New England Plant Conservation Program

Rhynchospora inundata (Oakes) Fern.
Inundated Beak-rush

Conservation and Research Plan
for New England

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Approved, Regional Advisory Council, March 2003

SUMMARY

Rhynchospora inundata (Oakes) Fern. (Cyperaceae) is a regionally rare taxon, commonly known as inundated beak-rush. With at most 12 current Element Occurrences (EOs) in New England, conservation of this obligate wetland species will require site protection and careful monitoring. These measures must be backed by the capability for judicious use of restoration, augmentation, or reintroduction, if the taxon is to be secure in the regional landscape for the next 20 years and into the future.

A perennial sedge of coastal plain pond shores and peaty quagmire habitats, *R. inundata* requires periods of both inundation and drawdown to maintain population health. It flowers and spreads vegetatively when flooded, but the seeds germinate only in a dry environment. Consequently, the number of plants in each population appears to fluctuate greatly from year to year as hydrologic conditions change, making accurate censusing especially difficult. An improved system of surveying known EOs and correlating population condition with hydroperiod is needed before stating with any certainty the degree of risk the species faces in the region. Another factor complicating its conservation status is that in those regions of the country where it is considered common, introgression with a closely related species may have compromised the genetic purity of *R. inundata*. Thus, the only pure strains may be those where the hybridizing species does not occur, making *R. inundata* rarer on the national level than is generally realized.

Two New England EOs have been acquired recently by conservation organizations to protect *R. inundata* and other rare species, but other important sites are threatened by ongoing or proposed development. Such direct threats must be mitigated immediately. Heavy traffic by off-road vehicles has also caused extensive, possibly long-lasting damage to several populations in the past decade. Other populations, even where the land is in conservation hands, may be jeopardized by changes in the cycles of flooding and drawdown on which the species depends.

This Conservation and Research Plan will emphasize the need for improved data collection and analysis to determine the optimal conditions for *R. inundata* in the region. This will make possible a more accurate assessment of the minimum size that populations must attain in order to be relatively secure for the long term. Armed with a better understanding of what the species needs, conservation management may include attempts to restore populations from the natural seed bank and to augment small populations. If these efforts are insufficient, it may be necessary to reintroduce propagules to sites where the species is known to have existed in the past. This report projects an ambitious, but realizable goal of having 12 good-to-excellent quality occurrences within the historical range of the species in southeastern Massachusetts and southwestern Rhode Island 20 years from now.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Full plans with complete and sensitive information are made available to conservation organizations, government agencies, and individuals with responsibility for rare plant conservation. This excerpt contains general information on the species biology, ecology, and distribution of rare plant species in New England.

The New England Plant Conservation Program (NEPCoP) of the New England Wild Flower Society is a voluntary association of private organizations and government agencies in each of the six states of New England, interested in working together to protect from extirpation, and promote the recovery of the endangered flora of the region.

In 1996, NEPCoP published "*Flora Conservanda*: New England." which listed the plants in need of conservation in the region. NEPCoP regional plant Conservation Plans recommend actions that should lead to the conservation of *Flora Conservanda* species. These recommendations derive from a voluntary collaboration of planning partners, and their implementation is contingent on the commitment of federal, state, local, and private conservation organizations.

NEPCoP Conservation Plans do not necessarily represent the official position or approval of all state task forces or NEPCoP member organizations; they do, however, represent a consensus of NEPCoP's Regional Advisory Council. NEPCoP Conservation Plans are subject to modification as dictated by new findings, changes in species status, and the accomplishment of conservation actions.

Completion of the NEPCoP Conservation and Research Plans was made possible by generous funding from an anonymous source, and data were provided by state Natural Heritage Programs. NEPCoP gratefully acknowledges the permission and cooperation of many private and public landowners who granted access to their land for plant monitoring and data collection.

This document should be cited as follows:

Craine, S. I. 2003. *Rhynchospora inundata* (Oakes) Fern. (Inundated Beak-rush) Conservation and Research Plan for New England. New England Wild Flower Society, Framingham, Massachusetts, USA.

I. BACKGROUND

INTRODUCTION

Rhynchospora inundata (Oakes) Fern. (Cyperaceae) is an obligate wetland sedge that is a regionally rare (Division 2) taxon in New England (Brumback and Mehrhoff et al. 1996). It is more common in the deep south, especially in the Okefenokee Swamp in Georgia and throughout Florida, but its national rank is uncertain (N?). This may be because it is possible that much of the southern population includes intergrades with *Rhynchospora careyana* (Gerry Moore, Brooklyn Botanic Garden, personal communication), in which case pure strains of *R. inundata* may, in reality, be much rarer on a global scale.

The species is one of the larger sedges in our region, averaging about 60 cm in height, with large, horned achenes spreading in a distinctively diffuse inflorescence. It has several common names including inundated beak-rush and drowned hornrush. Like most sedges, its stem is triangular in cross-section, though not strongly so. The tubercle at the end of the achene is characteristic of the genus; its length — about 1.5 cm — is characteristic of the "horned rushes," a section within the genus *Rhynchospora*. The leaves of *R. inundata* are slender, mainly originating at the base, and frequently overtopping the inflorescence. It does not form tussocks, but spreads by means of slender, scaly rhizomes. The only similar species found in New England wetlands, *R. macrostachya,* is distinguishable by the dense clusters of spikelets in its inflorescence, its taller stem and stouter leaves, and its cespitose habit.

Rhynchospora inundata reproduces both vegetatively and sexually. One individual can spread to form an extensive colony by means of rhizomes, while also producing wind-pollinated flowers that mature into large achenes by August or September in our region. Experimental work done with *R. inundata* from the Okefenokee Swamp in Georgia found that the plants grew, spread, and flowered best under flooded conditions, but the seeds required exposure to air, sunlight, and greater warmth in order to germinate (Gerritsen and Greening 1989). *Rhynchospora inundata* is, therefore, dependent on cycles of flooding and drawdown. Exactly what hydroperiod is ideal for population growth is unknown, especially here at the northern limit of its worldwide range, but it is clear that a site with stable water levels cannot provide for all stages in its life cycle.

The dependence of this species on a fluctuating environment gives *R. inundata* its "fugitive" character. That is, the part of the population that we can see appears to come and go as conditions change. However, the seeds of *R. inundata* can remain viable for many years when buried in peat at the bottom of a swamp, marsh, or small pond (Gunther et al. 1984). Thus, even when few mature plants are visible, a viable population may live on in the seed bank. An area with a large number of flowering plants in one year may have none the next year and vice versa. Numbers reported at New England Element Occurrences (EOs) generally follow this pattern. This complicates attempts to quantify the size of each population, identify demographic trends, and estimate the viability of the species across the landscape. However, while the taxon has probably always been rare in the Northeast, there are relatively few sites where it has simply dwindled away or disappeared without an obvious cause such as the conversion of a pond to a cranberry bog.

In addition to its hydroperiod requirements, *Rhynchospora inundata* is confined to habitats that are nutrient-poor and acidic, where organic material accumulates under the water. Such habitats are locally called quagmires and are most frequent in this region on the shores of very shallow coastal plain ponds with fluctuating water levels (Enser and Caljouw 1989). Nearly all New England occurrences of *R. inundata* are within about 10 km of the ocean. They are predominantly at mucky ponds on sandy glacial outwash substrates and below 40 m in elevation.

