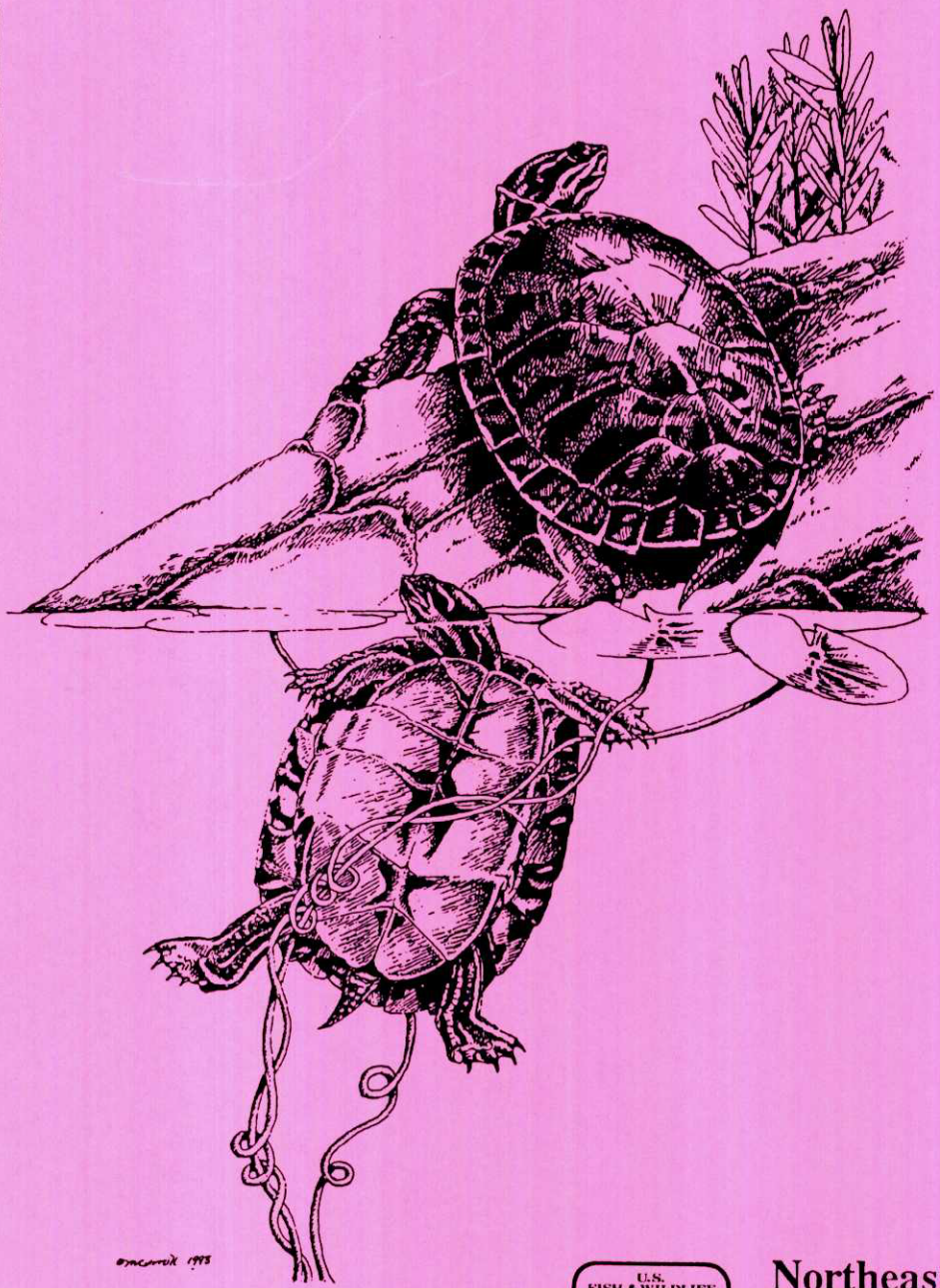
PLYMOUTH REDBELLY TURTLE

(Pseudemys rubriventris)



RECOVERY PLAN

SECOND REVISION

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

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(Pseudemys rubriventris)

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for

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

Approved: _____
ACTING Regional Director, Northeast Region
U.S. Fish and Wildlife Service

Date: MAY - 6 1994

EXECUTIVE SUMMARY

Plymouth Redbelly Turtle Revised Recovery Plan

Current Species Status: The Plymouth population of the redbelly turtle *(Pseudemys rubriventris)* is restricted to approximately 17 ponds and one river site in Plymouth County, Massachusetts. The total number of breeding age individuals is believed to be about 300. While an active headstarting program has introduced turtles to several new ponds and the river site, and has significantly increased the number of turtles in other ponds, juvenile and subadult headstarted turtles have not yet reached breeding status. It is therefore premature to evaluate the ultimate success of this effort. Continued threats to the species include restricted range, habitat alteration, low population size, and high mortality of eggs, hatchlings, and small juvenile turtles due to nest failure, nest depredation, and predation on hatchlings following emergence. The Plymouth redbelly turtle was listed as endangered, with critical habitat, in 1980.

Habitat Requirements and Limiting Factors: The Plymouth redbelly turtle is a large, freshwater basking turtle of deep coastal plain ponds. It subsists primarily on aquatic vegetation, and requires good water quality and suitable basking, nesting, and overwintering sites free from disturbance. Among many limiting factors are habitat alteration and fragmentation, nest predation, and high hatchling and juvenile mortality rates.

Recovery Objective: Reclassification to threatened status may be feasible by the year 2000, and eventual delisting is an attainable long-term objective. Further research on limiting factors and appropriate intervention strategies will be necessary before full recovery can be achieved.

Recovery Criteria: Reclassification to threatened status will be considered when numbers increase to 600 or more breeding-age turtles distributed among 15 or more self-sustaining populations. Delisting will be considered when numbers increase to 1,000 breeding-age turtles in 20 or more self-sustaining populations (in ponds, lakes, and possibly rivers). In addition to population targets, maintenance of sufficient habitat to allow long-term survival of the population, and an understanding of the turtle's life history and habitat requirements sufficient to adequately manage the population will be required to meet the full recovery objective.

Actions Needed:

1. Monitor the status of populations, and search for additional populations.
2. Conduct research into limiting factors, particularly high nest predation and mortality of hatchling and juvenile turtles, as well as life history studies and possible contaminants issues.
3. Protect and manage occupied and potential habitat.
4. Continue the headstart program to enhance small populations and establish new populations.
5. Conduct information and education programs.

Estimated Cost of Recovery (in thousands)*:

YEAR	Need 1	Need 2	Need 3	Need 4	Need 5	TOTAL
FY1	4.0	16.5	15.0	3.5	3.5	42.5
FY2	3.0	16.5	12.5	3.5	3.5	39.0
FY3	4.0	16.5	11.5	3.5	3.5	39.0
FY4	3.0	8.0	8.0	3.5	2.0	24.5
FY5-17	63.0	63.0	99.0	25.5	26.0	276.5
TOTAL	77.0	120.5	146.0	39.5	38.5	421.5

* Land acquisition costs not included.

* * *

The Revised Recovery Plan for the Plymouth Redbelly Turtle reports on recovery progress to date and completion of various tasks specified in earlier versions of the recovery plan for this endangered species (U.S. Fish and Wildlife Service 1981, 1985). It also delineates further actions needed to protect and recover the Plymouth redbelly turtle.

The plan does not represent the official position of any individuals or agencies other than the U.S. Fish and Wildlife Service. Recovery plans are subject to modification as dictated by new findings, changes in species status, and completion of recovery tasks. Recovery objectives will be attained and funds expended contingent on budgetary constraints affecting the parties involved, as well as the need to address other priorities.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1994. Plymouth Redbelly Turtle *(Pseudemys rubriventris)* Recovery Plan, Second Revision. Hadley, Massachusetts. 48 pp.

Additional copies of this plan may be obtained from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
301-492-6403
or
1-800-582-3421

Fees vary according to document length.

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PART I: INTRODUCTION

The Plymouth redbelly turtle was listed as an endangered species, with critical habitat, on April 2, 1980 (*Federal Register* vol. 45, no. 65). The initial recovery plan for this species was completed in 1981 and revised in September 1985.

In order for recovery plans to retain utility, periodic revisions are essential. In the nine years since the Plymouth redbelly turtle plan was revised, an active recovery program focusing on the headstarting of hundreds of hatchling turtles has been carried out. In addition, two recent studies have led to a re-evaluation of the taxonomy of the Plymouth redbelly turtle. Therefore, the purpose of this revised plan is to provide an update on recovery actions and taxonomic studies, and to confirm the direction of the recovery program for the next five years. This revision also identifies criteria for delisting the species, an objective not considered attainable at the time the earlier plans were developed.

GENERAL DESCRIPTION AND ECOLOGY

The redbelly turtle, *Pseudemys rubriventris*, is a large basking turtle 10-12 inches (254-305 mm) in carapace length when mature. Coloration and pattern are highly variable, but in general, the carapace is mahogany to black with light chestnut to reddish vertical bars on the laminae. The name *rubriventris* is from the Latin words *rubidus* for reddish, and *venter* for belly, referring to the reddish plastron (Graham 1991).

Considerable sexual dimorphism exists in body size and scute proportions (Graham 1991). Female redbelly turtles are larger and have a longer plastron, higher shell, and wider bridge, and plastral scutes are relatively longer at the midline, except the femoral scute, which is slightly longer in males. Redbelly turtles, especially males, tend to become melanistic with

age. Background color of the adult male plastron is pale pink overlaid with dark vermicular mottling; in females it is coral red with grey figures narrowly bordering the plates (Graham 1971b).

The front of the upper jaw has a terminal notch flanked on each side by a distinct maxillary cusp. The presence of maxillary cusps distinguishes the redbelly group, which also includes the Florida redbelly turtle *(P. nelsoni)* and the Alabama redbelly turtle *(P. alabamensis)*.

