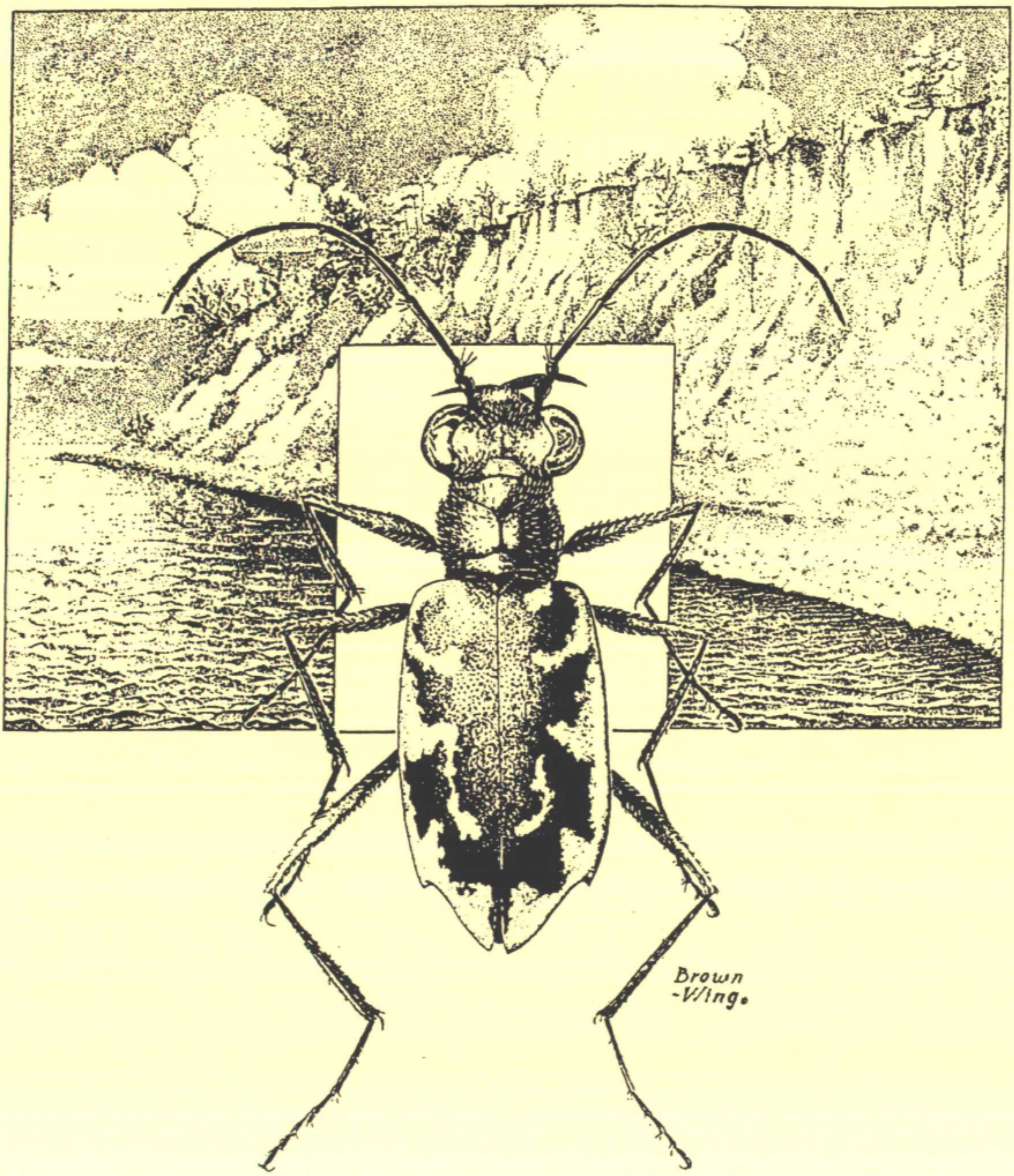
PURITAN TIGER BEETLE
(Cicindela puritana)

Recovery Plan



U.S Fish and Wildlife Service, Northeast Region

Puritan Tiger Beetle (*Cicindela puritana* G. Horn)
RECOVERY PLAN

Prepared by:

James M. Hill
Department of Biology
Randolph-Macon College
Ashland, Virginia 23005

and

C. Barry Knisley
Department of Biology
Randolph-Macon College
Ashland, Virginia 23005

for

U.S. Fish and Wildlife Service
Northeast Region

Approved: [signature]
Regional Director, Region Five
U.S. Fish and Wildlife Service

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EXECUTIVE SUMMARY
Puritan Tiger Beetle Recovery Plan

Current Status: This tiger beetle occurred historically along the Connecticut River in Connecticut, Massachusetts, and New Hampshire, and along the Chesapeake Bay shoreline in Maryland. Only two small Connecticut River populations remain, one in Massachusetts and one in Connecticut. Approximately six localities with more than 500 adults, and approximately 13 smaller populations, occur along the Chesapeake Bay in Calvert County and near the mouth of the Sassafras River in Kent and Cecil Counties, Maryland. *Cicindela puritana* was listed as threatened on August 7, 1990.

Limiting Factors: Along the Connecticut River, *C. puritana* has declined from its historical level of 11 known populations, most probably due to inundation and disturbance of its shoreline habitat from dam construction, riverbank stabilization, and other human activities. The beetle larvae, in particular, are sensitive to natural and human-induced changes to beaches and bluffs, as well as human traffic and water-borne pollution. In the Chesapeake Bay region, the species is threatened by habitat alterations associated with human population growth, such as increased development and shore erosion control projects.

Recovery Objective: To delist the Puritan tiger beetle.

Recovery Criteria: The species can be removed from threatened status when:

1. A minimum of six large (500-1000+ adults) populations and their habitat are protected in perpetuity at current sites along both shores of the Chesapeake Bay.
2. Sufficient habitat between these populations is protected to support smaller populations, providing an avenue for genetic interchange among large populations and ensuring a stable metapopulation structure.
3. A minimum of three metapopulations, at least two of which are large (500-1000+ adults), are maintained (at extant sites) or established within the species' historical range along the Connecticut River, and the habitat they occupy is permanently protected.
4. There exists an effective and long-term program for site-specific management that is based on an adequate understanding of life history parameters, human impacts, factors causing decline, population genetics, and taxonomy.

Actions Needed:

1. Monitor known populations, including any additional populations that are found.
2. Determine population and habitat viability.
3. Identify and protect viable populations and their habitat.
4. Implement appropriate management at natural population sites.
5. Study anthropogenic influences.
6. Study life history parameters and taxonomic relationships.
7. Develop techniques for and conduct reintroductions at appropriate sites.
8. Conduct a public education program.
9. Coordinate the recovery program.

Projected Costs ($000):

YEAR	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Need 8	Need 9	Total
FY1	15.0	10.0	38.0		1.0	26.5	11.5	4.0	1.0	107.0
FY2	15.0	10.0	26.0			22.0	9.5	2.5	1.0	86.0
FY3	12.0	5.0	16.0	10.0	15.0	12.0	12.5	2.0	1.0	85.5
FY4-15	96.0		48.0	110.0	15.0		61.0	12.0	12.0	354.0
TOTAL	138.0	25.0	128.0	120.0	31.0	60.5	94.5	20.5	15.0	632.5

DELISTING MAY BE INITIATED IN 2008 (depending on success of reintroductions).

ACKNOWLEDGMENTS

This plan, prepared in cooperation with the Chesapeake Bay Field Office of the U.S. Fish and Wildlife Service, could not have been written without input and review by the following knowledgeable individuals: Rodney Bartgis of the Maryland Natural Heritage Program; Laurie MacIvor of The Nature Conservancy, Maryland Office; Philip Nothnagle, the primary source for information on the New England populations; Steve Roble of the Virginia Natural Heritage Program; and Tim Simmons of The Nature Conservancy, Massachusetts Field Office.

Judy Jacobs of the Chesapeake Bay Field Office ably coordinated the recovery planning effort, was instrumental in organizing data, and gave this plan its final form.

* * *

The following recovery plan delineates a practical course of action for protecting and recovering the threatened Puritan tiger beetle (*Cicindela puritana*). Attainment of recovery objectives and availability of funds will be subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This plan has been prepared by private consultants for the U.S. Fish and Wildlife Service, in cooperation with species experts. It does not, however, necessarily represent the views or official position of any individuals or agencies 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. 1993. Puritan Tiger Beetle (*Cicindela puritana* G. Horn) Recovery Plan. Hadley, Massachusetts. 45 pp.