Maintaining the species in the New England environment for the long term will require site protection, regular monitoring, and possibly intervention informed by a conservation-oriented research program. Some sites need immediate physical protection from off-road vehicles or new development. At all sites the nutrient-poor, mucky habitat with fluctuating water levels must be maintained or, if necessary, reestablished. Small populations may need intervention to enhance germination from existing natural seed banks. If necessary, the number and size of occurrences can be increased somewhat by such restoration measures. As a last resort, if natural populations are in decline, propagules can be reintroduced to historical sites or introduced to new locations with appropriate habitat. However, all these steps can be effective only if they are based on a much better understanding of the species' habitat needs and the threats to its survival. The fact is that neither the available data nor current theory are sufficient for us to state with any degree of certainty how large an individual population must be to be minimally viable or how many such populations are needed for the species to be secure in the region. Therefore, more research, including improving the collection and analysis of observations on the existing population dynamics, is a central part of this plan. If we can learn enough about the species, the goal of 12 good to excellent populations (see appendix 2 for current Massachusetts ranking specifications) within 20 years is more likely to be met.

DESCRIPTION

Rhynchospora inundata (Oakes) Fern. (Cyperaceae), or inundated beak-rush, is a perennial sedge of oligotrophic wetland habitats with fluctuating water levels. Its stem is triangular in cross-section, as is typical of the sedge family, and reaches as tall as 1 m in some locations, though usually not more than 60 cm in New England (Godfrey and Wooten 1979). Leaves are slender (4–7 mm wide [Gleason 1952]), erect, and flat or slightly rolled inward, and the major ones originate at the base of the stem (Rhode Island Natural Heritage Program

1989). Some leaves overtop the terminal inflorescence (Massachusetts Natural Heritage and Endangered Species Program 1990).

The inflorescence is diffusely branched and can be 10–25 cm in diameter (Rhode Island Natural Heritage Program 1989). It has a distinctively open appearance because the spikelets grow in small, loose clusters of 2–6 or are occasionally solitary (Gleason 1952). At anthesis, each spikelet is about 1–1.5 cm long (Hamilton no date). Each spikelet is made up of spirally imbricate scales, most of which are empty, but the uppermost of which subtend two to four tiny, apetalous florets. The lower one or two of these florets are usually bisexual, while one or two upper ones are male only (Moore 1997).

The flattish, obovate achene, or single-seeded fruit, is about 4–5 mm, or rarely 6 mm long and 2–3.5 mm wide. It is surrounded by five or six more-or-less equal bristles, each longer than the achene, at about 8–9 mm (Godfrey and Wooten 1979). At the distal end of the achene is a tubercle, representing the persistent base of the style, which is a key generic characteristic of *Rhynchospora* (Gleason 1952). In this species the tubercle, or "beak" is very long (14–19 mm), awl-shaped, and extends well beyond the end of the spikelet (Godfrey and Wooten 1979). The entire achene, along with its bristles and tubercle, is enveloped by several scales or bracts (Rhode Island Natural Heritage Program 1989). *Rhynchospora inundata* can also reproduce vegetatively by means of slender, scaly, stoloniform rhizomes, 10 cm or longer (Fernald 1918), which enable it to spread widely into extensive colonies.

The only other large *Rhynchospora* species found in wetland areas in New England is *R. macrostachya* Torr. It is generally taller (1–2 m) and has broader, stouter leaves (Gleason 1952). It grows in tussocks rather than spreading by stolons (Godfrey and Wooten 1979). Spikelets are grouped in dense clusters of 10–30 that are minimally branched, and sometimes even sessile on a single axis (Godfrey and Wooten 1979). Multiple clusters may appear on short peduncles in the terminal inflorescence, but individual clusters also grow lower on the stem, in leaf axils (Gleason 1952). The fruit of *R. macrostachya* and *R. inundata* are similar, but the achenes, bristles, and tubercles of the former are all slightly longer than in *R. inundata* (Gleason and Cronquist 1991). While both are obligate wetland species, *R. macrostachya* generally is found at drier, slightly more elevated locations (Massachusetts Natural Heritage and Endangered Species Program 1990).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Rhynchospora inundata was named by Merritt L. Fernald in 1918 based on a specimen described by Oakes in 1841, which he had called *Ceratoschoenus macrostachys* var. *inundatus* (Fernald 1918). Oakes' specimen was collected in Plymouth, Massachusetts, at the same pond where MA .008 was located in 1928. As of 1918 it was known only from this site, one or two ponds on Long Island, New York, and a few sites in New Jersey (Fernald 1918). Fernald moved the species to the genus *Rhynchospora*, which had been named by

Martin Vahl in 1806. *Rhynchospora* derives from the Greek words for beak *(rhynchos)* and seed *(spora)* (Gleason 1952). The beak, or tubercle, which extends from the achene, is characteristic of the genus (Gleason 1952). In one section of *Rhynchospora*, including *R. inundata,* this tubercle is especially long. Linnaeus had classified some of what we now call *Rhynchospora* in his genus *Schoenus*, but that name is no longer used (Britton and Brown 1913 [1970]). The specific name references the species' dependence on flooding. This, too, is reflected in several of the species' common names—inundated beak-rush and drowned hornrush (NatureServe Explorer 2001). It has also been called inundated horned sedge (Sorrie and Somers 1999) and narrow-fruited horned beaksedge (USDA/NRCS 2002) to reflect its presence in the sedge (not the rush) family. A few other combinations of these descriptive names have been used as well.

The genus *Rhynchospora* includes some 210 species, of which 45 are native to the United States (Ueno and Koyama 1987). *Rhynchospora* is represented on all five continents, but there are far more species in the Americas than in the Old World, and more in the tropics than in the Temperate Zone (Ueno and Koyama 1987). Four species of eastern North America constitute the *Rhynchospora corniculata* complex (Moore 1997). They include *R. corniculata* (Lam.) Gray, *R. inundata, R. macrostachya,* and *R. careyana* Fern., all of which have longer achenes and tubercles than most members of the genus (Godfrey and Wooten 1979).

Fernald (1918) recognized all four as distinct species, but this has not been universally accepted. A recent analysis of morphological characteristics of the four species taken from separate areas showed them to be clearly distinct, but sympatric populations of *R. inundata* and *R. careyana* did include considerable intergradation (Moore 1998). Since individuals with intermediate characteristics were found to have reduced seed production, Moore (1998) hypothesized that these intergrades represent hybrids between distinct taxa. This contributes to some confusion in identifying these species when they grow in the same areas. Many botanists in Florida, for example, do not distinguish *R. careyana* from *R. inundata,* both of which are reported as widespread, occurring in almost every county (Atlas of Vascular Plants of Florida 2002). However, if *R. careyana* is recognized as a distinct species, the total numbers of *R. inundata* in that state should be reduced, probably significantly (G. Moore, personal communication).

These taxonomic uncertainties have repercussions for the rarity and conservation status of the species and for the importance of preserving its northern populations. If, in fact, most or all populations of *Rhynchospora inundata* from Florida to North Carolina are affected to some extent by hybridization with *R. careyana*, the importance of conserving *R. inundata* in New England and the northeast is increased (G. Moore, personal communication). It is only in states north of Virginia that the genetic purity of *R. inundata* is probably not compromised, since these states are beyond the range of *R. careyana*. However, in all of these states, *R. inundata* is Endangered or Threatened, if it occurs at all.

Historically, *Rhynchospora inundata* has also been known as *Ceratoschoenus macrostachys* var. *inundatus* Oakes (1841) or *R. macrostachya* var. *inundata* Fern. (1906). However, it is the only name currently in use for this taxon (Moore 1995).