Although most of their time is spent in freshwater ponds, Plymouth redbelly turtles may also be found on land. In late spring and early summer, females select nesting sites in sandy soil, usually within 100 yards (90 m) of the pond. Females occasionally travel greater distances from the ponds in search of suitable nesting sites (J.D. Lazell, Conservation Agency, Conanicut Island, Rhode Island, *in litt.* 1980). In each nest, an average of 12 eggs (range 5-17) are deposited (Haskell 1993). T.E. Graham and cooperators (Graham 1993) recently confirmed that a small number of breeding females re-nest in a given year (produce two clutches). Incubation takes 73-80 days at 25°C (Graham 1971a). The microclimate at redbelly turtle nests can affect the sex ratio of hatchlings (temperature dependent sex determination or TSD). Cool nests will produce more males and warm nests more females.

Hatchlings average about 1.25 inches (32 mm) in length (range 25.8-40.8 mm). Hatchlings may emerge from nests to enter ponds in late summer, or overwinter in the nest chamber and emerge the following spring. Sexual maturity in Plymouth redbelly turtles is probably reached in 15-20 years in females and, perhaps, less in males (T.E. Graham, Wetlands and Wildlife Associates, Rutland, Massachusetts, unpubl. data).

Plymouth redbelly turtles are usually active from late March to October. During the winter they rest on the bottoms of ponds under the ice in a state of relative inactivity or hibernation. In regard to their feeding habits, current data gathered from wild specimens suggest that submergent aquatic vegetation is the primary diet for all age classes, although crayfish are also eaten (Graham 1969, 1981).

RANGE AND TAXONOMY

The redbelly turtle, *Pseudemys rubriventris* (LeConte 1830), has a relatively continuous coastal plain distribution across seven mid-Atlantic states from eastern North Carolina to central New Jersey, and a disjunct population in southeastern Massachusetts (Ernst and Barbour 1972; Figure 1). The Plymouth, Massachusetts population is disjunct from the more southern range of *P. rubriventris* by approximately 250 miles (400 km).

South of New England, the northernmost redbelly population known occurs in Middlesex County, New Jersey. Redbelly turtles are also known historically from New York (Babcock 1938, Carr 1952), and an introduced population has apparently become established in Charleston, Staten Island, New York (R. Zappalorti, Herpetological Associates, Inc., *in litt.* 1992).

At the time of listing, the Plymouth redbelly turtle was only known to occur in 12 ponds in one county, and the total population of subadult and adult redbelly turtles was estimated to be fewer than 200 turtles (T.E. Graham unpubl. data). This population is now thought to occupy 18 sites, in the towns of Plymouth and Carver, Plymouth County, Massachusetts (Table 1, Figure 2). Based on mark-release-recapture data, the adult and subadult redbelly population in Massachusetts, including both headstarted and non-headstarted individuals (see Conservation Measures), is now estimated to number 300-400 turtles.

Ten of the ponds thought to support the turtle are within a 1500-acre (608-ha) area (U.S. Fish and Wildlife Service 1981); nearly half of the currently known population (not including headstarted turtles) is found in a single location, Federal Pond. Eight of the sites have no previous redbelly turtle records before the initial release of headstarted hatchlings (including three ponds and one river site to which the turtles were first introduced in 1993): East Head Pond in Myles Standish State Forest, Muddy Pond in Carver, owned by the Massachusetts Division of Fisheries and Wildlife, and Halfway Island Pond (French 1990), as well as Great South Pond, Halfway Pond, Little Long Pond, Forge Pond, and the Weweantic River.

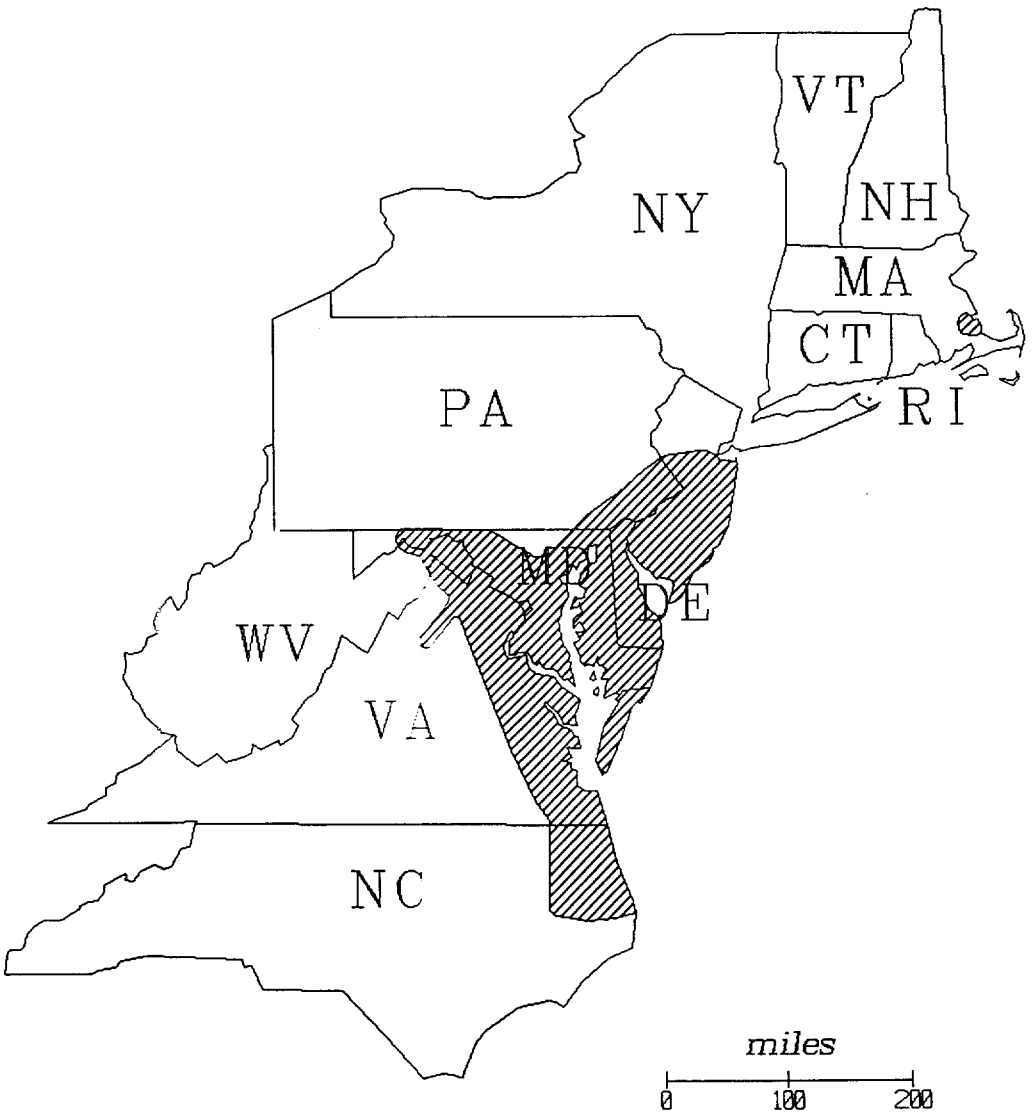

Figure 1. Current known range of the redbelly turtle, *Pseudemys rubriventris*

Table 1. Current Plymouth redbelly turtle distribution

Occupied Sites	Site Status
Island Pond	Natural population; headstarted hatchlings first released in 1986
Crooked Pond	Natural population; headstarted hatchlings first released in 1985
Gunners Exchange Pond	Natural population; headstarted hatchlings first released in 1987
Hoyts Pond	Natural population; headstarted hatchlings first released in 1987
Federal Pond	Largest natural population; headstarted hatchlings first released in 1987
Wenham Pond	Natural population; headstarted hatchlings first released in 1987
Muddy Pond	Introduced population; headstarted hatchlings first released in 1989
East Head Pond	Introduced population; headstarted hatchlings first released in 1987
Louts Pond	Natural population; headstarted hatchlings first released in 1990
Billington Sea Pond	Natural population; headstarted hatchlings first released in 1990
Big West Pond	Natural population; headstarted hatchlings first released in 1987
Boot Pond	Natural population; headstarted hatchlings first released in 1987
Great South Pond	Introduced population; headstarted hatchlings first released in 1992
Halfway Island Pond	Introduced population; headstarted hatchlings first released in 1992
Halfway Pond	Introduced population; 24 headstarted hatchlings released in 1993
Little Long Pond	Introduced population; 24 headstarted hatchlings released in 1993
Weweantic River	Introduced population; 34 headstarted hatchlings released in 1993
Forge Pond	Introduced population; 13 headstarted hatchlings released in 1993