Additional copies of this plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
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PART I: INTRODUCTION

Tiger beetles are an interesting and ecologically important group of insects. They are typically the dominant invertebrate predators in many habitats where they occur, on open sand flats, dunes, water edges, beaches, woodland paths, and sparse grassy areas. These insects have become important models for testing ecological theories about community structure (Pearson 1986), competition (Pearson and Mury 1979), food limitation (Knisley and Pearson 1981, Pearson and Knisley 1985, Knisley and Juliano 1988), thermoregulation (Pearson and Lederhouse 1987, Dreisig 1985, Knisley et al. 1990), and predator defense (Schultz 1986). The diversity of the family Cicindelidae is exhibited by the fact that nearly 100 species and over 100 subspecies and color forms exist in the United States alone (Boyd 1982). Worldwide, some 2028 species have been described, and the taxon is considered to be an excellent indicator of regional patterns of biodiversity (Pearson and Cassola 1992). This diversity has contributed to the great popularity of these insects among amateurs and professionals, as exemplified by the journal Cicindela, published since 1969, which is devoted entirely to tiger beetles.

Cicindela puritana, the Puritan tiger beetle, is found in shoreline habitat along the Connecticut River in New England and the Chesapeake Bay in Maryland. The species has disappeared from a large part of its range in New England, and the Chesapeake Bay populations appear to be highly susceptible to habitat loss and degradation. Due to its declining range and vulnerability to natural and human-related threats, this species was listed as threatened in August of 1990 (U.S. Fish and Wildlife Service 1990). C. puritana is also listed as endangered by the States of Massachusetts, Connecticut, and Maryland.

POPULATION STATUS AND DISTRIBUTION

The eleven historical records known from New England indicate that Cicindela puritana occupied riverine beach habitats along the Connecticut River between Claremont, New Hampshire and Cromwell, Connecticut. The extirpation of nine of these populations occurred in the early 1900s, with the latest collection records in the 1930s (Knisley 1987a). Two small C. puritana populations are currently known from New England, one along the Connecticut River near Hadley, Massachusetts and one near Cromwell, Connecticut (Table 1, Figure 1). The Massachusetts population, found in 1986 by Dr. John Stamatov, is tiny, containing a total of less than 25 adults at three small sites (P. Nothnagle pers. comm. 1993). The Connecticut population, which was discovered in 1989 (Nothnagle 1989), also consists of three small sites, totalling some 450 adults. There are probably no additional extant populations of C. puritana in the region (Nothnagle 1990).

In Maryland, Cicindela puritana is known from Calvert County along the Chesapeake Bay, and in Kent and Cecil Counties near the mouth of the Sassafras River in the upper Bay (Table 1, Figure 2). Although few historical records exist for C. puritana in the Chesapeake Bay region (Glaser 1976), recent intensive survey efforts (Knisley and Hill 1989, 1991b, 1993) have located some 16 extant sites within this region, all in Maryland. There are also specimen records from four sites in Calvert County where the beetles no longer occur.

Of the 16 extant sites, four are "large", averaging 1000 or more adults. The remaining 12 sites average fewer than 500 adults, and five average fewer than 100 adults (Table 2). The total number of sites is somewhat ambiguous, particularly in the upper Bay where sites are in close proximity and site occupancy and abundance vary greatly between years (Knisley and Hill 1991b;

Table 1. Current and historical Cicindela puritana sites.

LOCALITY	COUNTY	DATE	SOURCE
NEW HAMPSHIRE			
Claremont	Sullivan	--	Schaupp (1883-84)
Charleston SE New Hampshire	Sullivan	-- 	MCZ MCZ-Fall
MASSACHUSETTS			
Hadley South Hadley	Hampden	1901, 1926 1990, 1993	MCZ PN
Chicopee	Hampshire	1919 1921 --	NYSM CAL UMMZ
Springfield	Hampshire	1907 --	USNM, MCZ, AMNH MCZ
Longmeadow	Hampshire	--	MCZ
CONNECTICUT			
Warehouse Point	Hartford	1924	MCZ, AMNH, COR
East Windsor Windsor	Hartford Hartford	1901, 1902 1901 -- 1901 1901 1913 1918 1922 --	UMMZ YPM CAL AMNH MCZ, COR, CAL AMNH JS CAL MCZ-Fall
South Windsor	Hartford	1901 1910	CAL YPM
Hartford	Hartford	1901 1901	CAL AMNH
Cromwell Cromwell-Portland	Middlesex	1939 1990, 1993	CAL PN
MARYLAND - EASTERN SHORE			
Lloyd Creek	Kent	1989	K&H
East Lloyd Creek	Kent	1989	K&H
Turner Creek	Kent	1989	K&H
Ordinary Point NW	Kent	1989	K&H
Grove Neck	Cecil/Kent	1991	JH

Table 1. (continued)

LOCALITY	COUNTY	DATE	SOURCE
MARYLAND - WESTERN SHORE			
Chesapeake Beach	Calvert	1911 1911 1911 1911, 1912 1911, 1929 1914 1914 1924, 1929 1933 1934 1980, 1983, 1984, 1992	AMNH Davis 1912 MCZ UMMZ, AMNH MCZ USNM, JG, CAL UMMZ, AMNH AMNH JG AMNH JG
Chesapeake Beach/ Randle Cliff	Calvert	1948 1991, 1992	NLRC, FDPI K&H
Locust Grove Beach	Calvert	1986	CBK
Holiday Beach	Calvert	1986	CBK
Camp Roosevelt	Calvert	1967 1971 1980, 1981 1991	NJRC GD JG K&H
Plum Point	Calvert	1949, 1950 1950 1949 1985, 1992	JG, FDPI JG, FDPI NMNH CBK
Bayside Forest	Calvert	1990	K&H
Dare's Beach	Calvert	--	NMNH
Scientists Cliffs	Calvert	1991, 1992	K&H
Matoaka Camp Beach Calvert Beach Western Shores/Calvert Beach/Matoaka	Calvert	1972 1972 1973 1991, 1992	HPB AMNH NLRC K&H
Flag Ponds	Calvert	1959	NMNH
Calvert Cliffs/Camp Canoy Calvert Cliffs State Park	Calvert	1973, 1983 1976 1991 1976 1977 1979 1992	JG JG K&H NLRC JG GD RB
Little Cove Point	Calvert	1980 1991	JG K&H
Cliffs of Calvert	Calvert	1991	K&H
Solomons Point	Calvert	--	JG
? Dime Park	Calvert	1934	AMNH

Source abbreviations: AMNH (American Museum of Natural History), CAL (California Academy of Sciences), CBK (C.B. Knisley), K&H (C.B. Knisley and J. Hill), COR (Cornell University), FDPI (Florida Division of Plant Industries), GD (G. Dunn), HPB (H.P. Boyd), JG (J. Glaser), JH (J. Hill), MCZ (Museum of Comparative Zoology, Harvard), NLRC (Norman L. Rumpp Collection), NMNH (National Museum of Natural History), NYSM (New York State Museum), PN (P. Nothnagle), RB (R. Bartgis), UMMZ (University of Michigan Museum of Zoology), USNM (U.S. National Museum), YPM (Yale Peabody Museum)