SPECIES BIOLOGY

Rhynchospora inundata relies on both sexual and asexual reproduction to maintain itself in the face of major fluctuations in its environment, specifically alternation between periods of flooding and exposure. When growing in saturated soil or even in shallow water, a few individuals can quickly spread vegetatively by means of underground stoloniform rhizomes to form extensive colonies (Godfrey and Wooten 1979). Flooded plants also can flower and set seed (Gerritsen and Greening 1989). Seed germination, however, is dependent on dry conditions and in most places only occurs once every several years, when drought exposes the mucky pond bottoms in which it grows (Gunther et al. 1984). However, the longevity of its seed bank gives it the ability to emerge explosively when conditions are right for germination (Gunther et al. 1984). So this "inundated" plant actually depends on both periods of inundation and periods of drawdown to complete its life cycle.

The flowers of *R. inundata* are wind pollinated and produce fruit (achenes) from July to September in New England (Massachusetts Natural Heritage and Endangered Species Program 1990). Within each fascicle, the florets develop synchronously, and pollination is mediated by wind, not animal pollinators (Moore 1997). Moore (1997) hypothesized that in *R. inundata* fertile seed is generally the result of outcrossing, making hybridization with compatible congeners a possibility. Unlike *R. inundata, Rhynchospora macrostachya* appears to be primarily geitonogamous, meaning its ovules may be fertilized by pollen from the same plant and it is thus less likely to hybridize (Moore 1997).

Since each spikelet contains only one or two ovules and the inflorescence is not dense, each stem can produce on the order of only 100–200 seeds per season (personal observation). Given this relatively low number of seeds per plant, it is important that each individual be able to mature rapidly and set seed in the first season after germination (Gerritsen and Greening 1989). Note that most research on the biology and ecology of this species has been conducted in Georgia and Florida. Despite the possibility of genetic differences due to introgression (see discussion in previous section), the findings reported here and below are generally consistent with observations of *R. inundata* in New England.

Seeds germinate in response to oxygen (Conti and Gunther 1984), as well as to light and higher temperatures that are experienced only when pond or marsh sediments are exposed to air (Gunther et al. 1984). In experiments using soil cores from the Okefenokee Swamp in Georgia, *R. inundata* showed the strongest preference for germinating in dry conditions of any of the six most common species (Gerritsen and Greening 1989). These experiments were conducted in four different seasons for three months each. Peat taken from the top 10 cm of sediment in two sites was exposed to three experimental conditions: dry (watered to field capacity) for three months, flooded for three months, and one month dry followed by two months flooded. In each season, *Rhynchospora* germinations were significantly lower in the flooded condition. However, once germinated, the species grew the largest in the treatment where dry and flooded conditions alternated (one month dry, two months wet). *Rhynchospora inundata* was also the only species to flower in the course of the three-month trials. During the summer, more than 80% of the plants flowered in the dry-wet treatment, while less than 5% flowered in the dry treatment (Gerritsen and Greening 1989).

Since *Rhynchospora inundata* is able to take advantage of flooded conditions to spread and quickly produce seed, the seed bank in some marshes can be dominated by this species even when it is not dominant among the existing vegetation. In a study of the Okefenokee Swamp, 60% of the viable seeds in the underwater muck were of *Rhynchospora inundata* (Gunther et al. 1984). These seeds also can persist for many years, waiting for appropriate conditions for germination. Gunther and colleagues (1984) reported *R. inundata* seeds to have the greatest longevity of any discovered in the seed bank. (This paper has been misquoted several times to state that 400-year-old *R. inundata* seeds were able to germinate. In fact, very few seeds as old as about 400 years at one site and 1,700 years at another site did germinate, but the species of these seeds was not identified in the paper.)

This species has a chromosome number of $n = 9$ as do the other three species in the *Rhynchospora corniculata* complex (Moore 1998).

HABITAT/ECOLOGY

Rhynchospora inundata appears to be restricted to specific kinds of substrates and is dependent on a peculiar hydrologic regime. Both of these are provided by the coastal plain mucky pondshore habitat, where the species is most often found in New England. Shallow ponds and marshes that only occasionally go dry can build up a thick layer of peaty muck, or quagmire, which provides proper conditions for both the mature plant and its seeds. In quagmire soils, acidity is high, decomposition slow, and nutrients scarce (Hamilton no date).

Rhynchospora inundata's dependence on both floods and droughts makes it a "fugitive species," meaning it seems to disappear and reappear as hydrological conditions change. Many other rare pondshore herbs of this region also tolerate occasional inundation, especially by persisting in the seed bank until floods recede (Schneider 1994). These species may also require periodic flooding to control potential competitors that are better adapted to either permanently flooded or permanently exposed conditions (Craine 2002). However, *R. inundata* has a more intimate link to variable hydroperiod. It can germinate only in periods of drawdown (Conti and Gunther 1984); it spreads and produces seed when flooded; if inundation persists, the plant dies (Gerritsen and Greening 1989), but seeds survive in the soil ready to germinate when water levels retreat (Gunther et al. 1984), allowing the population to persist.

This fugitive life history makes the species difficult to track — the disappearance of vegetative plants, even for a few years, does not necessarily mean a population has been extirpated.

In Florida, *R. inundata* is considered an indicator of the wet prairie habitat (Austin 1998). Its habitat and ecology have been most carefully studied in the Okefenokee Swamp on the Florida-Georgia border. Average water acidity in the Okefenokee is pH 4.0 (Greening and Gerritsen 1987). The substrate consists of a bed of peat (96% organic matter), generally between 1.5 and 3 m deep, but in the interior as much as 6 m thick (Cypert 1972). *Rhynchospora inundata* is especially abundant on newly exposed peat (Hamilton no date), which can result either from a lowering of the water table, as during a drought, or from the upward movement of mats of peat, as large as 0.1 to 0.2 ha, that often float to the surface (Gunther et al. 1984). These mats are known locally as "peat batteries," and when they are first exposed to air and sunlight, *R. inundata* is usually the dominant or co-dominant species, often coexisting with *Xyris smalliana* and *Eleocharis* spp. (Gunther et al. 1984).

In another study of the Okefenokee, *R. inundata* was absent from two constantly flooded locations, which were dominated by floating vegetation such as *Nuphar advena, Utricularia* spp., and *Myriophyllum heterophyllum*. *Rhynchospora* was also absent from a site that experienced annual cycles of inundation and drawdown. This area was strongly dominated by *Carex stricta* var. *brevis* (formerly known as *Carex walteriana*). However, at another location that was flooded in all but six of the previous 20 years, *R. inundata* was plentiful for a few years after a drought, but later gave way to the same suite of species found at the constantly flooded site (Greening and Gerritsen 1987). The situation may be a bit different in Delaware, where one of the two current occurrences is at a seasonal pond that floods and goes dry every year (Bill McAvoy, Delaware Natural Heritage Office, personal communication). In New England, none of the wetlands that support *R. inundata* could be considered seasonal, except in years of very low precipitation, when they may go completely dry by midsummer (personal observation).

In New England, peaty marshes and pond shores, which are the primary sites for *R. inundata,* are smaller and more scattered than in an extensive wetland like the Okefenokee. Although there are several records of this species growing in fairly deep water, at all the Element Occurrences where *Rhynchospora* was seen in 2002 it was growing in exposed, but still waterlogged, peat or muck. Coastal plain ponds in southeastern Massachusetts and coastal Rhode Island are notorious for their large changes in water level. This is a natural phenomenon resulting from their dependence on the level of the water table and the variable input of local precipitation (McHorney 1998). Thus a hydrologic regime similar to that of the Okefenokee site that supported *R. inundata* in Greening and Gerritsen's (1987) study is maintained on many of the coastal plain ponds in this region.