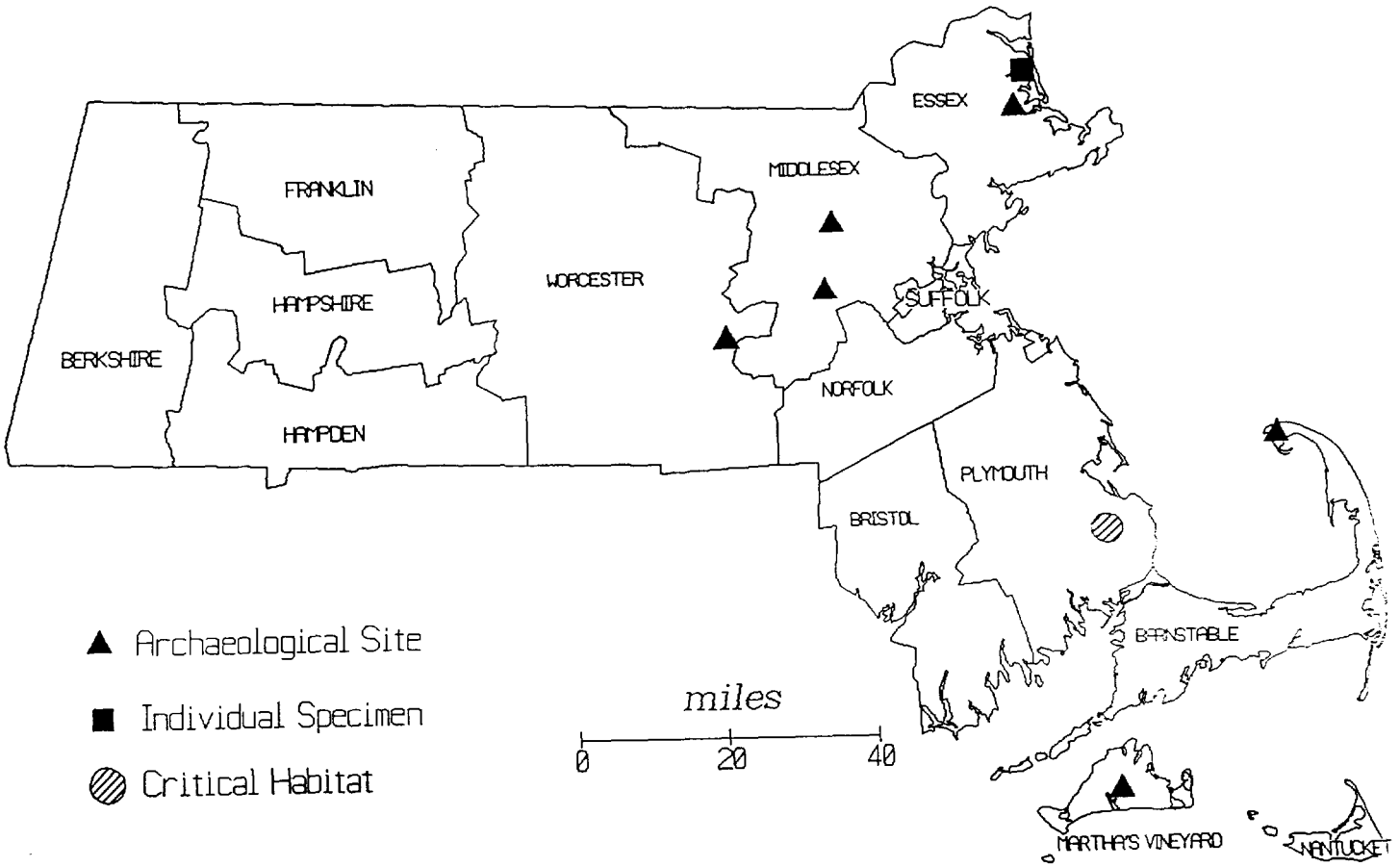

Figure 2. Locations of archaeological sites, individual collection sites, and critical habitat of the Plymouth redbelly turtle

Waters (1962) suggests that the Massachusetts population may be a relict from a once continuous, prehistoric distribution across the eastern coastal United States. *P. rubriventris* could have expanded its range when the continental shelf was emergent during the post-Wisconsin glacial period, later becoming isolated as the shelf submerged with the retreat of the glaciers.

Archaeological material from Indian shell middens indicates redbelly turtles were historically more widespread in Massachusetts (see Figure 2). Based on archaeological data, the pre-colonial distribution of redbelly turtles probably extended as far north as Ipswich, Essex County (Bullen 1949, Waters 1962) and Concord, Middlesex County (Rhodin and Largy 1984); as far west as Westborough, Worcester County (Rhodin 1992); and as far south as Martha's Vineyard, Dukes County (Waters 1962, 1966, 1969).

A previously reported Plymouth redbelly turtle specimen (MCZ 46965) found on Naushon Island in Dukes County in 1944 (Waters 1962, Lazell 1976) is now considered to represent *P. concinna* or *P. floridana*, which was probably released on the island (Graham 1982). The identities of three more recently sighted turtles (1968, 1971, and 1973) on Naushon Island (Lazell 1976), including a road-killed animal, remain in question. Another specimen (MCZ 162300) found dead in Stage Island Pool at the south end of Plum Island, Essex County in 1981 does represent *P. rubriventris*. This locality is within 1.2 miles (2 km) of the Great Neck, Ipswich archaeological site and 55 miles (88 km) of the nearest known population in Plymouth County (Graham 1982).

The existence of a population of *Pseudemys* turtles in Massachusetts was first recognized in 1869 (Lucas 1916). This population was studied by Harold Babcock (Babcock 1916, 1917, 1919), eventually leading to his description of a new subspecies, *Pseudemys rubriventris bangsi* (Babcock 1937), named in honor of the naturalist Outram Bangs who first called the population to Babcock's attention. Babcock differentiated *P. r. bangsi* from the nominate race by the relatively higher shell of the Massachusetts form, based on measurements of eight Massachusetts specimens and 12 specimens of the nominate, more southerly form.

Several authors have questioned the subspecific status of this population (Conant 1951, Carr 1952, Graham 1969), and subsequent morphometric studies have alternately corroborated (Graham 1978) and invalidated (Iverson and Graham 1990) subspecific designation. Iverson and Graham examined more than 200 redbelly turtles from throughout the species' range and found existence of clinal variation in some physical characters for males (e.g., plastron length at midline/maximum carapace length), but no obvious geographic patterns among females. Iverson and Graham's uni- and multivariate analyses led these authors to conclude that no geographic population exhibited enough morphological distinction to warrant subspecific status.

A recent study by Haskell (1993) and R.A. Browne (Wake Forest University, unpubl. data) examined genetic divergence between redbelly turtle populations in Massachusetts and New Jersey. Twelve protein enzymes were examined with allozyme electrophoresis using blood (N=123) and muscle (N=40) samples that were **nonlethally** collected from redbelly turtles. No variability was found for eight of 12 loci examined, and only slight variability was found for four loci. This study suggests that little genetic divergence has occurred between Massachusetts and New Jersey redbelly turtles (D^1=0.0001); i.e., redbelly turtles in Massachusetts are not genetically distinct from those in New Jersey. This low genetic divergence is further reinforced by remarkably similar nuclear sequence comparisons among populations throughout the species' range (S. Davis *et al.* pers. comm.).

Haskell (1993) points out that the amount of genetic divergence between the Massachusetts and New Jersey turtles may have been underestimated, because the number of loci examined greatly influences the measurable amount of divergence between allopatric populations (Richardson *et al.* 1986). The lack of variation observed could be partially the result of tissue selection (limited to nonlethal muscle biopsy and blood of Massachusetts specimens), with fewer variable loci thus observed. Nonetheless, other studies such as Scribner *et al.* (1986) have demonstrated genetic variation among populations of the freshwater yellow-bellied slider turtle *(Pseudemys s. scripta)* using only blood and muscle samples (Haskell 1993).

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[1] A Nei's D value of 0 indicates no difference, and a value of 0.02 for reptiles is usually sufficient for subspecific distinctions.

Based on the findings of Iverson and Graham (1990), and Haskell (1993) and Browne (unpubl. data), the Plymouth redbelly turtle appears insufficiently different from southern redbelly turtles to warrant subspecific status. Therefore, use of the trinomial *P. r. bangsi* is no longer appropriate (Iverson and Graham 1990). However, the common name, Plymouth redbelly turtle, retains utility in describing the geographically isolated Massachusetts population that is the subject of this plan.

STATUS AS A DISTINCT VERTEBRATE POPULATION

The recent change in taxonomy (Graham 1991) of *Pseudemys rubriventris* poses the question of whether the Plymouth redbelly turtle population qualifies for continued protection and recovery effort pursuant to the Endangered Species Act of 1973 (16 U.S. 1531 *et seq.*). An evaluation is warranted because the redbelly turtle does not currently appear to be threatened or endangered in the southern portion of its range, from New Jersey to North Carolina (Northeast Nongame Technical Committee 1993).

Congress, in passing the 1979 amendments to the Endangered Species Act, allowed the Secretary of Interior to list as an endangered or threatened species, any "... subspecies of fish or wildlife or plants, and any distinct population segment of any species [of] vertebrate fish or wildlife which interbreeds when mature." Current interim U.S. Fish and Wildlife Service policy (June 1992) requires that the primary factors to be considered when evaluating the appropriateness of listing a population segment are biological significance, ecological characteristics, and geographical distribution.

The Plymouth redbelly turtle meets the following criteria for protection as a distinct vertebrate population: it is isolated from all other redbelly populations by a distance of over 250 miles, it is genetically isolated, and Plymouth redbelly turtles exhibit a narrower habitat occurrence than the more southerly redbelly turtles. While Plymouth *P. rubriventris* have been found only in ponds, redbelly turtles south of New England are frequently found in riverain habitat (Graham 1991).

The Massachusetts redbelly turtles may have added biological significance insofar as they are adapted for their specific habitat and local conditions. Selective pressures are often strongest at range extremities, where the greatest environmental challenges to survival are faced (Schonewald-Cox *et al.* 1983).

CRITICAL HABITAT

Eleven ponds were originally proposed as critical habitat for the Plymouth redbelly turtle (*Federal Register* Vol. 43, no. 98, May 19, 1978); critical habitat was then re-proposed (*Federal Register* Vol. 44, no. 179, September 13, 1979) as a result of the 1978 Amendments to the Endangered Species Act. In that re-proposal, critical habitat was enlarged to an approximate 6900-acre (2790-ha) area based on the recognition that the redbelly turtle requires not only aquatic habitat, but also upland areas for egg laying and to accommodate its propensity to move considerable distances from the ponds.