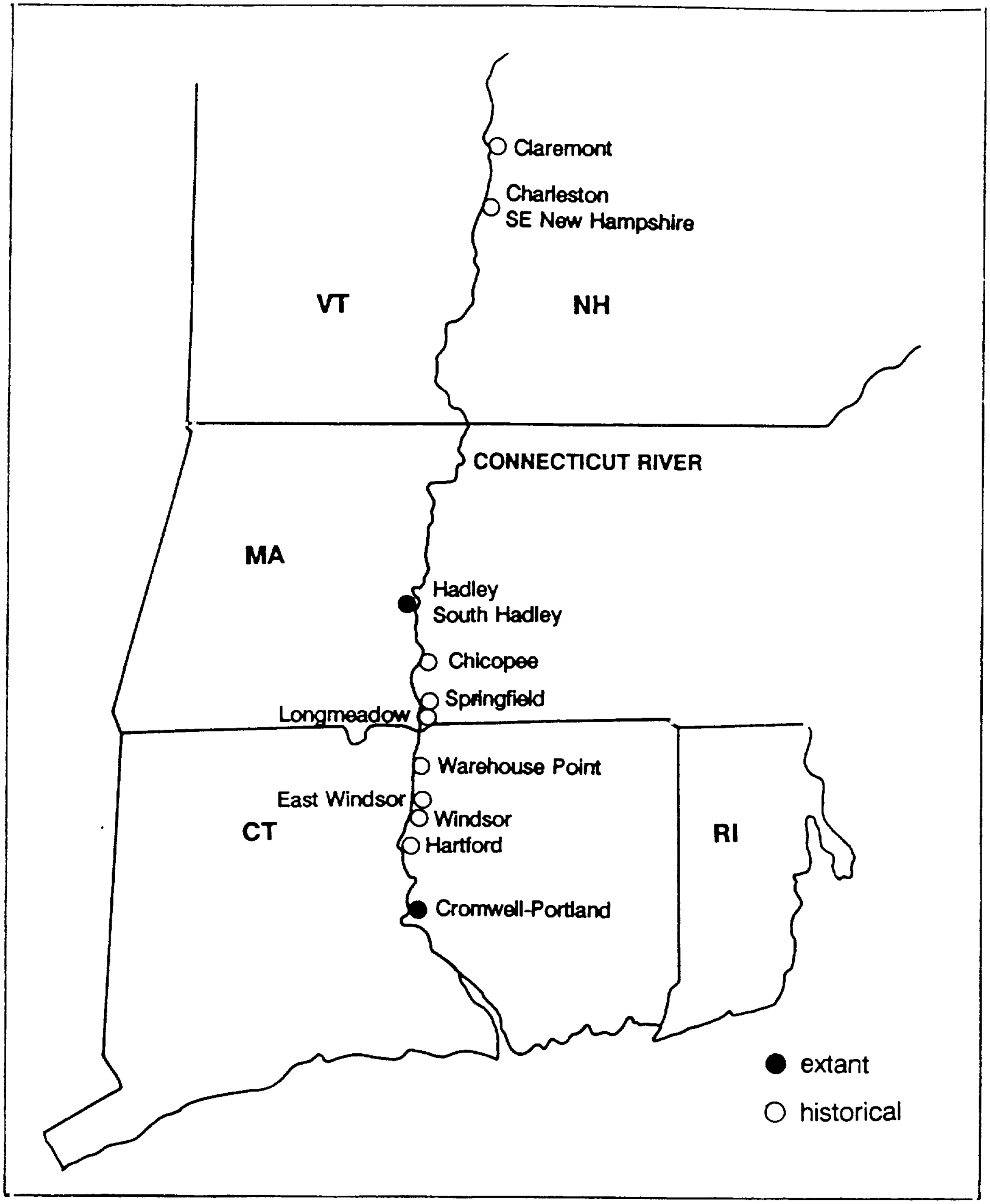

Figure 1. Current and historical *Cicindela puritana* distribution in New England

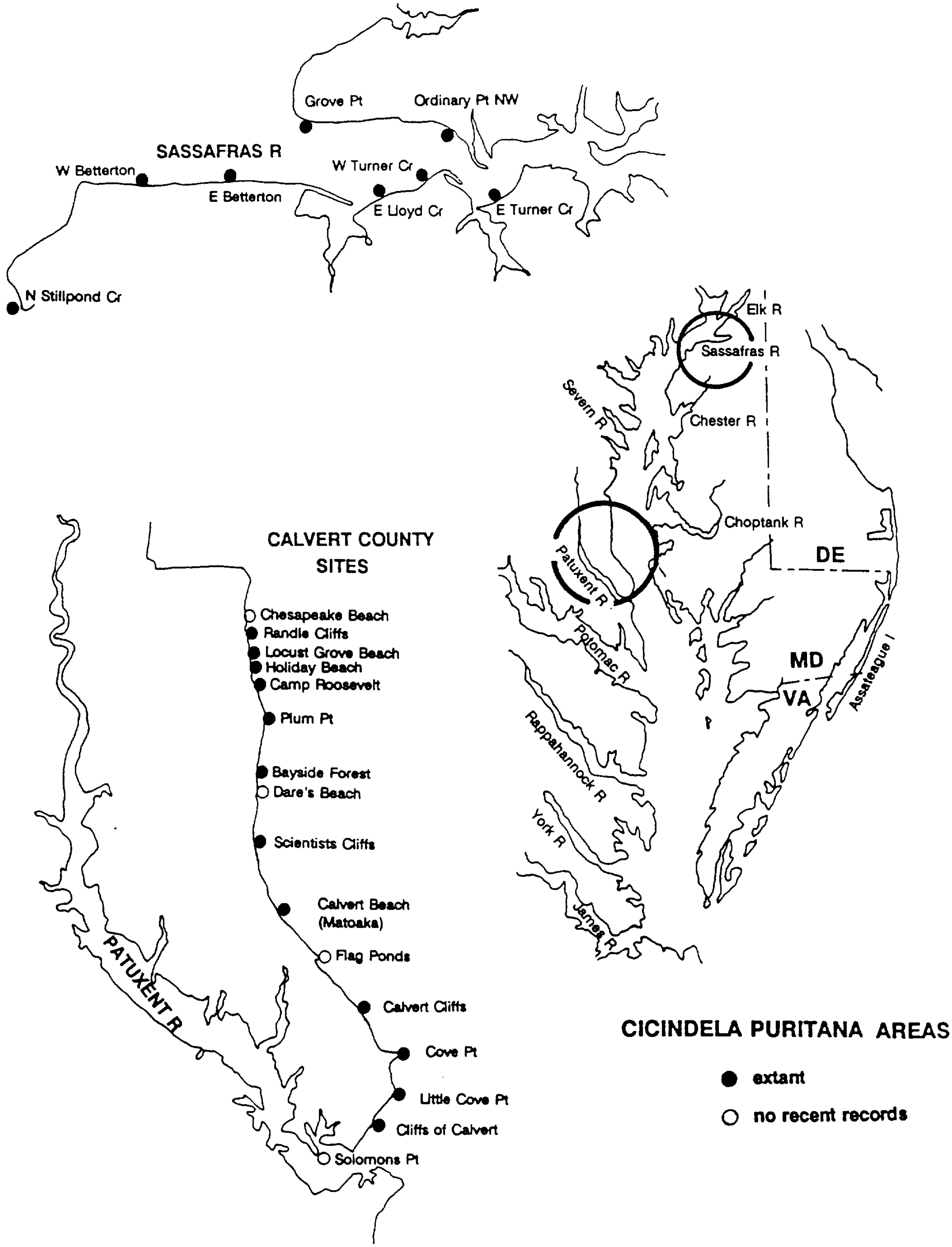

Figure 2. Current and historical *Cicindela puritana* distribution in the Chesapeake Bay region

Table 2. Population numbers for Cicindela puritana in Maryland

SASSAFRAS RIVER	1989	1991	1992	1993
Grove Point	---	c. 1000	1667	750
Ordinary Point NW	650	12	215	88
East Turner Creek	150	7	99	20
West Turner Creek	150	0	51	12
East Lloyd Creek	---	9	205	139
East Betterton	100	0	20	19
West Betterton	---	79	281	236
North Stillpond Creek	---	---	217	190

CALVERT COUNTY	1986	1988	1989	1990	1991	1992	1993
Randle Cliffs	200	93	119	133	57	65	54
Camp Roosevelt	20	73	4	---	17	10	---
Bayside Forest	75	22	6	64	38	75	68
Scientists Cliffs North	1000	3171	1047	1162	1647	1617	1705
Scientists Cliffs South	---	c. 400	444	180	410	412	301
Calvert Beach/Matoaka	?	2697	602	1225	1395	743	731
Calvert Cliffs State Park	?	2194	702	643	835+	2565	1177
Little Cove Point	250	328	85	102	738	232	757
Cliffs of Calvert	---	259	35	42	155	307	64

refer to Table 2), perhaps indicating relatively unrestricted interchange among sites.

The ecological and evolutionary significance of these small populations is not fully understood; however, adult numbers do fluctuate widely from year to year, such that small populations may become large at a later time. Small populations are likely important in providing habitat for dispersing beetles and for maintaining stable metapopulation structure.

