the composition of the bedrock or soil type (particularly soils with shallow confining layers or shallow to bedrock). It is often possible to pick out clusters on topographic maps or aerial photography.
6. In central and southern Maine, vernal pools are commonly associated with red maple swamps or mixed evergreen-deciduous swamps. Because pools may be included within larger wetlands, identification can be difficult. If a wetland is in the southern portion of a photo, there might be enough reflection of light off of water surfaces to highlight vernal pools. When viewing stands dominated by softwood, a cluster of red maple is sometimes an indicator of a potential vernal pool (particularly when working with fall true color photography). Conversely, patches of softwoods in hardwood uplands may indicate small areas of wet soils that could include vernal pools.

Common problems with photo-interpreting vernal pools

Many features can mimic vernal pools, including:

- overstory or superstory trees with large crowns that cast shadows over the top of the surrounding canopy and appear to be black spots. (This is particularly true of photos flown in spring or fall when solar angles are low. Looking at photos in stereo may eliminate some of these tree shadows);
- shadows created by narrow pockets in bedrock or streams with deep narrow gorges;
- gaps and openings in the canopy from recent forest harvesting operations; or
- tree shadows along skid trails and near large openings.

Vernal pools might be difficult to see because:

- they are small (often less than 2,000 ft^2);
- tree species typically associated with depressional pools in upland settings (particularly red maple and hemlock) often extend their branches into the pool opening, or the pool itself may be forested by flood-tolerant species.
- pools associated with forested wetland complexes, particularly in mixed and softwood stands, may be obscured by canopy cover or hard to distinguish from the overall wetland complex.

Are National Wetlands Inventory (NWI) maps useful for finding potential pools?

Vernal pools range widely in the types and amount of vegetation they contain and the duration of inundation (i.e., flooding); for that reason, individual pools might be classified as ponds (POW* or PUB), marshes (PEM, PAB), wet meadows (PEM), shrub swamps (PSS), or forested wetlands (PFO).

A 1997 pilot study in southern and central Maine was conducted to test the effectiveness of NWI maps in identifying potential vernal pools. Results from this study suggest:

- NWI maps can be used to locate many of the larger natural pools (isolated wetlands with PUB, PSS and PFO status are often good candidates), but keep in mind that the resolution of NWI maps is often limited to wetlands ≥ 15,000 ft^2 (~0.3 acres). Many of the PUB or POW classifications are likely to be permanent ponds (average mapping unit for NWI is 1-3 acres).
- Effectiveness of NWI maps for locating potential vernal pools depends on local knowledge of types of wetlands in which pools occur. For example, in this pilot study, vernal pool species occurred in some wetlands with temporary inlets and outlets and in forested wetland complexes associated with other wetland types. Therefore, NWI categories of PFO, even with outlets, were considered potential sites.

Ideally, NWI maps are used as one of a number of interpretive tools, including aerial photography.

* National Wetland Inventory classification codes (Cowardin et al., 1979).

Appendix 3

Resources for Identifying Vernal Pools

Note: This is a listing of potential resources; it is not an endorsement of these products or suppliers.

Vernal Pool Manuals

Calhoun, A. J. K. 1999. Maine citizen's guide to locating and documenting vernal pools. Maine Audubon Society, Falmouth, ME.

Maine Audubon Society
20 Gilsland Farm Road
Falmouth, ME 04105

Colburn, E. A. (ed.) 1997. Certified: A citizen's step-by-step guide to protecting vernal pools. Massachusetts Audubon Society, Lincoln, MA.

Massachusetts Audubon Society
Educational Resources Office
208 South Great Road
Lincoln, MA 01773
tel: (781) 259-9506 ext. 7255

Kenney, L. P. 1995. Wicked big puddles. Vernal Pool Association. Reading Memorial High School, Reading, MA.

Reading Memorial High School
Vernal Pool Association
62 Oakland Road
Reading, MA 01867
http://www.vernalpool.org

Tappan, A. (ed.) 1997. Identification and documentation of vernal pools in New Hampshire. New Hampshire Fish and Game Department, Concord, NH.

New Hampshire Fish and Game Department
2 Hazen Drive
Concord, NH 03301

Sources for Aerial Photography

Government Sources

- U.S. Geological Survey (USGS)

  U.S. Geological Survey
  Customer Services
  EROS Data Center
  47914 252nd Street
  Sioux Falls, SD 57198-0001
  tel. (800) 252-4547
  custserv@usgs.gov
  http://edcwww.cr.usgs.gov/

- U.S. Geological Survey (USGS) Business Partners

  http://mapping.usgs.gov

- U.S. Department of Agriculture (USDA)
  Natural Resources Conservation Service (NRCS)

  USDA Natural Resources Conservation Service
  East Regional Office
  5601 Sunnyside Avenue
  Mailstop 5410, Room 1-1290A
  Beltsville MD 20705-5410
  tel. (301) 504-2300
  eastregion@ea.nrcs.usda.gov
  http://www.nrcs.usda.gov

- "Inventory of Aerial Photography and other Remotely Sensed Imagery of New York State"

  a publication available from:

  Center for Geographic Information
  NYS Office for Technology
  State Capitol ESP
  PO Box 2062
  Albany, NY 12220-0062
  tel. (518) 443-2042

- *County planning departments* are also potential sources for aerial photos.

Private Sources

- James W. Sewall Company

  147 Center Street
  P.O. Box 433
  Old Town, ME 04468-0433
  tel. (207) 827-4456
  info@jws.com
  http://www.jws.com

- Aerial Survey and Photo, Inc.

  Airport Road
  P.O. Box 657
  Norridgewock, ME 04957
  tel. (207) 634-2006
  rod@aerialsurveyandphoto.com
  http://www.aerialsurveyandphoto.com

- Col-East, Inc.

  P.O. Box 347
  North Adams, MA 01247
  tel. (800) 359-8676
  http://www.coleast.com

- ADR Associates, Inc.

  9285 Commerce Highway
  P.O. Box 557
  Pennsauken, NJ 08110
  tel. (800) 257-7960
  rhickey@adrinc.com
  http://www.adrinc.com

- AirPhotoUSA, LLC

  7122 N. 27th Avenue
  Suite 500
  Phoenix, AZ 85051
  tel. (866) 278-2378
  http://www.airphotousa.com

Sources for Digital Orthophotography

Note: Small vernal pools are very difficult to detect consistently on digital orthophotography, due to pixel resolution issues.

- Rhode Island Geographic Information System (RIGIS)

  http://www.edc.uri.edu/rigis/

- Massachusetts Geographic Information System (MassGIS)

  MassGIS
  Executive Office of Environmental Affairs
  251 Causeway Street, Suite 900
  Boston, MA 02114
  tel. (617) 626-1000
  http://www.state.ma.us\mgis

- NYS Statewide Digital Orthoimagery Program

  http://www.nysgis.state.ny.us/orthoprogram.htm

National Wetlands Inventory Maps

- U.S. Fish and Wildlife Service (USFWS)

  http://www.nwi.fws.gov/

  for hard copies, contact:

  USGS/ESIC
  National Headquarters
  507 National Center
  Reston, Virginia 20192
  tel. (703) 648-5920 or (888) 275-8747

Field and Lab Equipment

- Forestry Suppliers, Inc.

  P.O. Box 8397
  Jackson, MS 39284
  tel. (800) 543-4203

- Ben Meadows Company

  P.O. Box 20200
  Canton, GA 30114
  tel. (800) 241-6401