Peat build-up is probably not as rapid (or has not been going on for as long), but there can still be very thick layers under some ponds in our area. At one pond on Cape Cod that may have supported *R. inundata* in the 1920s, the thickness of the peat layer was recently measured at about 3 m (Jerome B. Carr, Carr Research Laboratory, Inc., personal communication). Mats of peat from the bottom have also been known to rise to the surface of some of these ponds and float around for weeks before lodging themselves on a leeward shore (personal observation). At one *R. inundata* EO (RI .006 [Burrillville]), the species was found growing in such a mat at one end of a pond. Several years later, the species was seen only at the other end of the pond. It is likely that the mat simply floated from one end to the other. These floating peat mats provide another mechanism, in addition to pond-level fluctuations, for dormant seeds to be exposed to the air and light they require to germinate.

In New Jersey, *R. inundata* sites are characterized as low-nutrient habitats, including pine barrens and cranberry bogs (Hamilton no date). The same is true for southeastern New England. In fact, most of the New England occurrences are on small bodies of water that are or have been connected to cranberry bogs. Especially in Plymouth County, Massachusetts, where more than half of all New England EOs are located, most ponds have artificial channels leading in or out of them, indicating their hydrological connections to cranberry cultivation at one time or another (personal observation). This means these ponds experienced artificial as well as natural fluctuations in water levels over the years, since cranberry growers pump water into and out of adjoining ponds several times each year in order to change the level in their bogs (Thomas 1990). Whether this has led to the extirpation of some *Rhynchospora inundata* populations or whether some EOs owe their existence to these anthropogenic alterations in hydroperiod is unknown. What is clear is that cranberry cultivation excludes nearly all other species from its active bogs.

The current and historical range of *R. inundata* in New England also gives some clues as to its other habitat requirements. All but two of the sites (RI .003 [Hopkinton] and RI .006 [Burrillville]) are within about 10 km of the ocean — Block Island Sound, Buzzards Bay, or Massachusetts Bay. All these sites are also on glacial till or glacial outwash soils. All the Massachusetts sites are in, or south of, the recessional moraines of the Wisconsinan glaciation — the Ellisville moraine in Plymouth County and the Sandwich moraine on Cape Cod (Skehan 2001). With the same two exceptions, all are below 40 m in elevation. All except RI .006 (Burrillville) are within the USDA's hardiness zone 7, meaning that the climate is a bit milder than in the rest of New England, with winter minima ranging from –12 to –18 C. It is difficult to separate these coinciding factors of geology, elevation, and climate, but one or more of them do appear to determine where this species can grow. It is clear that the sandy outwash plains characteristic of the southeastern New England coastal zone provide plenty of wetlands that may develop the intermittently inundated quagmires that *Rhynchospora inundata* requires.

There is no information available on predators and pathogens that may affect *R. inundata*, except that it has been reported that ducks feed on its seeds (Center for Aquatic and Invasive Plants 2002). While this could reduce deposits to the natural seed bank, it could also aid in the dispersal of the species to new sites. Even though most seeds are digested, a certain portion will pass through the duck's gut unharmed. Furthermore, as the achenes of *R. inundata* soak in water, their bristles retract away from the axis. This spreading of the bristles not only allows the achenes to float longer for greater dispersal by water, but the barbed bristles are also more likely to attach to a passing animal and get a longer ride (Moore 1997).

Associates of *Rhynchospora inundata* observed in New England include: *Juncus militaris, J. canadensis, Cladium mariscoides, Xyris smalliana, Scripus subterminalis, Rhynchospora alba, R. macrostachya, R. capitellata, R. scirpoides, Eleocharis equisetoides, E. tuberculosa, Lobelia dortmanna, Rhexia virginica, Triadenum virginicum,* and *Sabatia kennedyana.* In deeper water, *Nymphaea odorata*, *Nuphar* spp., *Utricularia* spp., and others are found, while the shrub zone around these wetlands is usually dominated by such species as *Myrica gale, Vaccinium corymbosum, Clethra alnifolia, Chamaedaphne calyculata,* and *Cephalanthus occidentalis*.

<u>THREATS TO TAXON</u>

Rhynchospora inundata has very specific habitat needs, especially with regard to water availability. Most research indicates that it does not do well in any one stable hydrological condition, but requires fluctuations in water levels to complete its life cycle and maintain its population numbers. In addition, variable flooding prevents domination of the wetland margins *R. inundata* inhabits by either aquatic or upland species, many of which could be superior competitors in a stable environment (Wisheu and Keddy 1994). From this fairly restricted starting point, the number of appropriate sites for *R. inundata* has been further reduced by development for human use. Plymouth County and Cape Cod, Massachusetts and coastal areas of Rhode Island are all under considerable pressure for new housing development. At two occurrences (MA .003 [Plymouth] and MA .004 [Plymouth]), recent housing construction is close enough to pond shores to raise concerns about its impact on the species. At one historical site (MA .010 [Mashpee]), housing now surrounds both of the ponds at which the species may have been observed in the 1920s. Some sites, such as MA .011 (Carver), face the possibility of future construction projects. Even in cases where buffer zones have been established, such as around MA .004 (Plymouth), nearby housing can create impacts through water extraction and septic inputs.

Cranberry cultivation is probably even more destructive of the coastal plain quagmire habitat than residential development. At least one EO (MA .002 [Plymouth]) was probably extirpated many years ago by the development of a cranberry bog on the site, and one current population (MA .011 [Carver]) is on the property of a major cranberry company, which may use the site for cultivation or sell it for residential development. *Vaccinium macrocarpon* is a native of this habitat, so almost anywhere species like *R. inundata* exist is likely to be useable for growing cranberries. In Plymouth County, Massachusetts, especially, almost every boggy pond is or has been involved in the cultivation of cranberries. Commercial cranberry bogs become virtual monocultures, eliminating any other species that may have grown there. In addition, many wetland areas that are not actually planted with cranberries are indirectly involved as their water levels are artificially manipulated for the sake of flooding nearby cranberry bogs.

Both residential and agricultural development have direct, obvious impacts on wetland habitat. However, they can have indirect effects too, especially by altering the area's hydrology. Increased human use of underground water resources lowers the water table, resulting in less frequent and less extreme flood periods on coastal plain pond shores on Cape Cod (McHorney 1998). This can affect even ponds that are completely protected from aboveground interference. Species like *R. inundata* that depend on both periods of inundation and periods of drawdown are likely to suffer when this happens. Additionally, more prolonged dry spells mean a reduction in peat build-up since exposed peat oxidizes and is blown away (Cypert 1972).

Another identifiable risk that seems inherent in the very cycling of inundation and exposure that this species requires is off-road vehicle (ORV) traffic. When shallow coastal plain ponds dry out, the resulting mud flats provide an ideal terrain for dirt bikes and other ORVs. The largest single population ever observed in New England (MA .001 [Plymouth] in 1993) was also seriously stressed by vehicular traffic. That year the dry, oval pond bed looked like a racetrack, and many, if not all, of the plants there were damaged. At another site (MA .006 [Plymouth]), a power line crosses the pond where *Rhynchospora* has grown, giving the spot easy access to ORVs despite the ownership of the rest of the shoreline by a conservation organization.