DESCRIPTION AND TAXONOMY

Cicindela puritana is a medium-sized (males average 11.5 mm and females average 12.4 mm in Calvert County) terrestrial beetle of the family Cicindelidae (Figure 3). This family is closely related to the family Carabidae and is included as a subfamily of Carabidae by some authors. The background coloration of *C. puritana* is dark bronze-brown to bronze-green with cream-colored markings on the elytral surfaces.

C. puritana was described by G. Horn (1876) and recognized as a separate species by Schaupp (1883-1884). The taxon subsequently was described as a subspecies of, first, *C. cuprascens* (Leng 1902, Horn 1930), then *C. macra* (Vaurie 1951). Willis (1967) established separate species status for each of these taxa, using only Connecticut River specimens of *C. puritana* for his analysis. The range of *C. puritana* is separated by several hundred miles from the overlapping ranges of *C. cuprascens* and *C. macra*.

The evolutionary history of this species is uncertain. Willis (1967) suggested that *C. puritana* evolved from southeastern populations of *C. cuprascens*, which became isolated in the Northeast after coastal plain populations were decimated by climatic changes during the Pleistocene. Boyd (1975) speculated that *C. puritana* moved south during periods of glaciation and north during warmer periods, surviving where habitat was suitable. Leng (1912) postulated that the species may have been an emigrant from more southerly populations.

Populations of *C. puritana* from the New England and Chesapeake Bay regions probably have been separated less than 5000-8000 years, as the Chesapeake Bay formed only within that period. Nevertheless, there are significant differences in larval ecology between the Chesapeake Bay and Connecticut River beetles, and preliminary data indicate substantial genetic differentiation between the two (Vogler *et al.* 1993).

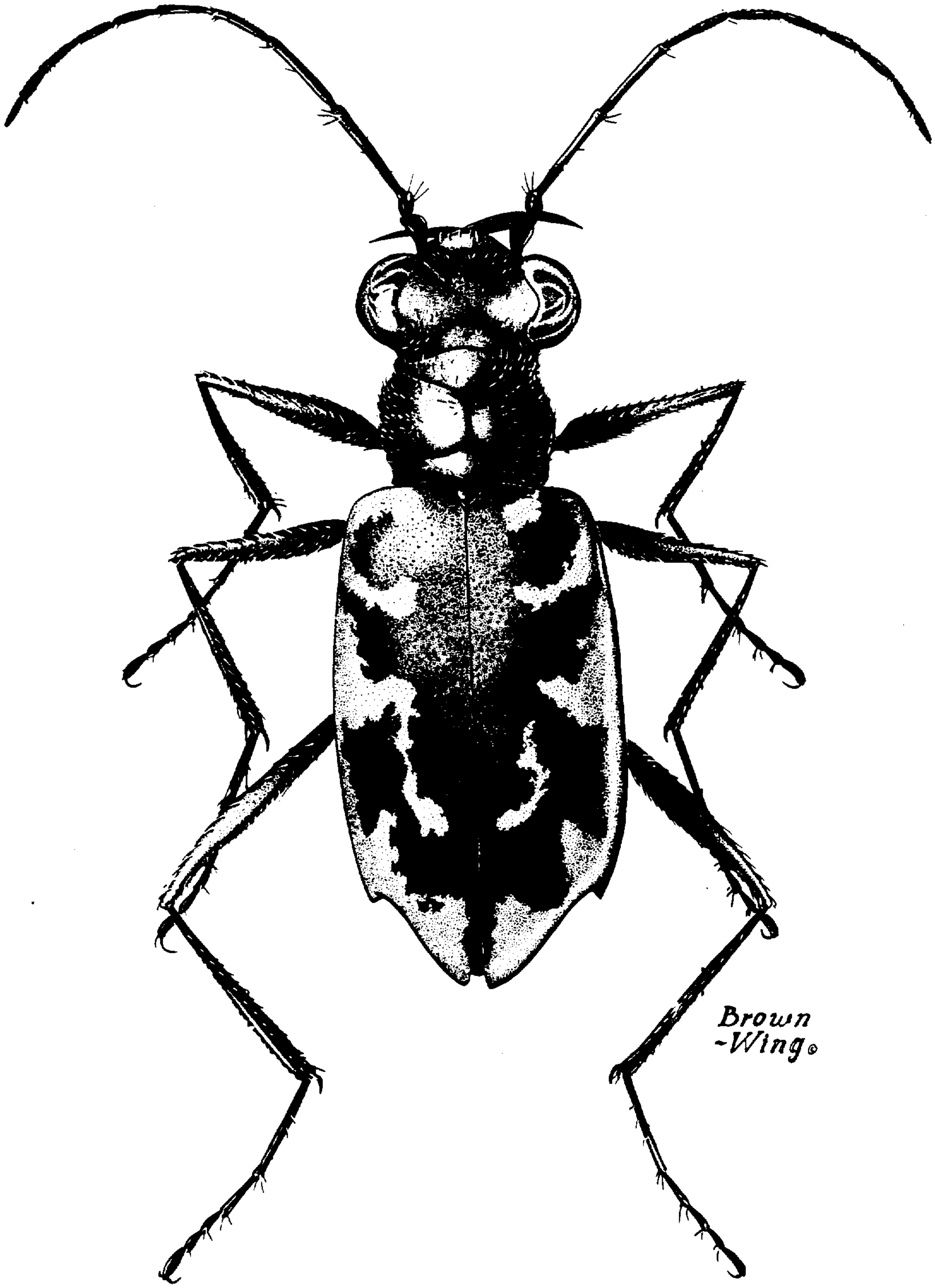

Figure 3. Cicindela puritana

ECOLOGY AND LIFE HISTORY

Cicindela puritana, like many tiger beetles, has very specific habitat requirements, which have been found to differ between the Chesapeake Bay and Connecticut River populations. In Maryland, C. puritana larvae live in deep burrows, which they dig in sandy deposits on non-vegetated portions of the bluff face. They may also burrow at the base of the bluffs in sediment deposits that have eroded from the bluff face. Knisley (1987a) and Hill and Knisley (1991) have found Chesapeake Bay populations to be most abundant where bluffs are long and high, with little or no vegetation, and composed at least in part of yellow or red sandy soil. Wave-producing storms and concomitant erosion of bluffs are necessary to maintain the bare bluff faces required for larval habitat. Larvae will not utilize densely vegetated bluffs; for instance, Hill and Knisley (1991) found that no tiger beetle larvae or adults occupied bluffs stabilized by kudzu at Calvert Beach, Maryland, although both C. puritana and C. repanda were numerous on adjacent natural bluffs.

In contrast to these observations in Maryland, Nothnagle (1987, 1989, 1990) found that larvae at the two extant populations on the Connecticut River generally do not use the low bluffs; instead, their burrows are found among scattered herbaceous vegetation at the upper portions of sandy beaches and occasionally near the water's edge. At the lower Connecticut River site, the larvae are thus subject to tidal flooding twice daily. It is not known whether the differences in habitat preference are inherent or have resulted from recent habitat changes. However, recent observation indicates the potential for some flexibility in larval behavior. P. Nothnagle (pers. obs. 1993) noted some C. puritana larval burrows in the vertical portion of a low (5 m) bank at the Cromwell-Portland site, where the beach almost disappears at high tide.

Adult C. puritana also exhibit some flexibility in habitat preference. Nothnagle (1991) reports that adult beetles preferred wide, sandy beaches in 1988 and 1989, but were found in greatest concentrations on narrow beaches below sandy clay banks in 1990. This year-to-year variability in microsite preference bears further study. It is noteworthy that both of the Connecticut River sites occur on sediment deposits along large river bends. Apparently, the composition of the sediment deposits (perhaps in combination with the dynamic river flow at these sites) provides a suitable substrate for larval burrows (P. Nothnagle pers. obs.).

Puritan tiger beetles typically undergo a two-year larval period before emergence, similar to that of other species in the genus Cicindela. Larvae hatch in late July or August as first instars. This stage lasts 2-4 weeks; larvae then molt and become second instars. Larvae generally over-winter as second instars and become active again (as evidenced by open burrows) the following spring, when they molt to the third instar. Recent observations indicate that the third instar may last another year, but further studies are required to substantiate this finding.

Larvae tend to be most active (as evidenced by open burrows) in the fall, with lesser numbers appearing in the spring and summer. Pupation occurs in late spring, and in Maryland adults emerge during mid- to late-June (Hill and Knisley 1991). The timing of adult emergence is 2-3 weeks later in the Connecticut River populations (P. Nothnagle pers. obs.).