Following a series of public participation meetings and hearings (October 17, 1979; January 15 and 29, 1980), review of public comments, and interactions with biologists of the Commonwealth of Massachusetts and Dr. T.E. Graham, the final critical habitat determination (*Federal Register* Vol. 45, No. 65, April 2, 1980; Figure 3) was reduced to approximately 3269 acres (1320 ha) (Anon. 1981). Based on the best scientific data then available, this configuration and acreage were deemed sufficient to provide for both the preservation and recovery of the species. Unfortunately, Federal Pond is not within the critical habitat because this important redbelly turtle population was not discovered until after the designation was made.

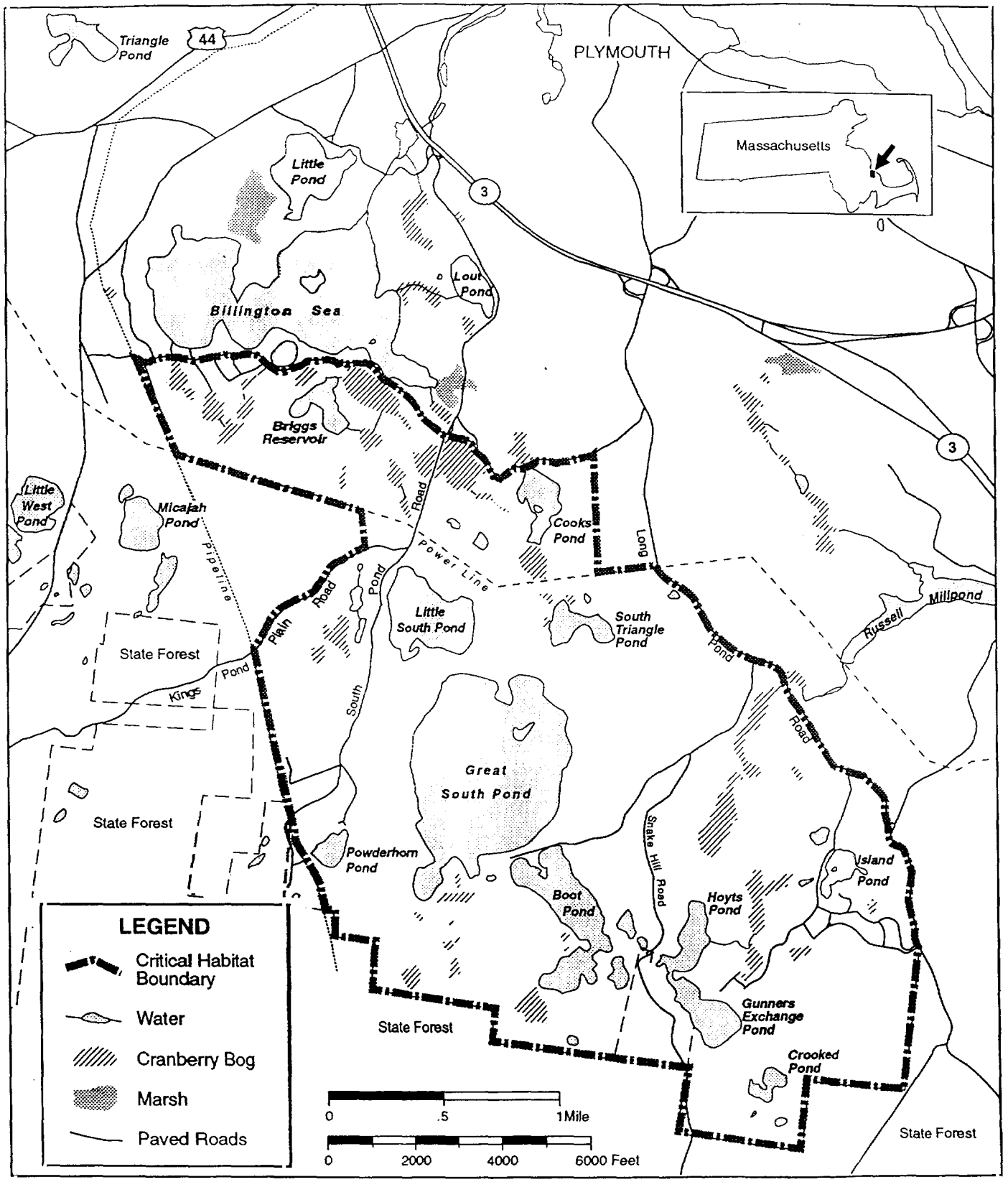

Figure 3. Critical Habitat of the Redbelly Turtle in Plymouth County, Massachusetts

FACTORS CONTRIBUTING TO ENDANGERED STATUS

In the final rule listing the Massachusetts redbelly turtle and designating critical habitat (U.S. Fish and Wildlife Service 1980), the following factors that may adversely affect the turtle and its habitat were identified: adverse modification of water quality, such as siltation from land clearing adjacent to ponds; pollution and eutrophication of ponds; pollution of groundwater or reduction in the levels of ponds from groundwater pumping, which could adversely affect aquatic invertebrates and vegetation (the basis for food and shelter for turtles); any draining or filling of wetlands adjacent to occupied ponds; and shoreline modification such as filling, dredging for beaches, dikes, real estate development or similar types of activity. A discussion of these and other known or potential limiting factors follows.

The Plymouth redbelly turtle's small population size and restricted range are foremost among the factors limiting its long-term viability. As a small, isolated population, the Plymouth redbelly turtle may be subject to inbreeding and genetic drift, which can reduce genetic variability and potentially decrease survivorship. Further, both mark-recapture (T.E. Graham unpubl. data) and genetic analyses of turtles from Federal Pond and nearby Island Pond (Haskell 1993) indicate that these ponds represent disjunct breeding populations, possibly affecting intra-population genetic variability. Genetic exchange and movement (immigration and emigration) may be necessary to sustain small populations through periods of natural demographic fluctuation.

Climatic factors could be contributing to the Plymouth population's tenuous status as a northern disjunct relict of a southern species in a diverse but primarily southern genus. Except for the versatile red-eared turtle (formerly *Pseudemys scripta elegans*, now considered in the genus *Trachemys*), no other member of the genus occurs farther north than Maryland. Climatic constraints play an important role in incubation, hatching success, and the success and timing of emergence of Plymouth redbelly turtles (T.E. Graham pers. comm).

It is difficult to determine to what extent anthropomorphic events have contributed to the Plymouth redbelly turtle's rarity; however, based on a review of turtle remains from several New England Indian middens, Rhodin (1992) reports that the former New England

distribution of redbelly turtles was wider than it is now, and suggests that local extirpations occurred at least partially as a result of the predatory pressure of prehistoric man.

The turtle has also been subject to environmental pressures in more recent times. The Plymouth County area, particularly land along pond shores, underwent a period of rapid residential and commercial development during the 1970s and 1980s. While the rate of development has slowed recently, continued habitat modification and urbanization are thought to be inimical to the Plymouth redbelly turtle.

Long-term changes in land use practices such as those associated with development and recreation may cause loss of undisturbed nesting and basking sites for the redbelly turtle. Closure of the forest canopy also plays a significant role in diminishing habitat suitability for the turtle. In pre-colonial and early colonial periods, the pine barren habitat that makes up most of Plymouth County was frequently burned. At that time, the region was a mosaic of pitch pine, scrub oak barrens with frequent openings, and grasslands in which the heath hen *(Tympanuchus c. cupido)* was common. Today, the area has largely been protected from fire and most of the remaining undeveloped areas are closed-canopy pine forest. These closed-canopy forests surround most ponds; hence, suitable nesting habitat that receives adequate heat (sunlight) for incubation is scarce. Such changes in habitat conditions may result in delayed sexual maturity and frequency of breeding. Although there appears to be a scarcity of good nesting habitat, the effects on nest site selection, incubation, and predation rates on the population as a whole are poorly understood.

Further, habitat fragmentation caused by development and barriers such as roads and stream channel alteration may have eliminated many of the natural movement corridors between ponds. Unpublished data (T.E. Graham) suggest that adult male turtles may move from pond to pond more frequently than females. The observation that fewer adult males than females are captured in the four study ponds suggests that males have a higher dispersal rate, a higher mortality rate, or both. However, sex ratios of adult turtles may also be influenced by temperature dependent sex determination (TSD).

Habitat alteration as a result of agricultural development and practices may also bear on the status of this redbelly turtle population. It is unknown to what extent Plymouth

redbelly turtles have been affected by the growth of the cranberry industry in Plymouth County. Cranberry bog acreage has increased substantially during the last century and the industry owns and manages considerable acreage in southeastern Massachusetts.[2] While the bogs are a monoculture of *Vaccinium macrocarpon*, and considered of low value to *P. rubriventris*, many of the reservoirs and upland watershed areas managed by the industry provide high quality habitat for the turtle. Some of these areas have become increasingly important to the conservation of the Plymouth redbelly turtle (such as Federal Pond), as other surrounding habitat was lost to residential development or became overshaded through forest succession.

Manipulation of aquatic vegetation, including herbicide use, may impact quality and quantity of food resources for the turtle. The turtles may also be affected by use of insecticides and other chemicals in forestry, agriculture, or mosquito abatement. Although the cranberry industry used a substantial amount of organochlorine-based and other pesticides in Plymouth County from the late 1940s to 1960s, no studies have been undertaken to determine whether long-lived redbelly turtles carry pesticide burdens. Since 1970, safer chemical agents (insecticides, herbicides, fungicides, and fertilizers) are being used by cranberry growers, as well as in mosquito abatement and silviculture. While most of these chemical treatments are considered less toxic to wildlife than were previous agents, the synergistic effects of two or more overlapping chemical agents is unknown. Unanswered questions aside, the cranberry industry in Plymouth County has been very supportive of the recovery effort, and individual growers are important partners in the program.