The apparent fluctuations in size and health of local populations make it especially difficult to evaluate their viability, or the likelihood of extirpation over any given time period. Population viability analysis (PVA) is a technique to quantify all the factors affecting the persistence, reproduction, and dispersal of an animal or plant population, including their stochastic variation, and calculate an estimated probability of extinction over a given period of time (Lande 2002). PVA addresses unavoidable stochastic (chance) variations from year to year as opposed to specific, potentially avoidable risk factors such as habitat degradation (Shaffer 1981). Precise conclusions from PVA are always problematic due to the wide confidence intervals for all its component parameters (Ludwig 1999). However, for a species like *R. inundata* with wide and erratic swings in population size, even collecting appropriate data to enter into such an analysis may be impossible. Nevertheless, the underlying contribution of PVA is still relevant — that even in an ideal, well-protected setting, very small populations are vulnerable to extinction simply by normal, random variation in reproductive success and fluctuation of environmental conditions.

The fact that *Rhynchospora inundata* populations appear to come and go even in the best of sites makes it very hard to know its real status at a given location or across the region at any particular moment and presents another sort of risk. A sudden "disappearance" of the species from one year to the next could represent normal processes that do not threaten its survival, or it could result from changes that will lead to its extirpation. It would be dangerous to base management decisions on any "snapshot" view of the species' health, which could lead to unrealistically optimistic or unnecessarily gloomy assessments. Instead, a systematic approach to monitoring of all sites will be needed, initially just to build a set of baseline data from which to make comparisons.

DISTRIBUTION AND STATUS

General Status

The current and historical range of *R. inundata* in the United States is concentrated at lower elevations along the Atlantic coastal plain from southeastern Massachusetts to all of peninsular Florida, as well as a bit of the Gulf coastal plain in western Florida and Alabama. It is also reported in Jamaica and Belize (NatureServe Explorer 2001). From South Carolina north, however, it is rare enough to be of some concern to state conservation authorities. In South Carolina its status is S? (unknown), but it is given a legal status of "Special Concern" (Julie Holling, South Carolina Department of Natural Resources, personal communication). North Carolina places it on a list of species (W7) which are suspected to be rare but for which there is "inadequate information about their distribution and rarity." In that state, it is confirmed present in only three southeastern coastal counties (John Finnegan, North Carolina Natural Heritage Program, personal communication). NatureServe considers *R. inundata* to be absent from Virginia (NatureServe Explorer 2001), but the USDA's PLANTS database indicates occurrences in one county (USDA/NRCS 2002). This may be based on the identification of the species on Assateague Island, Virginia in 1990 (Stalter and Lamont 1990), which later proved to be an error (B. McAvoy, personal communication).

North of Virginia, all states list this species as endangered or threatened, if it is present at all. It is ranked S1 in Maryland, Delaware, and Rhode Island, and S2 in New Jersey, New York, and Massachusetts. In all of these states together, there are only 37 extant occurrences (Table 1), and they are exclusively in coastal areas. In Maryland, it occurs at only three sites, in two counties, on the Chesapeake Bay side of the Delmarva Peninsula. Two of these populations, growing in natural ponds, are small, but one includes more than 1,000 individuals in an old millpond (Chris Frye, Maryland Department of Natural Resources, personal communication). There are two current and two historical occurrences in Delaware (B. McAvoy, personal communication). New Jersey has at least 14 confirmed extant occurrences, a few of which number in the hundreds under ideal conditions (David Snyder, New Jersey Department of Environmental Protection, personal communication). All 11 current and historical occurrences in New York State are at the eastern end of Long Island (Steve Young, New York Natural Heritage Program, personal communication). It has never been recorded present in Pennsylvania, Connecticut, or northern New England.

Despite its rarity in New England and the large fluctuations in size of each population, there appears to be relatively little decline in the total number of sites occupied by *R. inundata*.

The number of historical occurrences is much smaller than the number of currently occupied sites, and several EOs have been added in recent years. This is the opposite of the relationship of these figures for many other rare plants. The same impression of stability in number of sites coupled with instability in population sizes at each site has been noted in New Jersey (D. Snyder, personal communication).

Florida is the only state in which *Rhynchospora inundata* is considered widespread; the Atlas of Vascular Plants of Florida (2002) indicates it is present in all but 18 counties. However, as it is likely that many of the specimens counted as *R. inundata* should be classified as *R. careyana* or as hybrids between the two species, so the true frequency of pure *R. inundata* in the state is probably much lower (G. Moore, personal communication).

In 1998, *Rhynchospora inundata* was given a global rank of G3G4, implying it was difficult to decide whether it is "vulnerable to extinction" or "apparently secure" (NatureServe Explorer 2001). Its national rank, as of 1993, is uncertain (N?), and it was noted to be declining, especially north of the Carolinas (NatureServe Explorer 2001). This uncertainty is probably due to the uncertainty of classification of *R. careyana–R. inundata* intergrades. If ambiguous specimens were not counted, *R. inundata* would be far rarer than is presently assumed. In New England, the species is placed in Division 2, Regionally Rare Taxa, by *Flora Conservanda:* New England, the New England Plant Conservation Program (NEPCoP) list of plants in need of conservation (Brumback and Mehrhoff et al. 1996).

The North American distribution of *Rhynchospora inundata* (by state) is illustrated in Figure 1 on page 14 and summarized in Table 1, below. These data are taken from NatureServe (NatureServe Explorer 2001). The New England distribution (by town) is presented in Figures 2 and 3 on pages 24 and 25.

Table 1. Occurrence and status of *Rhynchospora inundata* in the United States and Canada based on information from Natural Heritage Programs.

OCCURS & LISTED (AS S1, S2, OR T &E)	OCCURS & NOT LISTED (AS S1, S2, OR T & E)	OCCURRENCE REPORTED OR UNVERIFIED	HISTORIC (LIKELY EXTIRPATED)
Delaware (S1, E): 2 current and 2 historical occurrences (B. McAvoy, personal communication)	Alabama (S?)	Georgia (SR) Abundant in Okefenokee Swamp (Greening and Gerritsen 1987)	
Maryland (S1, E): 3 current occurrences in 2 counties (C. Frye, personal communication)	Florida (S?) Present in all but 18 counties (Atlas of Vascular Plants of Florida 2002)		
Massachusetts (S2, T): 8 current and 3 historical occurrences	North Carolina (S3) Watch List (W7): "inadequate information about distribution and rarity"; present in 3 counties (J. Finnegan, personal communication)		
New Jersey (S2, T): 14 current and an approximately equal number of historical occurrences (D. Snyder, personal communication)	South Carolina (S?) Legal Status "Special Concern"; 17 current and 2 historical occurrences (J. Holling, personal communication)		
New York (S2, T): 6 current and 5 historical occurrences, all on eastern Long Island (S. Young, personal communication)			
Rhode Island (S1, E): 4 current and 1 historical occurrences			