The adult populations peak in late June to early July and begin to decline in late July. Population size then decreases rapidly until the middle of August, when only a few adults remain. A sympatric species, Cicindela repanda, exhibits an opposite seasonality, with adults emerging during the spring and fall, and larval activity occurring mostly during the summer months, although there is some interspecific overlap of both adults and larvae.

Adult C. puritana are active both day and night. Adults feed throughout the day, and mating activities are commonly observed during the afternoon. Pairing activity increases in late afternoon and seems to peak in the early evening. Oviposition behavior is unknown. Larvae are active (as evidenced by open burrows) day and night during cool weather in late spring and early fall. Their activity is reduced during hot, sunny weather (C.B. Knisley and J.M. Hill pers. obs.).

Little is known about adult dispersal. It is probable that some individuals disperse from their site of emergence, as indicated by mark-recapture studies in Maryland (Knisley and Hill 1989), which showed that adult numbers decline about two weeks after emergence. No recaptures of marked beetles were obtained from other sites, albeit search effort was minimal. Long-distance dispersal ability is suggested by the observation of two unmarked individuals near Annapolis, Maryland on Bodkin Creek and one individual at the mouth of the Patapsco River, all in Anne Arundel County (T. Koenig, Randolph-Macon College, pers. obs. 1989). These sites are approximately 30 miles north of the nearest known Calvert County sites, and about 25 miles from known sites near the mouth of the Sassafras River.

Knowledge of adult and larval feeding behavior is also limited. The larvae firmly position themselves at the mouths of their burrows by means of abdominal hooks and wait for small invertebrates to pass by. Adults feed actively in the wrack along the shoreline and probably also to some extent on the bluff face. Smaller invertebrates probably comprise the bulk of their diet.

Puritan tiger beetles are also the object of some predation. Robber flies (family Asilidae) and jumping spiders (family Salticidae) have been observed preying on adult tiger beetles (J.M. Hill and C.B. Knisley pers. obs.). Larvae are commonly parasitized by a tiphiid wasp of the genus Methoca. It is suspected that many larvae die when winter storms shear off large sections of bluff (Hill and Knisley 1991). Larval mortality associated with winter storms may contribute to the dramatic local fluctuations observed in some C. puritana populations.

REASONS FOR LISTING AND CONTINUING THREATS

Two main concerns led to the listing of Cicindela puritana: (1) only two populations remain within the species' former range in New England, and (2) the majority of Chesapeake Bay populations are thought to be in imminent danger of decline or extirpation as a result of anthropogenic habitat alteration.

The species' decline in New England is associated with the construction of 17 dams on the Connecticut River above Hartford. The network of flood control dams that extends throughout the Connecticut River watershed has resulted in profound changes to the river's hydrologic cycle: floods are no longer as high, and periods of low flow have been greatly altered by flow scheduling for hydropower, likely reducing the amount of beach habitat available for foraging adult C. puritana and perhaps reducing the amount of bank erosion. Loss of the New Hampshire sites may have been due to inundation above the dam at Bellows Falls, Vermont. Urbanization and bank stabilization probably contributed to loss of populations at Hartford, Connecticut, as well as Chicopee, Springfield, and Longmeadow, Massachusetts. Pollution of the Connecticut River from mill and factory effluent may also have contributed to the species' decline.

There has been an extensive and largely successful effort to clean up the Connecticut River over the past several decades (McCarry 1972); ironically, the river's current designation as Class C water (unfit for swimming) is probably responsible for less direct human impact on the beetle than would otherwise occur (Nothnagle 1991). Nevertheless, certain recreational uses of the river shoreline continue to imperil the two remaining populations as well as potential reintroduction sites. For instance, the three small Massachusetts sites are currently threatened by camping and beach recreation, which occur on larval habitat (Nothnagle 1987, 1990). The three Cromwell, Connecticut sites are often completely flooded, but greater threats are posed by habitat alteration (e.g., nearby residential construction), and off-road vehicle traffic and camping, which may directly destroy larvae.

Despite protection efforts, the Massachusetts C. puritana population has been declining steadily since 1988. It has been suggested that the tiger beetle habitat at these sites is being adversely affected by the invasion of woody plants (P. Nothnagle pers. comm. 1992). Trampling of larvae, which inhabit flat, sandy beaches along the Connecticut River that receive relatively concentrated recreational use, may also be affecting these populations. (Chesapeake Bay larvae occur on bluff faces, reducing the likelihood of trampling; however, as visitation to Chesapeake shoreline areas increases, the possibility of impacts from various recreational activities may also increase.)

At the present time, shoreline development and shoreline stabilization are the most serious and least controllable threats to Puritan tiger beetles in Maryland (Bartgis and MacIvor in press). Shoreline stabilization structures, including revetments, offshore breakwaters, and groins, are designed to minimize wave-induced erosion at the base of the bluff such that, over time, the slope of the bluff will decrease, eventually reaching a stable angle of repose. Slopes thus stabilized eventually become vegetated, making them unsuitable for C. puritana larval habitat (Hill and Knisley 1991 and pers. obs.).

Calvert County is the fastest growing county in Maryland, with a human population increase of over 300% since 1950. Most of the significant C. puritana sites in Calvert County, including Scientists Cliffs, Calvert Beach, Little Cove Point, and Cliffs of

Calvert, have been subdivided, and houses have been constructed a short distance from the top of the bluff. Based on known erosion rates, all these sites can be expected to require major shoreline stabilization projects in the near future (Bartgis and MacIvor in press). For example, a permit was recently issued for construction of a revetment at Little Cove Point, where a house was in imminent danger of falling into the Bay. A similar situation exists on the Sassafras River, where the U.S. Fish and Wildlife Service issued a jeopardy Biological Opinion in 1991 for a proposed erosion control revetment. Significant sections of bluffs in Calvert County have already been destroyed or stabilized at sites such as the Naval Station at Randle Cliffs and the nuclear power plant intake/docking facility at Calvert Cliffs.

Currently, only five of the 19 Maryland sites are relatively secure, insofar as they are located on properties that are State- or county-owned, or through the voluntary cooperation of private landowners. For those few sites occurring on large tracts with few impacts, current zoning ordinances discourage future high density development.

There appears to be a pivotal difference in the underlying processes threatening the continued existence of Connecticut River *Cicindela puritana* populations versus those in the Chesapeake Bay. On the Connecticut, the dynamic geological processes that originally created and maintained the beetle's habitat have been permanently altered by damming, whereas the dynamism of the Bay system remains. Although the majority of the species' habitat along the Chesapeake Bay has been pre-empted by stabilization and development, thus creating an urgent need for site protection in the region, at least the basic processes that maintain *C. puritana* habitat have not been altered. On the Connecticut, the lack of potential habitat combined with vegetational succession in some areas of occupied habitat indicates that more management intervention may be required to maintain early successional conditions on the few remaining areas of suitable habitat.

CONSERVATION MEASURES AND CURRENT RESEARCH

The States of Connecticut, Maryland, and Massachusetts list Cicindela puritana as endangered. Their State laws, as well as regulations promulgated under the Endangered Species Act of 1973, prohibit collection or harassment of this species. The Endangered Species Act also obligates Federal agencies to ensure that their actions do not jeopardize the continued existence of listed species, and provides a framework for the species' conservation.

Since mid-1985, Cicindela puritana studies funded by the U.S. Fish and Wildlife Service, Maryland Natural Heritage Program, Massachusetts Natural Heritage Program, Connecticut Natural Diversity Database, and The Nature Conservancy have been conducted in Maryland, Connecticut, and Massachusetts. These studies have provided initial data on distribution, annual and seasonal abundance, and certain aspects of larval ecology. In 1989, detailed ecological studies were begun at Calvert Beach in Maryland to determine aspects of reproduction, feeding, predation and parasitism, dispersal, competition, habitat relationships, and general behavior of C. puritana.

To help determine which areas can be managed for maintenance of Puritan tiger beetle populations in the State, the Maryland Natural Heritage Program analyzed land ownership and land use patterns along shoreline habitats occupied by the beetle (Bartgis and MacIvor in press). Based on the results of this analysis, priority areas have been identified for conservation of the Puritan tiger beetle in Maryland, including:

Sassafras River (Cecil County),
West Betterton (Kent County),
Scientists Cliffs (Calvert County),
Calvert Beach (Calvert County), and
Calvert Cliffs (Calvert County).