Limiting factors for (non-headstarted) hatchling and juvenile ($\leq$ 160 mm carapace length) Plymouth redbelly turtles are still largely unknown. Low nesting success and high juvenile mortality are suspected to be important factors limiting population growth, although protecting nests and releasing headstarted turtles may be effective short-term measures to counteract this problem. The survival of hatchlings and their recruitment into the breeding population are essential if the nest protection and headstart programs are ultimately to succeed. Available data (T.E. Graham unpubl. data, Haskell 1993) indicate that non-

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[2] Total acreage in southeastern Massachusetts owned by the cranberry industry including bogs, associated reservoirs, and upland watersheds is about 62,000 acres (J.L. Carlson, Cape Cod Cranberry Growers Association, *in litt.* 1993).

headstarted hatchlings released directly into ponds may experience close to 100% mortality; however, marker loss may also contribute to the lack of recoveries. Even headstarted turtles, particularly the smaller individuals, undergo significant annual mortality in Crooked Pond (averaging 35%) for turtles $\leq$ 65 mm carapace length (Haskell 1993).

Results of a long-term life history study of Blanding's turtles (*Emydoidea blandingii*) in Michigan were recently reported by Congdon *et al.* (1993). A life table developed for the study population resulted in a 37-year cohort generation time and required a 72% annual survivorship of juveniles between 1 and 13 years of age to maintain a stable population. The authors report that population stability was most sensitive to changes in adult or juvenile survival and less sensitive to changes in age at sexual maturity, nest survival, or fecundity. Congdon *et al.* (1993) concluded that successful management and conservation programs for long-lived organisms, like turtles and tortoises, will be those that recognize that protection of all life stages is necessary. Recovery programs limited to headstarting and/or protection of nesting sites, in the absence of efforts to reduce mortality of older juveniles and adults, will be less than adequate.

The widespread introduction and translocation of several predatory sportfish such as smallmouth bass *(Micropterus dolomieui)*, largemouth bass *(M. salmoides)*, chain pickerel *(Esox niger)*, brown bullheads *(Ameiurus nebulosus)*, and white perch *(Morone americana)* may be playing a key role in the low survivorship of hatchling turtles, although no studies have been undertaken to address this possibility. Recent work by Britson and Gutzke (1993) found that largemouth bass quickly learn to avoid eating hatchling red-eared slider turtles and speculated that once swallowed, the clawing and scratching of the young turtles made them unpalatable.

Relative to predation by indigenous animals, T.E. Graham (1984) reported that Plymouth redbelly hatchlings are consumed by bullfrogs *(Rana catesbeiana)*, and in 1993, five of eight bullfrogs captured and examined contained hatchling redbelly turtles, with two hatchlings present in the stomach of the largest frog (Graham 1993). Predation of hatchlings by other native species such as herons, snapping turtles *(Chelydra serpentina)*, and raccoons is suspected but poorly documented for the redbelly turtle. Depredation of unprotected nests at Federal Pond by raccoons *(Procyon lotor)* and striped skunks *(Mephitis mephitis)*, whose

populations tend to increase with residential development and habitat fragmentation, is relatively high (T.E. Graham unpubl. data) and is almost certainly among the limiting factors for this species in Massachusetts.

Other possible threats to Plymouth redbelly turtles include collection and harassment by humans as well as incidental mortality from highway traffic, agricultural vehicles (Graham unpubl. report 1991), shooting, and pets (Graham 1984).

CONSERVATION MEASURES

Regulatory Protection

In addition to its Federal listing as endangered and the designation of critical habitat, the Plymouth redbelly turtle is listed as an endangered species by the Commonwealth of Massachusetts (Mass. General Law, chapter 131 A, 321 CMR 10.00). In July 1986, a wildlife amendment to the Massachusetts Wetland Protection Act (Mass. General Law, chapter 131, sections 40 and 40A), and subsequent regulations approved in November 1987, provided relatively stringent protection to all the ponds known to be inhabited by redbelly turtles currently or during the past 25 years (French 1990). This amendment provides protection from alteration to ponds occupied by redbelly turtles. Most if not all ponds with redbelly turtles in Massachusetts have been designated as "estimated habitat for state-listed rare wetlands wildlife".

Habitat Protection

Habitat protection at ponds with existing or recent redbelly turtle populations is identified as a high priority management activity (U.S. Fish and Wildlife Service 1985). In 1980, the Massachusetts Division of Fisheries and Wildlife acquired a 70-acre property in Carver that included Muddy Pond. Because of the protected status of Muddy Pond and its proximity to existing Plymouth redbelly turtle populations, headstarted turtles were released there over a three-year period to establish a new population.

As recommended in the initial recovery plan, the U.S. Fish and Wildlife Service acquired 183 acres from The Nature Conservancy in 1983 which included Crooked and Duck Ponds and a section of the shoreline of Gunners Exchange Pond. This site was dedicated as the Massasoit National Wildlife Refuge in 1984, with its primary purpose being the protection of the Plymouth redbelly turtle. While the refuge is within the National Wildlife Refuge System, management is shared through a cooperative agreement with the Massachusetts Division of Fisheries and Wildlife.

Since the establishment of Massasoit National Wildlife Refuge, no other undeveloped pond with an existing or recent redbelly turtle population has been earmarked for habitat protection (French 1990). However, most of the habitat for this species is in private ownership, and options for ensuring long-term protection and managing nesting sites on undeveloped waterfront parcels require further evaluation.

The Nature Conservancy has developed a land registry program in Massachusetts that is designed to protect rare species and unique habitats on private lands. Sites on Great South Pond have been included in this system. Owners of these sites voluntarily agree to avoid activities on their lands that would be detrimental to the turtle. These agreements are not legally binding but have a history of success.

Protection of Nests

Nest predation can severely limit recruitment of young turtles into a breeding population (Congdon *et al.* 1987). Accordingly, during the redbelly turtle nesting season in Massachusetts (late May to early July), researchers locate nests at Federal Pond and protect them from predation by installing wire exclosures. In the period from 1982 to 1984, 16 nests were protected with exclosures, while 31 additional unprotected nests were raided by predators. From 1987 through 1993, a total of 230 nests found at Federal Pond were protected, and in 1993 alone, a record 71 nests were protected (Graham 1993). From 1987 to 1991, the hatching success of 95 protected Federal Pond nests was 83% (Haskell 1993); hatching success at unprotected nests is presumed to be low, although it has not been quantified.

Nests protected with wire exclosures are checked when hatching and emergence are anticipated. Emerged young are then measured, marked, and either transferred to headstarting institutions or released directly into their natal pond.

Headstarting

Headstarting is a conservation measure used to increase turtle numbers by offsetting the high mortality rate of first-year turtles in the wild. Eggs and/or hatchling turtles are brought into captivity, and hatchlings are held in aquariums at above ambient water temperatures and fed a diet of red leaf or romaine lettuce supplemented with Repto-min @. Headstarted hatchlings grow rapidly and can generally attain sizes two to six times (carapace length) that of similar-aged turtles in the wild. When released, headstarted turtles are presumed, simply by their larger size, to experience greatly reduced mortality from predators such as great blue herons, raccoons, bullfrogs, and fish. Young headstarted turtles can be either returned to their natal pond or translocated to new habitat to support recovery objectives.

An initial experimental release of five headstarted Plymouth redbelly turtles was conducted in 1980. In 1984, an active headstarting program was initiated and has been conducted annually since. In total from 1985 through 1993, 823 headstarted turtles were released into 17 ponds and one river (Table 2).

Survival of hatchling turtles in captivity is high (about 90%). Average survival of all headstarted hatchlings released in Crooked Pond (Massasoit National Wildlife Refuge), as indicated by recaptures of marked individuals in subsequent years, also appears to be high (80%) (Haskell 1993, T.E. Graham unpubl. data). Three of five headstarted turtles released in 1980 were found alive and healthy twelve years after release (1992), suggesting relatively successful long-term survival.

In order to avoid depleting the "source" population, less than half of the emerged young from Federal Pond nests are retrieved for the headstarting program in any given year, i.e., by design, an equal or greater number of emerged hatchlings are released directly into Federal Pond. Unfortunately, the fate of these hatchlings is unknown. None of the 852

Table 2. Summary of all headstarted Plymouth redbelly turtles released from 1985-1993 into ponds located in Plymouth, Massachusetts. Adapted from Haskell 1993 and T.E. Graham unpubl. data.

	Release Year									
Release Pond	1985	1986	1987	1988	1989	1990	1991	1992	1993	Subtotal
Island	--	9	--	10	6	--	--	3	--	28
Crooked*	13	30	9	11	8	5	5	--	--	81
Gunners Exchange	--	--	10	14	15	--	--	--	--	39
Hoyts	--	--	10	13	--	--	--	--	--	23
Federal	--	--	23	32	24	16	10	17	--	122
Wenham	--	--	9	9	15	--	--	--	--	33
Muddy	--	--	--	--	15	19	10	--	--	44
East Head	--	--	23	29	25	11	10	--	--	98
Louts	--	--	--	--	--	20	6	17	--	43
Billington Sea	--	--	--	--	--	20	11	17	--	48
Big West	--	--	9	10	14	--	--	--	--	33
Boot	--	--	14	20	15	--	10	--	--	59
Great South	--	--	--	--	--	--	--	35	24	59
Halfway Island	--	--	--	--	--	--	--	18	--	18
Halfway	--	--	--	--	--	--	--	--	24	24
Little Long	--	--	--	--	--	--	--	--	24	24
Weweantic River	--	--	--	--	--	--	--	--	34	34
Forge	--	--	--	--	--	--	--	--	13	13
Total	13	39	107	148	137	91	62	107	119	823

* Hatchlings (HA) also directly released into Crooked Pond: 5 Island Pond HA were released in 1980, of which 3 were known to be alive in 1992; also, 5 Island Pond HA and 10 Federal Pond HA were released in 1982 (all < 50 mm), of which none were ever captured again and all are presumed dead.