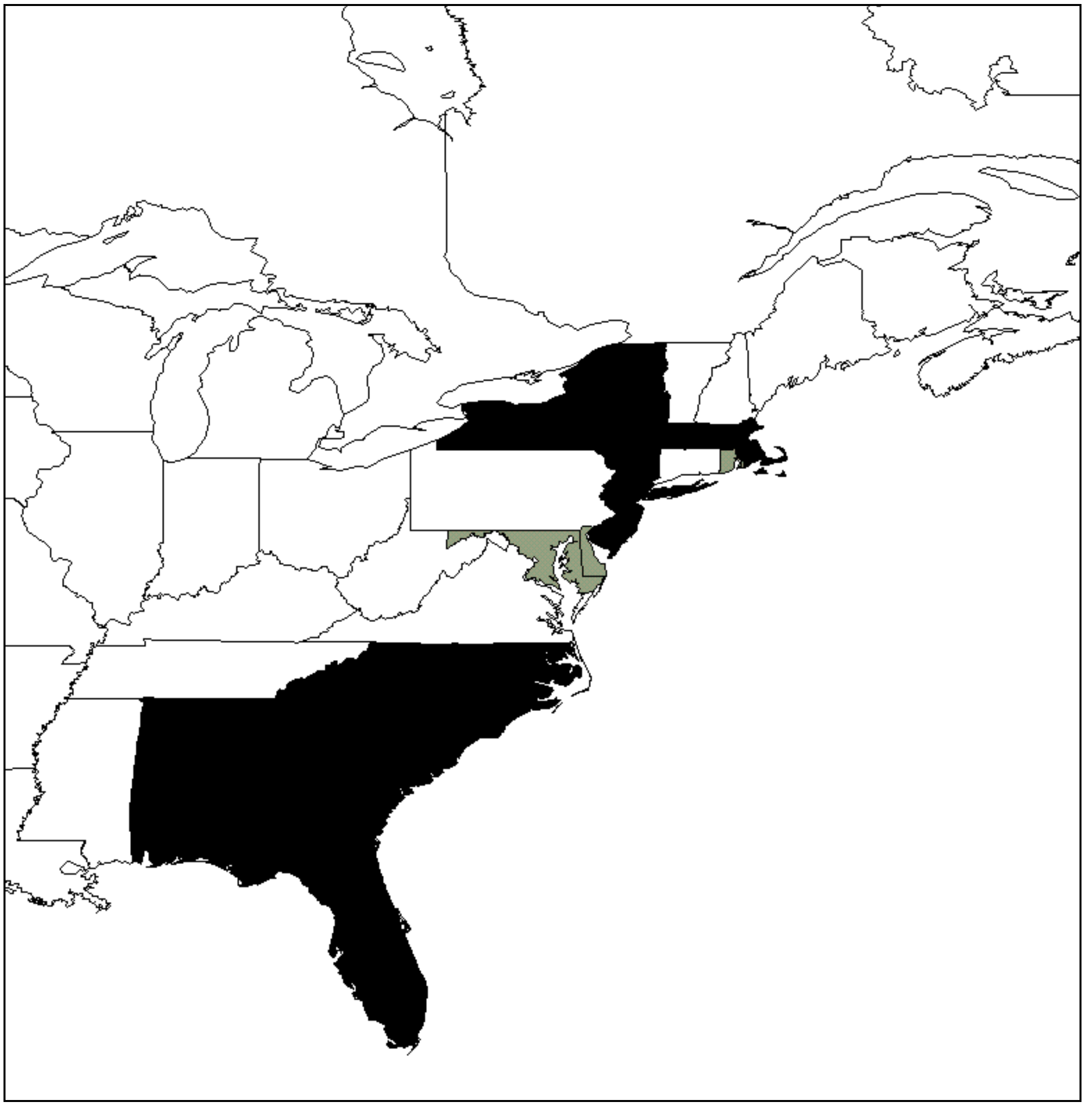

Figure 1. Occurrences of *Rhynchospora inundata* in North America, by state. States and provinces shaded in gray have one to five current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences.

Table 2. New England Occurrence Records for *Rhynchospora inundata*. Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
MA	**.001**	**Plymouth**	**Plymouth**
MA	.002	Plymouth	Plymouth
MA	**.003**	**Plymouth**	**Plymouth**
MA	**.004**	**Plymouth**	**Plymouth**
MA	**.005**	**Barnstable**	**Yarmouth**
MA	**.006**	**Plymouth**	**Plymouth**
MA	**.007**	**Plymouth**	**Plymouth**
MA	.008	Plymouth	Plymouth
MA	.010	Barnstable	Mashpee
MA	**.011**	**Plymouth**	**Carver**
MA	**.012**	**Plymouth**	**Plymouth**
RI	**.002**	**Washington**	**Richmond**
RI	.003	Washington	Hopkinton
RI	**.004**	**Washington**	**Charlestown**
RI	**.005**	**Washington**	**Hopkinton**
RI	**.006**	**Providence**	**Burrillville**

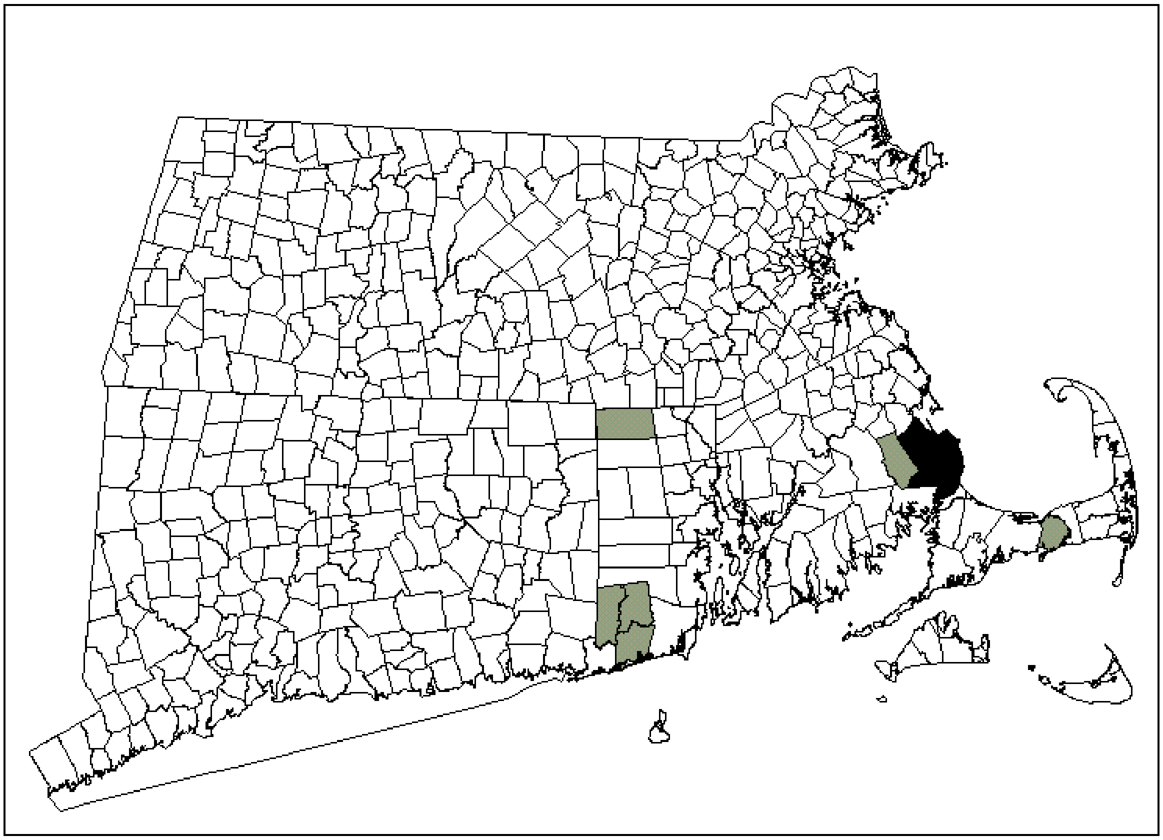

Figure 2. Extant occurrences of *Rhynchospora inundata* in New England, by town. Town boundaries for southern New England states are shown. Towns shaded in gray have one to five confirmed, extant occurrences of the taxon. Towns shaded in black have more than five extant occurrences.