Although these large population areas provide a focus for priority conservation efforts, it is also imperative to protect smaller sites in the vicinity of the priority areas, in order to assure perpetuation of sufficient habitat to maintain stable metapopulation structures. Smaller population sites may be of critical importance in (1) providing reserve population sources in the event of local disaster and/or (2) supplying presently unknown but key habitat features.

The Maryland Natural Heritage Program, in cooperation with The Nature Conservancy, is pursuing fee acquisition, easements, or management agreements at three of the priority conservation sites. Landowners of smaller but critical tracts have also been contacted by Natural Heritage Program staff. Randle Cliffs is under active consideration for acquisition as a local nature park (Maryland Natural Heritage Program 1992).

Maryland Natural Heritage Program staff have provided management recommendations for significant Puritan tiger beetle populations to the three counties with populations of these beetles. This information is intended to be included in local land use ordinances as part of the counties' Chesapeake Bay Critical Areas Programs. Protection areas have already been established for some sites in Calvert and Cecil Counties, and several Kent County sites are being proposed. Calvert County has established a Cliff Policy Task Force, one goal of which is to determine which areas are unsuited for development, and, where development will be allowed, to establish appropriate setback distances from the bluffs (D. Brownlee, Calvert County Department of Planning and Zoning, pers. comm. 1993).

Much of the bluff area at Calvert Cliffs State Park has been fenced off since 1989 due to dangerous erosion conditions, and this has probably helped in habitat preservation, as evidenced by the fact that the fenced-off areas have the largest *C. puritana* populations.

Searches for additional sites were conducted in Calvert County from 1985 to 1992, and searches have been conducted since 1987 along the Sassafras River in the upper Chesapeake Bay. These searches have yielded knowledge of several sites, as summarized in the section on Population Status and Distribution.

Discovery of the Cromwell, Connecticut site was also a result of recent search efforts. Further, because of the cleanup of the Connecticut River during the past several decades, some New England sites may now be suitable for reintroductions.

An experimental reintroduction of adult C. puritana to a historical location in South Windsor, Connecticut was attempted in 1993. Of 39 beetles released, only three were seen again. In contrast, eight of 16 beetles in a control group (handled identically but released on their site of capture) were seen again (P. Nothnagle pers. comm. 1993). This corroborates results obtained in similar experiments with Cicindela dorsalis and underscores the need for developing reliable techniques for rearing and introducing larvae, which may adapt to reintroduction sites better than do adults (see Recovery Tasks 7.1 and 7.3).

RECOVERY STRATEGY

The primary strategy for recovery within the Chesapeake Bay portion of the species' range will be to classify and protect as much extant C. puritana habitat as feasible. Habitat protection will be accomplished through public education, acquisitions, easements, and working with landowners and local planning authorities to initiate and implement regulations for habitat conservation. Work has already begun in this area.

Habitat protection is also vital along the Connecticut River, and some vegetation management may be required to maintain open habitat at the extant Connecticut and Massachusetts sites. Establishment of additional Connecticut River populations will be required for full recovery; results of recent morphological and captive rearing studies give reason for optimism regarding the potential success of this recovery strategy.

In order to refine management techniques and ensure successful establishment of additional populations, further information will be required on life history, laboratory rearing, metapopulation dynamics, and genetics. Finally, careful monitoring and assessment of threats to the species will be an ongoing and key component of the recovery program.

PART II: RECOVERY

RECOVERY OBJECTIVE

The objective of the Cicindela puritana recovery program is to restore this threatened species to a secure status within its historical range, thereby enabling its removal from the Federal list of endangered and threatened wildlife and plants.

Delisting will be considered when:

1. A minimum of six large (500-1000+ adults) populations and their habitat are protected in perpetuity at current sites along both shores of the Chesapeake Bay.

2. Sufficient habitat between these populations is protected to support smaller populations, thereby providing an avenue for genetic interchange among large populations and ensuring a stable metapopulation structure.

3. A minimum of three metapopulations, at least two of which are large (500-1000+ adults), are maintained (at extant sites) or established[1] within the species' historical range along the Connecticut River, and the habitat they occupy is permanently protected.

4. There exists an effective long-term program for site-specific management that is based on an adequate understanding of life history parameters, human impacts, factors causing decline, population genetics, and taxonomy.

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1 "Established" is defined as self-maintaining for at least 10 years, with no foreseeable threats.

RECOVERY TASKS

1. Monitor known populations.

This information is essential to the management and recovery of C. puritana. Regular monitoring can provide an indication of population fluctuations and allow detection of population changes over time in relation to habitat changes or limiting factors. Monitoring will show the relationship between habitat size, habitat quality, and population size and stability.

1.1 Monitor adults. The monitoring schedule will include: (1) a minimum of one visit per year to all Maryland sites that support large Puritan tiger beetle populations, (2) biennial visits to all other known occupied sites in Maryland, and (3) two or three visits per year, as deemed necessary, to the Connecticut River sites. The purposes of these site visits will be to count adults and to note the general condition of the population sites along with any changes in land use or human activity in the vicinity.

1.2 Monitor larvae. Surveys for larvae in permanent plots on bluffs or beaches should be conducted over a 2-3 year period, during peak season (September), at a minimum of three Chesapeake Bay sites harboring large ($\geq$ 500 adults) populations and at the Cromwell, Connecticut site. Larvae will be counted on 5-10 meter wide permanent plots distributed along the site. The purposes of these counts will be to assess annual fluctuations in larval numbers, mortality, and recruitment, and to determine if management is needed to maintain or increase these populations. In addition, bi-weekly or monthly visits to both a large Chesapeake

Bay population and the Connecticut population should be made between April and October to count larvae.

1.3 Search for additional populations. Searches will be conducted in areas where additional sites may exist, particularly in the Chesapeake Bay region. Documentation should be provided for each site checked in the field, since even unoccupied sites could become colonized later by natural dispersal. An unoccupied site may constitute suitable habitat even though the previous population was extirpated, especially if there is no close source population.

Newly located populations will be monitored in accordance with Tasks 1.1 and 1.2.

2. Determine population and habitat viability.

While information regarding population viability and habitat requirements will be critical for long-term acquisition, reintroduction, and conservation efforts, current gaps in quantified data should not deter initial recovery efforts.

2.1 Analyze population viability. A preliminary estimate of 500-1000 adults as a minimum viable population size for this species (Hill and Knisley 1991) is based on estimates in the literature (Mettler and Gregg 1969, Lacy 1987, Thomas 1990) and on preliminary observations of population stability and decline at several sites. However, at present no long-term genetic or demographic information is available to accurately model how many adults on how large an area, and in what proximity to other large or small populations, are needed to sustain long-term population viability.

Data collected in Tasks 1.1 and 1.2 will be analyzed to determine the size at which a population becomes unstable. Although long-term data are necessary to accomplish this task fully, it is believed that monitoring of additional small population sites for three years will provide a good base of information for conducting initial analyses. Population viability analysis will be conducted by contrasting population size, trends, and genetic variability with habitat availability, quality, and isolation (Murphy et al. 1990).

2.2 Model effects of habitat changes. A predictive model of shoreline/habitat changes relative to population performance is needed. This will involve determining whether changes in shoreline configuration or other habitat features at individual sites are associated with corresponding changes in tiger beetle population levels at these sites. This analysis will require several years of beetle population data to control for year-to-year fluctuations associated with local weather conditions. Data on shoreline changes in Calvert County are currently being gathered and assembled into a GIS database. Similar data should be collected throughout the species' range.

3. Identify and protect viable populations and their habitat. Initially, protection efforts should concentrate on sites with high defensibility.

3.1 Identify and pursue long-term protection of priority sites. Protection of the priority sites in Maryland (Sassafras River, West Betterton, Scientists Cliffs, Calvert Beach, and Calvert Cliffs, as discussed in Conservation Measures) has already been initiated (Bartgis and MacIvor in press). Both of the Connecticut River populations are considered to be of the highest priority for conservation.

Acquisition, leases, easements, and management agreements will be used, as appropriate, to protect priority habitat. County officials will be urged to initiate a long-range land use planning process that will ensure protection of C. puritana sites in perpetuity. This task is ongoing, and considerable progress has already been made (see Conservation Measures).