(non-headstarted) hatchlings marked and released directly into Federal Pond between 1984 and 1992 have been observed again (T.E. Graham unpubl. data). However, researchers question whether or not the small scutal notch inscribed in the tiny hatchling turtles is detectable in subsequent years. The efficacy of a permanent marking scheme, such as an implant tag, is being explored.

The success of the headstarting program will be gauged by the establishment (or enhancement) of self-sustaining populations. Based on a comparison of the size of nesting female redbelly turtles (defined as females $\geq$ 280 mm straight-line carapace length) with the size of headstarted turtles recaptured in the field (range 146-186 mm), it may be another five years before female headstarted turtles reach sexual maturity (Haskell 1993). Three headstarted male turtles released in 1980 and recaptured in 1992 exhibited secondary sexual characteristics (Haskell 1993).

As no female headstarted redbelly turtles have reached sexual (reproductive) maturity yet, it is premature to evaluate the ultimate effectiveness of the headstarting program. This notwithstanding, progress has been made toward the parallel objectives of increasing the overall number of Plymouth redbelly turtles, particularly the number of turtles in ponds with small populations, and in establishing "new" populations such as those at East Head Pond, Muddy Pond, and Halfway Island Pond.

Through extensive trapping efforts (T.E. Graham unpubl. data), Haskell (1993) evaluated both age- and size-specific survival rates of headstarted redbelly turtles. Haskell reports that, overall, survivorship of headstarted turtles in Crooked Pond appears to be lower during the first year following release (73%); thereafter the probability of surviving is higher (> 85%). The lower survivorship of first-year turtles appears to be size-related, with individuals measuring $\leq$ 65 mm carapace length having substantially lower probability of surviving than turtles > 65 mm carapace length in size. This is suspected to be the case in other release ponds as well. Headstarted turtles that have not reached reproductive maturity are exhibiting strong site fidelity to their release ponds (T.E. Graham unpubl. data, Haskell 1993).

Population pressures may become evident as the upper limit to the number of headstart turtles that a pond ecosystem can support is reached and exceeded. For example, population estimates for redbelly turtles in Crooked Pond during the period 1986 to 1991 remained relatively stable at 40 turtles despite the release of 68 headstarted hatchlings into the pond during the same period. Further, intraspecific competition between redbelly turtles in Crooked Pond is suspected because of the increased incidence of carapace bite wounds (T.E. Graham unpubl. data).

The Federal Pond population serves as the almost exclusive source of headstarted turtles released in Island Pond and many other ponds. The resultant paucity of gene flow between pond populations may be detrimental to the species, especially if further mitochondrial genetic research indicates that Federal Pond turtles have lower genetic heterozygosity than Island Pond turtles. The study by Haskell (1993) and R.A. Browne (unpubl. data), which examined variability between the Massachusetts and New Jersey redbelly populations, also looked at the degree of genetic variability among subpopulations of the Plymouth redbelly turtle. In this study, measures of genetic variability (%P and mean heterozygosity, respectively) were higher for the Island Pond population (0.250, 0.042) than those recorded for the Federal Pond population (0.083, 0.002). This suggests that supplementing the Island Pond population (where genetic variability is higher) with headstarted turtles collected from Federal Pond could result in lower genetic variation. However, considering the limitations of allozyme electrophoresis in assessing genetic variability, further analyses (mtDNA) of Massachusetts populations are strongly recommended before conclusions are drawn.

Population Monitoring

Redbelly turtle populations in several ponds (Federal, Crooked, Gunners Exchange, Hoyts, and Island) have been monitored to evaluate general health, relative population size, movement of marked turtles, and survivorship of individuals. Population estimates for these ponds are presented in Table 3. Periodic monitoring efforts will continue for selected ponds, with increased emphasis placed on recording the trapping effort, in order to obtain more meaningful comparisons and trend data.

Table 3. Population size and recaptures of headstart and extant redbelly turtles between 1979 and 1991 at four ponds in Plymouth County, Massachusetts (adapted from Haskell 1993).

Pond	Pond Size	Year	N[a]	(SE)	∑ of HS* Released[b]	∑ of Nos. Captured	Proportion of Total Captures: Headstarted Turtles	Proportion of Total Captures: New Marks[c]
Crooked	4 ha	1979[d]	3	e	0	3	0.00	0.67
	(9.9 ac)	1986[f]	37	(5.52)	43	27	0.89	0.00
		1991[f]	40	(1.39)	81	39	1.00	0.00
Island	5 ha	1979[d]	25	e	0	24	0.00	0.38
	(12.4 ac)	1991[f]	70	(4.16)	25	60	0.20	0.25
Gunners Exchange-Hoyts	18 ha	1979[d]	12	e	0	11	0.00	0.55
	(44.5 ac)	1987[f]	22	(2.63)	20	22	0.36	0.27
		1991[f]	67	(13.36)	62	24	0.70	0.06
Federal	52 ha	1981[d]	158	(9.74)	0	120	0.00	0.62
	(128.4 ac)	1991[f]	171	(36.45)	105	66	0.20	0.21

* headstarted turtles

[a] estimated population sizes in 1979 were calculated using the Schnabel estimator; all others calculated using program CAPTURE.
[b] cumulative sum of all headstart turtles released into a specific pond by that survey year.
[c] proportion of extant turtles captured during that year not caught in previous years.
[d] survey occurred before headstart turtles were introduced.
[e] data not available.
[f] survey occurred after headstart turtles were introduced.

Only previously marked headstarted turtles were captured in Crooked Pond in 1991. Of 40 animals captured, most appeared to be in good health, and carapace measurements confirmed that Crooked Pond redbelly turtles grew appreciably during the year prior to their recapture (Graham 1992). These findings provide encouraging evidence of the general good health and successful recruitment of headstarted turtles into the population (Graham 1992).

Habitat Management

Research suggests that because undisturbed nesting sites with ample sunlight are scarce in Plymouth County, management to improve or provide nesting habitat may benefit both hatching success and early hatchling survival. However, to date there have been only limited efforts to improve or manage habitat at occupied ponds. In 1985, the Youth Conservation Corps cleared a small area (20 x 60 feet) along the shore of Crooked Pond in the Massasoit National Wildlife Refuge. Unfortunately, this pond currently has no adult female redbelly turtles, so it is not possible to evaluate the potential effectiveness of the management effort. Snapping turtles and painted turtles *(Chyrsemys picta)* have utilized the site, which T.E. Graham (pers. comm.) reports is quickly succeeding to pine scrub.

In some locations such as Federal Pond, cranberry growers incidentally maintain open nesting habitat, and redbelly turtles actively seek out the sandy roads, dikes, and adjacent uplands to nest. Brush clearing and occasional earth moving in areas used by the turtles seem to enhance the desirability of these locations, since nesting females sometimes demonstrate preferential use of recently graded sites (T.E. Graham pers. comm.).

Researchers sometimes provide additional basking sites (logs) during the release of headstarted turtles by placing fallen trees found close to the water's edge into shallow water.

Efforts to identify unique features of Plymouth redbelly turtle habitat have been inconclusive. Preliminary results of a multivariate analysis of habitat parameters (primarily water chemistry) showed no significant differences in habitat characteristics between ponds that were inhabited and ponds not inhabited by the turtle (T.E. Graham unpubl. data).

RECOVERY STRATEGY

The future emphasis of Plymouth redbelly turtle recovery will be on habitat protection and turtle survival. Efforts will be made to ensure long-term genetic viability by maintaining gene flow among the separate ponds that comprise this population's habitat.

While headstarting will continue to be used as a means to bolster existing pond populations or introduce turtles to additional ponds, the program will be seen as an integral component of a multi-faceted approach rather than as the central focus of recovery. Turtles will not be introduced to additional rivers unless and until the implications of the initial river introduction are more fully understood.

Increased attention will be given to monitoring turtles during all life stages, and to determining the significance of the various limiting factors described in the preceding section of this plan. If evidence of sufficient recruitment and survival is shown over time, the Plymouth redbelly will be reclassified from endangered to threatened status, and the recovery program will proceed toward achieving full recovery.

PART II: RECOVERY

RECOVERY OBJECTIVES

The primary objective of this revised recovery plan is to restore a self-sustaining population of the Plymouth redbelly turtle in southeastern Massachusetts so that protection under the Endangered Species Act is no longer necessary. While the reclassification objective outlined in the 1985 revised Recovery Plan (U.S. Fish & Wildlife Service 1985) has not been modified in the present document, a new delisting objective has been identified.

Reclassification to threatened status will be considered when:

- the Plymouth redbelly turtle increases from the current population level of approximately 300 breeding-age individuals to a total of 600 breeding-age individuals distributed among a minimum of 15 self-sustaining populations.

Although the turtle's restricted range may remain a limiting factor, delisting will be considered when:

- the distribution of the species is expanded to 20 or more self-sustaining populations (in lakes, ponds, and possibly rivers) and numbers are increased to a total of 1,000 or more breeding-age individuals.

- Sufficient habitat is protected to allow long-term maintenance of the population.

- Knowledge about their life history, habitat requirements, and limiting factors is sufficient to effectively protect and manage the turtles and their habitat.

Due to the delayed sexual maturity of this large turtle, recovery will be gradual, even under optimum conditions. The estimated date for reclassification is the year 2000, and the projected date for delisting is the year 2015.

RECOVERY TASKS

An outline of the following recovery tasks, which directly address the recovery objectives stated above, is presented in Table 4.

1. Inventory

1.1 Monitor the status and population trends of known populations. Status and population trends have been monitored at two occupied ponds almost annually since 1979. Since Federal Pond contains by far the largest population and Crooked Pond occurs within the Massasoit National Wildlife Refuge and is the best protected, these two sites will continue to be the focus of monitoring and research efforts. Efforts to monitor population size and headstart survival in Island, Gunners Exchange, and Hoyts Ponds should also continue. Other ponds will be monitored with lesser intensity.