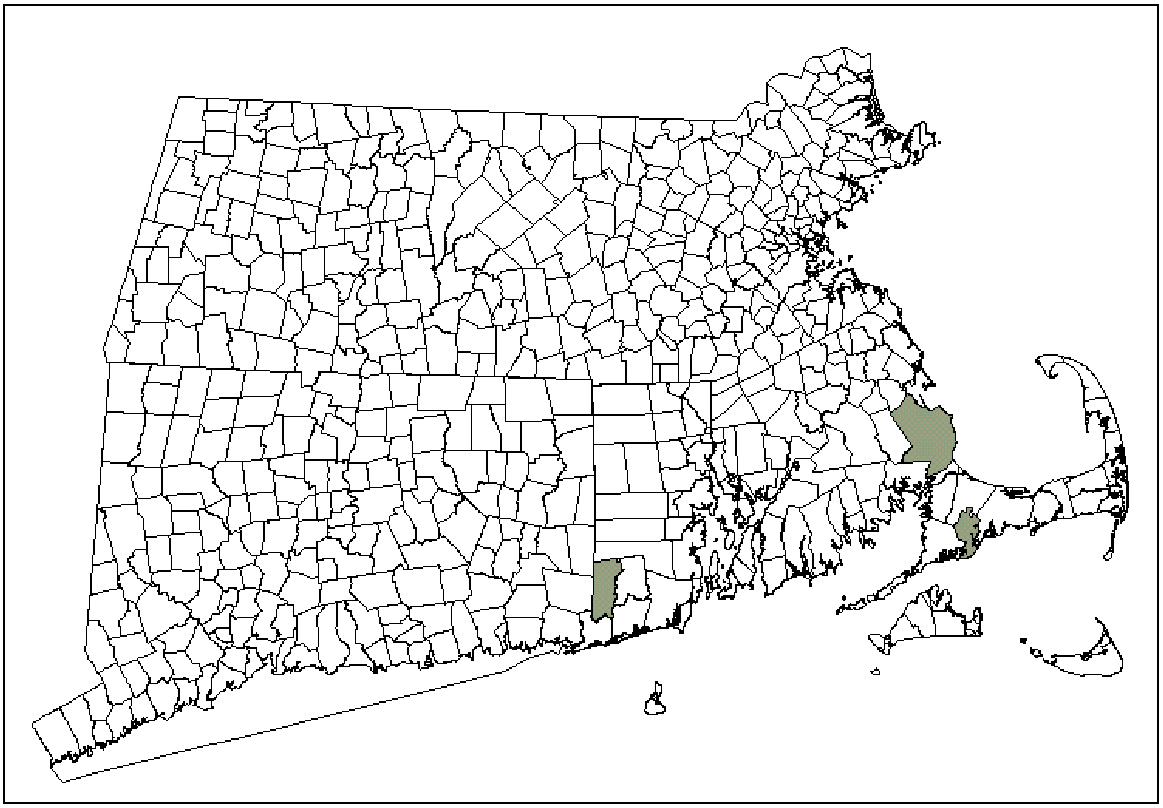

Figure 3. Historical occurrences of *Rhynchospora inundata* in New England, by town. Towns shaded in gray have one to five historical records of the taxon.

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Of the 12 current Element Occurrences of *Rhynchospora inundata* in New England, there are two where *R. inundata* has not been observed in 15 to 20 years, and one where only a single plant was reported on a single visit, in 1997. Furthermore, of the remaining nine EOs, seven are on private land with no permanent legal protections in place. With at most 12, but possibly only nine, occurrences of variable condition, it is clear that this species is at risk in the New England region. *Rhynchospora inundata* will remain at risk in New England until the number and quality of occurrences can be increased.

It is difficult to determine how many occurrences are actually needed and how large they must be to provide a reasonable assurance of security, especially given the "fugitive" nature of this species. How large is a population that, for the time being, consists only of thousands of seeds in the ground? Is it less viable in the long run than one made up of a handful of flowering plants in a less than ideal setting? We have seen that the number of mature plants in most populations fluctuates greatly in response to hydrological conditions. We also know that *R. inundata* seeds can survive many years when buried in a mucky pond or marsh bottom. Furthermore, in the past 75 years, relatively few EOs have simply disappeared without an obvious, external cause, despite the fact that numbers at some sites have dropped to zero from time to time.

A first step for more effective conservation of this species, therefore, will be to learn the demographic patterns to expect from these populations in response to environmental fluctuations. This process will combine some basic research on the species, along with data collected during regular annual monitoring of all its occurrences. It will require an improved system of data collection, storage, and access. By correlating population trends with hydrologic conditions, we can be more confident of what constitutes a minimum viable population size, perhaps developing a useful measure using the average (or maximum) number of plants over a standard period or under specified hydrological conditions. Once this is done, the system of ranking specifications for *R. inundata* occurrences can be further refined. While a quantitative population viability analysis may never be possible for this species, an improved system of ranking EOs will be helpful in assessing progress toward securing the species in New England. In any case, even with the best quantitative analysis, it is best to err on the side of caution.

While this longer-term monitoring work is needed for all extant EOs, some *R. inundata* sites may face threats that will demand immediate action. The current possibility that land around one occurrence may become part of a large housing tract is a case in point. Whenever such a situation arises, protection of the site affected will become the top priority for conservation of the species. Since most of the occurrences are not on conservation property and development pressures remain intense throughout the region, this problem could arise elsewhere at almost any time. In some cases the only effective way to protect a site may be for a conservation organization or government agency to acquire ownership, as was done in the 1990s at MA .006 (Plymouth) and RI .002 (Richmond). In other cases, agreements with landowners and enforcement of existing regulations may be adequate.

As these activities help protect existing Element Occurrences from development, and other identifiable human disturbance, work is also needed to expand the number of occurrences. Eight to twelve small populations, no matter how well protected, would still be too few to rely on, since each is vulnerable to uncontrollable events that could wipe it out. These include natural disasters as well as demographic and genetic stochasticity (the probability that natural fluctuations in reproductive success will at some point result in no reproduction within a population) (Gilpin and Soulé 1986). Population viability analysis theory indicates that populations of species that respond dramatically to variable environmental conditions, as *R. inundata* does, are especially vulnerable to environmental stochasticity (Menges 1991). Furthermore, *Rhynchospora inundata* is wind-pollinated and primarily not self-fertile (Moore 1997). For plants that depend on outcrossing, effective population size is a smaller fraction of total, or census, population (Menges 1991). Wind pollination is a less efficient system than animal pollination, so this probably also lowers reproductive output. Smaller effective population size and reduced fecundity will mean larger populations will be needed to achieve minimal security. On the other hand, the species can also reproduce vegetatively and its seedbank has considerable longevity. Both of these factors tend to lower the minimum size needed for a viable population (Doak et al. 1996).