3.2 Pursue landowner contacts for all known populations. Landowners, caretakers, or managers of all sites with existing populations (regardless of their protection priority) will be notified about the existence of C. puritana on their property. An effort should be made during each contact to provide the landowner with information pertaining to the species and to solicit support for the recovery effort. As appropriate, permission will be sought to monitor, study, and manage the species over the long term. The landowner should be apprised of any Federal, state, or local laws regarding protection of listed species. Considerable progress has been made on this task as well (Maryland Natural Heritage Program 1992).

3.3 Use existing laws and regulations to protect the beetle populations. State and Federal laws prohibiting take of C. puritana and/or any Federal activities that would jeopardize the species' continued existence will be fully implemented in order to maximize protection of populations.

3.4 Identify additional protection needs. Possible limiting factors, such as vegetation encroachment on the Connecticut River and Maryland sites, may need to be addressed (see also Task 6.2). Any needed management actions should be implemented as soon as possible, particularly on small sites, to avert further population declines.

4. Implement appropriate management measures at natural population sites.

Based on results of studies described in the above tasks, it may be deemed necessary or desirable to undertake certain management actions. For example, it may become necessary to remove or control invading vegetation from certain tiger beetle sites. Habitat manipulations should be approached very cautiously, always keeping in mind the overriding goal of maintaining the species in its **natural** habitat. Such management activities would be initiated only with the cooperation of landowners and the community, if the land is privately held. In some cases, purchase of the site may be appropriate (see Task 3.1).

5. Study anthropogenic influences.

Human impacts appear to be key factors in the reduction of C. puritana populations. Detailed studies should be conducted with the aim of maximizing the compatibility of human activities with the species' continued existence.

5.1 Study the effects of recreational use on beetle habitat and survival. Intensive recreation and foot traffic may be significant factors in larval destruction, particularly for the Connecticut River populations. The level of impact should be determined in order to develop protective actions, if warranted. In addition, if recreational use intensifies along the Chesapeake Bay, effects on these populations should be ascertained.

5.2 Examine possibilities for shoreline erosion control in Maryland. Erosion control structures, particularly rip-rap placed along the shoreline, are presently considered incompatible with the long-term survival of C. puritana, which requires a continuously eroding, bare, relatively vertical bluff face for larval development, and a sandy beach for adult feeding activity. Paradoxically, it is very likely that many larvae die when large sections of bluff slough off during winter storms. It may be possible to engineer a structure or other method of erosion control that would decrease but not wholly eliminate erosion of the cliff face. Such a design would be worth investigating, and even testing, on a short section of C. puritana habitat. Until such an experimented is conducted, however, all existing shore erosion control structures must be viewed as incompatible with long-term Puritan tiger beetle survival.

6. Study life history parameters and taxonomic relationships. This information is essential to the management and recovery of Cicindela puritana. Research activities should be coordinated between New England and Chesapeake Bay populations.

6.1 Determine natural limiting factors. Although much has been learned recently concerning factors limiting C. puritana, certain aspects of its life history remain unknown. Investigation of the following limiting factors will provide data for an accurate population viability analysis (Task 2): (1) habitat factors that affect larval distribution, both within and between sites; (2) the importance of various sources of mortality, including winter storms, larval parasitism, and predation on adults; (3) seasonal movements of larvae in New England; (4) the importance of competition and interactions with sympatric congeners (for example, does the presence of large numbers of C. repanda increase parasitism by Methoca or in any other way decrease survival of C. puritana?); and (5) reproductive output per female. Comparative studies in New England and the Chesapeake Bay should be conducted, as limiting factors may differ geographically.

6.2 Examine limiting factors specific to Connecticut River sites. It is vitally important to investigate the possibility that these sites are being encroached upon by woody plants, and to undertake necessary vegetation control measures if such proves to be the case. Other factors, such as recreational use, water pollution, and water level and sediment changes associated with dams should be investigated and remedied, as appropriate.

6.3 Determine the importance of dispersal. A knowledge of dispersal capabilities is important because survival of this species seems to depend on colonization of a dynamic and transient habitat. Knowledge of dispersal abilities will also aid in identifying suitable reintroduction sites and in meeting recovery goals. The bluff habitat along the Chesapeake Bay may increase or decrease in suitability depending on the number or intensity of winter storms in different years. Along the Connecticut River, sandbars and beaches that are necessary for larval habitat may shift with changes in the river's flow regime.

Both the percentage of the population that disperses and the average and maximum distance of dispersal should be determined. This can be accomplished by marking several thousand beetles at a large Calvert County population site approximately once a week prior to anticipated dispersal flights, then visiting other shoreline sites in Calvert County during the month following dispersal in order to capture and sex all recoveries.

6.4 Conduct morphometric and breeding behavior studies. Traditional morphometric studies of *C. puritana*, comparing Chesapeake Bay and New England populations, will be used to supplement the molecular analyses described in Task 6.5. In addition, studies of mate choice between New England and Chesapeake Bay populations will be used to provide a real-animal substantive basis for interpreting genetic analyses. To date, analysis of 13 traits indicates no consistent morphological differences between the two stocks (Knisley and Hill in prep.). Furthermore, mating studies show fairly free inter-mating between the Bay and Connecticut River populations (Knisley and Hill in prep.).

6.5 Analyze genetic variability. The phylogenetic relationship of the Chesapeake Bay and New England populations has been recently examined, using mitochondrial DNA techniques (Vogler *et al.* 1993). In contrast to morphometric studies (Task 6.4), the comparative analysis of DNA sequences indicate that *C. puritana* from the Chesapeake Bay and Connecticut River populations represent distinct genetic units.

Given this result, it seems prudent to proceed initially by treating Bay and Connecticut River *C. puritana* as separate "conservation units". Therefore, this plan recommends the strategy of increasing the stock of Connecticut River *C. puritana* genomes, possibly through captive rearing, to provide individuals for release elsewhere in New England. Preliminary results of rearing studies (Task 7.1) indicate that this approach to reintroductions may be feasible. Nevertheless, it should be kept in mind that the results of the morphological and behavioral experiments provide reason for optimism that Bay stock could successfully be used to re-establish or replenish Connecticut River populations if these sites were to become extirpated through stochastic fluctuations or if inbreeding depression has already occurred in these populations.

7. Develop techniques for and reintroduce populations to appropriate habitat along the Connecticut River.
Due to the small and tenuous condition of the two Connecticut River *C. puritana* populations, reintroductions may be critical to the continued existence and recovery of this species in the New England portion of its range. Some (although not an abundance of) presently unoccupied, suitable habitat is believed to exist along the Connecticut River. Unoccupied suitable habitat may be attributed to a previous local extirpation, with no nearby population to provide a source for recolonization.

7.1 Develop techniques for captive rearing. Given the low number and small sizes of the Connecticut River populations, development of captive rearing and larval translocating techniques appear necessary if the genetic integrity of Connecticut River *C. puritana* is to be maintained. This is especially true in light of recent failures of adult reintroduction attempts. Research into various captive rearing techniques may result in the development of methodologies that are less laborious than present techniques and yield a large number of larvae for reintroduction. For example, preliminary observations made incidentally to *Cicindela* mating experiments conducted in 1993 indicate that captive-bred *C. puritana* and *C. dorsalis dorsalis* females will oviposit and produce larvae through at least the first instar stage in captivity (C.B. Knisley pers. comm. 1993). This research should be continued in 1994.

7.2 Identify, acquire access to, and prepare appropriate reintroduction sites. Museum specimens have been useful in identification of the historical range of C. puritana, although only a few of the historical sites in New England may prove adequate today for successful reintroduction activities. Additional sites will need to be checked and prepared before releases of adults can take place. In some cases, this process may require lengthy negotiations, along with site preparation measures such as fencing or removal of existing shoreline control structures. The long-range distribution of populations will be considered when selecting reintroduction sites. Initial priority will be given to sites on public lands, particularly those with other rare or listed species. Ideally, each reintroduction site should be large enough to allow for dispersal within its boundaries, with nearby sites also available for dispersal.

7.3 Design and test reintroduction protocol. Based on available information, it currently appears advisable to use only stock from the largest Connecticut River site (Cromwell, Connecticut) for reintroduction to sites along the Connecticut River. Ultimately, this may depend on results of captive rearing techniques to create sufficient stocks. Use of Chesapeake Bay stock will be considered if captive rearing does not work or if the only known remaining natural Connecticut River populations disappear. In order to avoid depleting the source population, no more than 10% of the Cromwell population should be removed; roughly 8% of the Cromwell adults were moved in the 1993 South Windsor experiment (P. Nothnagle pers. comm.). A re-focus on larval transplants (see below) may prove more successful and would preserve the existing adult stock at Cromwell.