1.2 Periodically monitor ponds that are known to have formerly been inhabited. A rangewide survey will be conducted every three years to assess overall changes that might not otherwise be evident. Most of these sites will be visited incidentally at more frequent intervals.

1.3 Search for additional populations. Efforts to locate previously unknown populations will continue. A number of new specimen and locality records have been reported by the public in recent years as a result of increased media attention. The population in Federal Pond, which contains approximately half of the total known individuals, was first discovered in 1979 after the initial recovery plan was drafted. Organized searches will be conducted every five years at a minimum.

1.4 Continue to define the historical range through examination of archaeological evidence. Examination of Indian middens continues to provide valuable insights into the historical distribution and pre-colonial era human use of the

Table 4. Recovery task outline

1. Inventory

   1.1 Monitor the status and population trends of known populations.
   1.2 Periodically monitor ponds that are known to have been formerly inhabited.
   1.3 Search for additional populations.
   1.4 Continue to define the historical range through examination of archaeological evidence.

2. Research

   2.1 Expand studies to determine and mitigate limiting factors.
   2.2 Continue natural history studies.
   2.3 Examine pesticide and heavy metal levels of salvaged specimens and surrogate species found in the same ponds.

3. Habitat Protection and Management

   3.1 Protect occupied and potential habitat.
   3.2 Improve habitat at ponds with known populations by clearing or creating nesting beaches and providing basking sites where necessary.
   3.3 Annually locate and protect nests at ponds with major populations.
   3.4 Enforce all laws protecting the Plymouth redbelly turtle and its habitat.
   3.5 Work with the cranberry industry and other agricultural enterprises to avoid potentially harmful activities and further promote the conservation of the species.

4. Population Management

   4.1 Continue to conduct and improve the hatchling headstart program.
   4.2 Evaluate the status of each pond/river population, and supplement turtle numbers if and where warranted.
      4.21 Continue efforts to establish populations at protected sites.
      4.22 Consider establishing additional populations in suitable pond or river habitat.

5. Education

   5.1 Develop slide-tape programs and presentations on the Plymouth redbelly turtle for use in local schools and with other groups.
   5.2 Continue public education through the news media and other published materials.
   5.3 Present the results of conservation and research efforts at scientific symposia and in both popular articles and scientific journals.

turtle. Information obtained incidental to other investigations will be assessed for its implications regarding the historical distribution of this redbelly turtle population.

2. Research

2.1 Expand studies to determine and mitigate limiting factors. These studies should include determining the post-emergence survival of hatchlings, identifying the primary sources of mortality and predators of hatchling and first year turtles, developing an effective permanent marking scheme for tracking non-headstarted hatchlings, and evaluating other natural or anthropogenic factors affecting redbelly turtle reproduction and survival.

Even though the Plymouth redbelly has been studied since 1905 and intensively by Graham since 1979, the limiting factors for this turtle are still largely unknown. Research designed to identify these factors should remain a high priority because of the fundamental need to understand these limitations before sound recovery actions can be implemented.

Haskell (1993 and pers. comm.) used a life stage-based model to evaluate the long-term status of Plymouth redbelly turtles in Federal and Island Ponds. Haskell's model indicates that the Massachusetts redbelly population is at risk and may currently be declining at an annual rate of 2% or greater. The model further shows that the population is stable or slowly increases only when survival rates of stage 1 (from egg laying to hatching) are $\geq$ 0.30, when stage 2 turtles (juveniles with carapace length > 45 mm but $\leq$ 90 mm) are $\geq$ 0.51, and when 90% of females nest annually. These conditions may occur only infrequently. The model also indicates that increasing survivorship of subadult (carapace length 90-280 mm) and adult turtles (carapace length $\geq$ 280 mm) would stabilize the population faster than would increasing hatching success and juvenile survival.

Increasing the numbers of young turtles through nest protection and headstarting will accomplish little to benefit the recovery effort unless these turtles survive and are recruited into the breeding population, and their progeny survive to repeat this cycle. Determining the survivorship of non-headstarted hatchlings, as well as tracking the survivorship of headstarted turtles, will provide important information on the need to undertake further steps to protect these young turtles from predation, environmental contamination, or other mortality factors.

Determining the causes of mortality, the sources of environmental contamination, or predators on young turtles will be vital to accurately direct further protection efforts, such as predator control. Developing a permanent and safe marking scheme for hatchling turtles (such as implant tags) will greatly enhance research efforts to monitor survival, movement, and recruitment into the breeding population.

Land use changes associated with agricultural and residential development result in greater demands for water withdrawals, fire suppression, and transportation corridors, and cannot be overlooked as potential contributing factors to this population's decline.

2.2 Continue natural history studies. These studies should include determination of habitat requirements, nest site selection preferences, the proportion of adult female turtles that nest annually or twice annually (double clutching), and the age and size of turtles at reproductive maturity. Survival rates of hatchlings that overwinter in the nest chamber, along with environmental conditions that trigger this behavior, should be investigated. These and other studies should continue in order to provide data needed for implementation of sound management. The emphasis of these studies should evolve as the data base improves and new research goals are developed.

Review of the multivariate analysis of habitat characteristics conducted by T.E. Graham (unpubl. data) may provide insight into additional studies needed to identify unique habitat requirements.

2.3 Examine pesticide and heavy metal levels of salvaged specimens and surrogate species found in the same ponds. There is no data regarding the possible effects of pesticides, heavy metals, or other environmental contaminants on the Plymouth redbelly turtle. Since most populations are found in close proximity to commercial agriculture, the potential impact of insecticides or other chemicals used in agriculture or mosquito abatement should be investigated. Any analysis of redbelly tissues will by necessity be restricted to opportunistically salvaged material, but surrogate species such as painted turtles, common snapping turtles, and stinkpots (*Sternotherus odoratus*) that occur in the same ponds (including eggs and hatchlings) could be systematically sampled.

3. Habitat Protection and Management

Essential habitat, including but not limited to the area of designated critical habitat, will be delineated and assessed with respect to protecting required habitat components and supporting a viable metapopulation of the Plymouth redbelly turtle.

3.1 Protect occupied and potential habitat. Haskell (1993) examined the viability of the Plymouth redbelly turtle using a stage-based model, and suggested that the population is at risk. Increasing survivorship of subadults and adults stabilized the population faster than increasing hatching success or juvenile survivorship. One of the few means available to increase the survivorship of subadult and adult turtles is to protect and enhance critical and essential habitat.

Habitat having existing or recent Plymouth redbelly turtle populations, as well as nearby potential habitat, including corridors for interchange among pond populations, will be delineated. Measures to protect these areas may range from fee acquisition (from willing sellers only) and easements to zoning,

registry agreements, or other methods determined to be appropriate on a case-by-case basis.

3.2 Improve habitat at ponds with known populations by clearing nesting sites and providing basking sites where necessary. In July 1985, an area approximately 20 x 60 feet (6 x 24 m) along the shore of a protected pond was cleared to provide a suitable nesting beach. This pond had previously been completely surrounded by a closed canopy forest.

Other ponds should be examined to assess the availability of nesting beaches and basking sites. Efforts to manage or improve the quality (and number) of basking sites and nesting beaches should be pursued. Opening new beaches in close proximity to ponds will provide additional nesting opportunities and create a more favorable microclimate for eggs and hatchlings. Trees removed to expose nesting beaches to sunlight could be limbed and anchored in shallow water to provide additional basking sites.

Suitable nesting areas at Federal Pond, which supports the largest population of turtles, continue to be maintained by ground disturbance associated with surrounding cranberry cultivation. However, care should be taken to avoid crushing of nest exclosures by trucks and farm equipment involved in these operations.

3.3 Annually locate and protect nests at ponds with major populations. During the nesting season, daily searches for turtle nests are conducted by T.E. Graham and his assistants at Federal Pond. Generally, nests that are found in nearby dirt roads are moved to safer sites, and all known nests are covered with wire exclosures to prevent predation and to later retain the hatchlings so that they can be measured and individually marked. To date, few nests have been found at other ponds, but this number may increase as additional nesting beaches are maintained.

3.4 Enforce all laws protecting the Plymouth redbelly turtle and its habitat. This turtle is protected by the Federal Endangered Species Act (50 CFR 23) and by the Massachusetts Endangered Species Act (MGL, Chapter 131A) and associated regulations (321 CMR 10.00). The turtle's habitat is provided a degree of protection through Federal designation of critical habitat and by the Massachusetts Wetlands Protection Act (Chap. 131, Sections 40, 40A, Mass. General Laws). All of these laws and regulations will continue to be fully enforced.

3.5 Work with the cranberry industry and other agricultural enterprises to avoid potentially harmful activities and further promote the conservation of the species. Federal Pond is a reservoir created for the purpose of providing water for cranberry cultivation. Cranberry operations along the south shore of Federal Pond have partially created and sustain perhaps the best nesting habitat available for redbelly turtles in Plymouth County. Cranberry growers in Plymouth County have cooperated in the research and recovery program for this endangered turtle by granting researchers and agency biologists access to private pond shores, storing equipment, and alerting employees to watch for nesting or dispersing turtles and to avoid crushing marked or caged turtle nests with farm vehicles and equipment.

While the activities of cranberry cultivation at and adjacent to Federal Pond are of significant benefit to redbelly turtles, some of the agricultural practices associated with the industry **in general,** including water withdrawals, drift and runoff from chemical applications, back pumping of water from treated fields into ponds, destruction or crushing of turtle nests/exclosures by vehicles, and the conversion of undeveloped wetlands or uplands into cranberry bogs should be assessed for possible effects on the Plymouth County turtle population, with the aim of alleviating such effects. This precaution should also be taken with any other land use, such as forestry and other agricultural uses as well as mosquito abatement programs, that could potentially have a deleterious effect on the turtle population.