Release protocols presently (1993) being used for adult Cicindela dorsalis dorsalis and Cicindela puritana have been as follows: Releases are made soon after elytra have hardened, i.e., early July. An equal sex ratio is preferable. Adult beetles are collected, placed individually in vials, chilled on ice, rushed to the reintroduction site, released in small groups, and observed until they have regained mobility.

Preliminary data regarding both the northeastern beach and Puritan tiger beetles indicate that a large percentage of introduced adult beetles disperse from the introduction site (Knisley and Hill 1991a; Hill, Koenig, and Knisley unpubl. data; P. Nothnagle pers. obs.). Thus, efforts should now focus on developing methods to increase site fidelity or decrease mortality of introduced individuals. An alternative currently under consideration is translocation of larvae rather than adult beetles. It is possible that larvae emerging at a translocation site may exhibit greater site fidelity (whether through "imprinting", minimal behavioral disruptions of adult stage, etc.). In consideration of the species' two-year life cycle, larval releases should, at a minimum, be implemented in two successive years at each release site, to produce annual adult emergence. Supplementation should be continued as needed, possibly for several years, to ensure population establishment. When additional C. puritana populations are established, appropriate management will be implemented as described in Task 4.

One reintroduction could be attempted in New England in 1994, if Task 7.2 has been completed sufficiently.

7.4 Conduct reintroductions and monitor results. If the introduction referred to in Task 7.3 proves successful, one to three operational reintroductions should be attempted each year until recovery objectives are met. The number of reintroductions to new sites or augmentations of founder populations will likely be limited by availability of parental stock. Revised rearing procedures will be developed (Task 7.1), and captive-reared individuals will be used for future reintroductions as appropriate. If initial reintroductions using stock from the Cromwell population fail within three or four years, then the possibility of using Chesapeake Bay stock may be re-examined. A reintroduction will be deemed successful if adult reproduction results in two successful cohorts, i.e., larvae emerge as adults in two successive years, and subsequent monitoring shows the population to increase initially and to be increasing or stable for at least ten years. A ten-year criterion is necessary (a) because populations may show considerable natural year-to-year fluctuations, and (b) due to the two-year life cycle; a ten-year criterion actually represents a five-year period for two largely separate populations.

8. Conduct a public education program.

Knowledgeable conservation professionals will inform interested parties about proposed or ongoing management activities, conveying the value and benefits of endangered species in general and C. puritana in particular. Educational efforts will be directed toward the general public as well, in a way that elicits positive attitudes about endangered species. The concept of an endangered or threatened insect is unfamiliar to many people. Educating the public about rare tiger beetles will have a positive effect for the cause of endangered species conservation in general.

Educational brochures (Hill 1988), posters, slide shows, films, and/or other materials will be prepared for widespread distribution. Publication of scientific papers and general interest articles in non-technical publications by those involved in research and recovery should be encouraged.

9. Coordinate implementation of the recovery program.
An informal group of biologists, land use planners and managers, and educators will be convened as needed to coordinate implementation of the recovery program. Among the group's first tasks will be to continue monitoring selected sites and to identify potential reintroduction sites.

An *ad hoc* task force, to include non-governmental members of the recovery group, will periodically attend field meetings to offer scientific insights on matters related to recovery goals.

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PART III: IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program over the next three years. It is a guide for meeting the objectives discussed in Part II 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
R5	--	USFWS Region 5 (New England to Virginia)
ES	--	USFWS Ecological Services (includes Endangered Species)
LE	--	USFWS Law Enforcement
SMA	--	State management agency
Priv	--	Private individual or organization
TNC	--	The Nature Conservancy

IMPLEMENTATION SCHEDULE
Puritan Tiger Beetle

September 1993

Priority	Task Description	Task Number	Duration	Responsible Agency: USFWS	Responsible Agency: Other	Cost Estimates, $000: FY1	FY2	FY3	Comments
1	Monitor *C. puritana* adults.	1.1	Ongoing	R5/ES	SMA, Priv	8.5	8.5	8.5	+ 5K/yr for 12 years.
1	Pursue long-term protection of priority sites.	3.1	Ongoing	R5/ES	SMA,Priv	20.0	15.0	10.0	Does not include cost of land acquisition.
1	Pursue landowner contacts for known populations.	3.2	Ongoing	R5/ES	SMA, TNC	10.0	8.0		+ 1K/yr for 12 years. Considerable progress has already been made.
1	Use existing laws and regulations to protect the beetle populations.	3.3	Ongoing	R5/ES/ LE	SMA	3.0	3.0	3.0	+ 3K/yr for 12 years.
2	Monitor *C. puritana* larvae.	1.2	Ongoing	R5/ES	SMA, Priv	3.5	3.5	3.5	+ 3K/yr for 12 years.
2	Search for additional populations.	1.3	2 years	R5/ES	SMA	3.0	3.0		
2	Determine population and habitat viability.	2.	3 years	R5/ES	SMA, Priv	10.0	10.0	5.0	
2	Identify additional protection needs.	3.4	Ongoing	R5/ES	SMA, TNC	5.0		3.0	This task will require funding primarily on an as-needed basis.
2	Implement management at natural population sites.	4.	10 years	R5/ES	SMA			10.0	+ 10K/yr for 11 years.
2	Study the effects of recreational use on beetle habitat and survival.	5.1	1 year	R5/ES	SMA, Priv	1.0			
2	Determine natural limiting factors.	6.1	2 years	R5/ES	SMA	10.0	10.0		
2	Examine limiting factors specific to Connecticut River sites.	6.2	2 years	R5/ES	SMA	4.0	4.0		

Puritan Tiger Beetle Recovery Plan, Implementation Schedule (continued), September 1993

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates, $000 FY1	FY2	FY3	Comments
2	Determine the importance of dispersal.	6.3	3 years	R5/ES	SMA	8.0	8.0	8.0	
2	Analyze genetic variability.	6.5	Periodic	R5/ES	SMA			4.0	Further assessments may be required for future reintroductions.
2	Develop techniques for captive rearing.	7.1	3 years	R5/ES	SMA, Priv	5.0	4.0	4.0	Ongoing funding will be necessary for implementation of proven techniques. Additional funds, 36K total for 12 years.
2	Identify, acquire access to, and prepare reintroduction sites.	7.2	3 years	R5/ES	SMA, TNC	4.0	3.0	3.0	
2	Design and test reintroduction protocol.	7.3	3 years	R5/ES	SMA	2.5	2.5	0.5	
2	Conduct reintroductions and monitor results.	7.4	6 years	R5/ES	SMA			5.0	+ 5K/yr for 5 years.
2	Coordinate implementation of the recovery program.	9.	Ongoing	R5/ES	SMA, Priv	1.0	1.0	1.0	+ 1K/yr for 12 years.
3	Examine possibilities for shoreline erosion control in Maryland.	5.2	Ongoing	R5/ES	SMA, DNR			15	+ 3K/yr for 5 years. Structure could be built in one year, but would require subsequent long-term monitoring.
3	Conduct morphometric and breeding behavior studies.	6.4	1 year	R5/ES	SMA	4.5			
3	Conduct a public education program.	8.	Ongoing	R5/ES	SMA, Priv	4.0	2.5	2.0	+ 1,000/yr for 12 years.

APPENDIX

LIST OF REVIEWERS

Following is the list of individuals and agencies that submitted comments on the Agency draft plan. All comments have been reviewed and incorporated, as appropriate, into this recovery plan. Comments are on file in the Service's Chesapeake Bay Field Office, Annapolis, Maryland.

Robert A. Bachman
Director
Maryland Department of Natural Resources
Tawes State Office Building
Fish, Heritage and Wildlife Administration
580 Taylor Avenue
Annapolis, Maryland 21401

Clifford Day
Supervisor
New Jersey Field Office
U.S. Fish and Wildlife Service
927 North Main Street (Building D-1)
Pleasantville, New Jersey 08232

James M. Hill
Natural Resources Division
Maryland-National Capitol Park and Planning Commission
8000 Meadowbrook Lane
Chevy Chase, Maryland 20815

C. Barry Knisley
Department of Biology
Randolph-Macon College
Ashland, Virginia 23005

Dr. Philip Nothnagle
RFD#1 Box 459
Windsor, Vermont 05089