4. Population management.

4.1 Continue to conduct and improve the hatchling headstart program. The headstart program has become well established since its initiation in 1980. Annually, a portion of emerged hatchlings from Federal Pond nests are brought into captivity. A group of 7-10 volunteer organizations and private cooperators each receive and raise, for 8-10 months, about 10 hatchlings for the headstart release in early June. A goal of between 100-150 hatchlings, for a minimum of 5-7 groups of 20+ turtles each, should be headstarted and released each year (see French 1990).

Annual monitoring will be conducted to determine if released headstart hatchlings are surviving to be recruited into the breeding population. Since dispersal rates of headstarted turtles and non-headstarted juveniles from natal ponds appears to be very low, release of headstarted hatchlings will continue to be used as a means of bolstering the overall population. Headstarted hatchlings should be carefully examined for the presence of infectious diseases prior to release.

4.2 Evaluate the status of each pond/river population, and supplement turtle numbers if and where warranted. In order to ensure population viability and attain the conditions required for reclassifying and delisting the species, approximately five new populations may need to be established. Releases should be made only where habitat evaluation suggests that target ponds or rivers are likely to support self-sustaining redbelly turtle populations. If shown to be warranted, releases to new ponds and rivers should be conducted for at least three consecutive years and should take into consideration the estimated carrying capacity of the habitat.

4.21 Continue efforts to establish populations at protected sites. Because of the relative security of Myles Standish State Forest property from further adverse development, ponds in the Forest should continue to receive headstarted turtles until it appears that a population has

become established. East Head Pond received 98 hatchlings between 1987-1991. If additional suitable ponds can be identified within Forest boundaries, the establishment of more populations should be considered. Myles Standish State Forest contains approximately 17,000 acres (6,880 hectares) of land that lie roughly between two inhabited ponds. Populations within the Forest would presumably be easier to protect than those on private lands.

4.22 Consider establishing additional populations in suitable pond or river habitat. Continued augmentation of existing pond populations and introduction of the turtle into available suitable pond habitat may be key to the turtle's recovery. However, ponds in southeastern Massachusetts that provide suitable habitat for this species have been found to be limited in both number and size.

Headstarted turtles were released into the Weweantic River in 1993, and, while it may become necessary to establish populations in other nearby rivers (such as the Agawam, Taunton, and Wankinco Rivers), additional river introductions will be delayed until the results of the Weweantic introduction are evaluated and the feasibility of other rivers to support redbelly turtles is determined. While turtles in a riverain population would have the advantage of easy movement and could potentially result in greater dispersal and colonization of new habitats, monitoring the fate of released turtles in river systems will be difficult.

5. Education

5.1 Develop slide-tape programs and presentations on the Plymouth redbelly turtle for use in local schools and with other groups. A slide-tape program should be developed by the Nongame and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. Copies could then be made available for ongoing use by the local school systems and for short-term loans to other groups in the region.

Numerous slide presentations have been given to local school groups, and the Plymouth redbelly turtle is included in all of the Nongame and Endangered Species Program's presentations statewide. The ability to reach a broad spectrum of the public with these presentations has, however, been limited by the time constraints of researchers and Division staff. Making these materials available to teachers would greatly increase the dissemination of this information.

5.2 Continue public education through the news media and other published materials. Frequent media coverage has made the Plymouth redbelly turtle relatively well known to the local public. This high profile has contributed to a heightened environmental awareness by a growing segment of the community and has resulted in a number of new specimen and locality records that would have otherwise gone unreported. This level of coverage and attention should continue. In addition, owners of pond shores should be contacted and provided with information on what to do if nesting female turtles are encountered.

5.3 Present the results of conservation and research efforts at scientific symposia and in popular articles and scientific journals. New scientific information has been published by Graham and Iverson from recent research, but much of the information resulting from contracts with the U.S. Fish and Wildlife Service and the State of Massachusetts has not yet been reported. These and other data (e.g., Haskell 1993) should be presented at scientific meetings and published in both popular and scientific literature.

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PART III: IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program. It is a guide for meeting the objectives discussed in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions and duration, responsible agencies, and estimated costs. It should be noted that the Implementation Schedule reflects the total financial commitment, roughly estimated, for the recovery of the Plymouth redbelly turtle.

Key to column 1, Task Priority:

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 meet the recovery objectives.

Key to column 5, Agency Roles:

EPA - Office of Pesticide Management within the Environmental Protection Agency
HSC - Headstart cooperators such as the New England Aquarium, Springfield Museum, Museum of Science, and several additional agencies and private individuals
MAS - Massachusetts Archaeological Society
MDFW - Massachusetts Division of Fisheries and Wildlife.
MCGA - Massachusetts Cranberry Growers Association
ES - Ecological Services Division of the U.S. Fish and Wildlife Service
LE - Division of Law Enforcement of the U.S. Fish and Wildlife Service
DRW - Division of Refuges and Wildlife of the U.S. Fish and Wildlife Service
FWCU - Fish and Wildlife Cooperative Unit, University of Massachusetts Amherst
TNC - The Nature Conservancy

IMPLEMENTATION SCHEDULE
Plymouth Redbelly Turtle Recovery Plan, Second Revision

April 1994

Priority	Task Description	Task Number	Duration (Years)	Responsible Agency		Cost Estimates ($000)				Comments
				USFWS	Other	FY1	FY2	FY3	FY4	
1	Expand studies to determine and mitigate limiting factors.	2.1	5+	ES	MDFW MCGA	10.0	10.0	10.0	5.0	+ 60K total from FY5 on
1	Protect occupied and potential habitat.	3.1	Ongoing	ES DRW	MDFW TNC	5.0	3.5	2.5	1.5	+19.5K total for FY5-17. Land acquisition costs not included
2	Monitor the status and population trends of known populations.	1.1	Ongoing	ES	MDFW	2.0	2.0	2.0	2.0	+ 63K total in FY5-17 for Tasks 1.1-1.3
2	Continue natural history studies.	2.2	5	ES	MDFW	3.0	3.0	3.0	3.0	+ 3K in FY5
2	Examine contaminant levels of salvaged specimens and surrogate species found in same ponds.	2.3	3	ES	EPA MDFW MCGA	3.5	3.5	3.5		
2	Improve habitat at ponds with known populations.	3.2	3	ES DRW	MDFW	2.5	2.5	2.5		
2	Annually locate and protect nests at ponds with major populations.	3.3	Ongoing	ES	MDFW	5.0	5.0	5.0	5.0	+ 60k total for FY 5-17
2	Continue to conduct and improve the hatchling headstart program.	4.1	7	ES	MDFW HSC	1.0	1.0	1.0	1.0	+ 13K for FY5-17 Indicated costs are administrative; largely a volunteer effort
2	Consider establishing additional populations in suitable pond and river habitat.	4.22	Ongoing	ES	MDFW	2.0	2.0	2.0	2.0	+ 26K total for FY5-17
3	Monitor ponds that are known to have been formerly inhabited.	1.2	Every 2-3 years	ES	MDFW	1.0		1.0		See comment for Task 1.1

Priority	Task Description	Task Number	Duration (Years)	Responsible Agency		Cost Estimates ($000)				Comments
				USFWS	Other	FY1	FY2	FY3	FY4	
3	Search for additional populations.	1.3	Ongoing	ES	MDFW	1.0	1.0	1.0	1.0	See comment for Task 1.1
3	Continue to define historical range.	1.4	Indefinite		MAS					
3	Enforce all laws protecting the Plymouth redbelly turtle and its habitat.	3.4	Ongoing	LE	MDFW	1.0	1.0	1.0	1.0	+ 13K total for FY5-17
3	Work with the cranberry industry to mitigate potentially harmful activities and further promote conservation of the turtle.	3.5	Ongoing	ES LE	MDFW EPA	1.5	0.5	0.5	0.5	+ 6.5K total for FY5-17
3	Continue efforts to establish populations at protected sites.	4.21	Ongoing	ES	MDFW	0.5	0.5	0.5	0.5	+ 6.5K total for FY5-17
3	Develop slide-tape programs for use in local schools and with other groups.	5.1	3	ES	MDFW	1.5	1.5	1.5		
3	Continue public education through the news media and other published materials.	5.2	Ongoing	ES	MDFW FWCU	1.0	1.0	1.0	1.0	+ 13K total for FY5-FY17
3	Present results of recovery efforts at scientific symposia and in both popular and scientific media.	5.3	Ongoing	ES	MDFW FWCU	1.0	1.0	1.0	1.0	+ 13K total for FY5-17

APPENDIX 1. Recent participants in the headstarting program for the Plymouth redbelly turtle. [3]

NAME	LOCATION
Worcester State College (DNES)	Worcester, Massachusetts
Tufts University - School of Veterinary Medicine	Grafton, Massachusetts
New England Aquarium	Boston, Massachusetts
Springfield Science Museum	Springfield, Massachusetts
New England Science Center	Worcester, Massachusetts
Boston Museum of Science	Boston, Massachusetts
Roger Williams Zoo	Providence, Rhode Island
Franklin Park Zoo	Boston, Massachusetts
Triton Regional High School	Byfield, Massachusetts
Berkshire Museum	Pittsfield, Massachusetts
Alison Haskell	Amherst, Massachusetts

[3] Many other individuals too numerous to list have also participated in the program or otherwise generously donated time, space and other resources to the headstarting effort.

APPENDIX 2. List of reviewers.

The comments and suggestions received during the recovery planning process were reviewed and incorporated, to the extent appropriate, into this final plan. Copies of these comments are on file in the New England Field Office of the U.S. Fish and Wildlife Service. The Service greatly appreciates the factual corrections and constructive comments received from the following agencies, organizations, and individuals:

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