Further searching for this species may reveal new or previously unknown populations, which could increase our confidence in its ability to survive in New England. Since appropriate habitat occurs in discrete areas that are readily identifiable, *de novo* searches should be easy to organize. On the other hand, most wetland habitats in the region have been well studied for many years, so the likelihood of finding a previously unknown population is small. If, after five years, protection of existing Element Occurrences and searching for new ones do not result in at least nine good-to-excellent occurrences, serious consideration should be given to more aggressive intervention through restoration and/or reintroduction. To prepare such a situation, appropriate new sites for restoration or reintroduction will have to be located. A few historical EOs could be used for this purpose, but only two appear likely candidates based on information now available. Both of these sites would require improved legal protection before investing heavily in a long-term restoration or reintroduction project. Throughout the historical range of this species in New England, from Cape Cod to southwestern Rhode Island, there are many more mucky ponds and marshes with variable water levels. The absence of *Rhynchospora inundata* from these wetlands does not, by itself, indicate that the habitat is unsuitable. It may result from nothing more than the historical accident of where seeds were dispersed. Some of these sites are already protected from development by conservation organizations, governments, or water companies. Since legally protected sites avoid a whole suite of problems associated with private ownership, these should be looked at first for restoration and introduction attempts.

First consideration should be given to locating any new populations close to existing ones, although spreading to new, more distant areas within the historical range is a worthwhile objective, too.

At appropriate sites, experiments should be conducted to induce germination from the natural seed bank. More work is needed to discover effective techniques for enhancing *in situ* germination that create a minimum of other disturbance. If successful, such techniques could become a tool for bolstering existing populations if they become too small to be viable or appear to be in serious decline. The first step would be to remove soil cores and see what germinates from various depths. Experimental work in the Okefenokee Swamp, summarized above, shows that *R. inundata* seeds can remain viable for many years buried in peat (Gunther et al. 1984). Germination from deep sediments might provide information on prehistoric distribution of the species, as well. On any ponds where some *R. inundata* seed may remain in the seed bank — whether a historical EO or a population that appears to be in serious decline — restoration would not raise the problem of introducing exogenous genetic material.

The process of collecting and germinating seeds and establishing new populations will also increase our knowledge of the requirements of *R. inundata.* This, in turn, will make it easier to protect and maintain appropriate natural conditions where the species already occurs. Armed with a more accurate idea of what its optimal hydroperiod actually is, managers could focus on how that flooding regime can be guaranteed at *Rhynchospora* sites. This will require both engineering and legal expertise, since altering current water usage, even if it is restoring a "natural" condition, faces difficulties in both these areas.

If protection and restoration of declining sites and any discovery of new ones fail to maintain an adequate number of large, healthy populations, a few carefully chosen introductions or reintroductions could be considered. Unlike restoration, these steps imply bringing propagules from other sites. New England Plant Conservation Program policy endorses the use of reintroduction and introduction when it is necessary to increase the viability of a taxon, but emphasizes a number of caveats (New England Wild Flower Society 1992). The potential for disrupting the natural genetic variation of the species requires that introductions be used only after careful planning (Fahselt 1988). It has also been argued that introducing rare species in new sites takes the pressure off those who might want to destroy a natural habitat, since they can claim that establishing rare species on new sites will mitigate the impact of their project (Falk et al. 1996). However, these introductions are not in any way linked to mitigation and would be done only in conjunction with doing everything possible to preserve all extant populations.

Introduction attempts require considerable resources and a very long time frame for evaluation. They must, therefore, be undertaken only on protected land that can be managed for the benefit of the species (New England Wild Flower Society 1992). Plans for introduction need to be detailed, site- and species-specific, and include guarantees of accountability. Extensive knowledge of the species, its habitat, and it relationship to other organisms in the environment is needed before introduction should be attempted. At the same time, introductions—even when ultimately unsuccessful—can add greatly to our understanding of these questions (Falk et al. 1996). Introductions must always be considered essentially experimental (Falk et al. 1996), and newly-introduced populations should not be counted as Element Occurrences until they achieve viability (New England Wild Flower Society 1992). Measures such as these should never be taken without careful consideration. Therefore, all proposals in this report assume a process of review by appropriate bodies such as the Regional Advisory Council of the New England Plant Conservation Program prior to taking any action in the field.

Being prepared for an introduction program, if it is needed, will also require more work on the *ex situ* seed bank. The efforts of the New England Wild Flower Society should be expanded. Seeds can be collected safely whenever a particular population includes more than about 100 fruiting individuals. More important than increasing the number of seeds in the seed bank, however, will be determining a successful protocol for storage and germination. This seems to have been the greatest difficulty with the *Rhynchospora* seed bank thus far. In germination experiments carried out between 1991 and 1996, rates of germination remained well below 10% (C. Mattrick, personal communication). It might be instructive to attempt germination, *ex situ,* from the natural seed bank, following similar procedures to those reported by Gerritsen and Greening (1989). Presumably, the sediments of some of these EOs have preserved *R. inundata* seeds in a dormant but viable condition for many years. Their condition and the conditions that foster optimal germination could be studied and applied to *ex situ* seedbanking.

Lastly, more research is needed on the relationship of northeastern populations of *R. inundata* to those in the South. This could help determine whether information on the species' life history and habitat requirements gathered in places like the Okefenokee Swamp are applicable to our populations. It might also redefine the true range of *R. inundata,* possibly leading to a realization that it is far rarer on a global scale than previously thought and, therefore, perhaps eligible for additional legal protections.

An ambitious but realizable goal for the status of *Rhynchospora inundata* in New England 20 years from now would be to have 12 good-to-excellent occurrences (see appendix 2 for current Massachusetts ranking specifications). These should be of sufficient size to permit the development of a seed bank that can sustain the population through anticipated fluctuations in water availability. They should be within landscapes that will protect natural conditions, especially hydroperiods, that are conducive to *R. inundata.* Using more systematically collected data, the ranking specifications should be refined within the first five years of this plan. The goal of 12 EOs implies protecting and improving the condition of at least eight of the 12 that are now officially extant and finding or establishing four more. If introductions are determined to be necessary, efforts should be made to locate introductions in all three of the historical centers of *R. inundata* in New England — southwestern coastal Rhode Island, Plymouth County, Massachusetts, and central Cape Cod.

In order to assess progress toward these overall goals, some specific targets should be set for the first five years of this plan.

1. No occurrences should have been lost to controllable human factors such as development or artificial changes in hydroperiod.
2. A protocol for annual monitoring, including information on hydrologic conditions, should be in place that will begin to provide the necessary data to assess population viability.

3. A program of basic research on the species should be underway. It should be based on the more rigorous monitoring protocol as well as experimental work and should address questions of habitat identification, reproductive and germination requirements, and genetic diversity.

4. The *ex situ* seed bank should be larger and more diverse than at present, and storage and germination techniques should have been improved.

5. At three or four of the weakest existing populations and/or historical sites, attempts at restoration should have been initiated by promoting increased germination from the natural seed bank.

6. If at the end of five years there are fewer than nine good to excellent EOs, a concrete discussion should be initiated on the desirability of introductions and reintroductions and specific sites chosen for this purpose.

7. Literature on this and other rare wetland species, should be prepared and disseminated to the public, especially in the immediate area of occurrences, to heighten popular understanding of how to protect their habitats.

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IV. APPENDICES

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1. **State of Massachusetts Element Occurrence Ranking Specifications for *Rhynchospora inundata***

2. **An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe**

1. State of Massachusetts Element Occurrence Ranking Specifications for *Rhynchospora inundata*

A-Rank Specifications:

Condition: Evidently reproducing (flowering and fruiting), vigorous, growing within a coastal plain pondshore community
Size: >500
Landscape: Natural site with natural processes approximating natural conditions (unaltered hydrology, no disturbance)

B-Rank Specifications:

Condition: Vigorous, evidently reproducing
Size: 100–500 plants
Landscape: Natural site with natural processes approximating natural conditions (unaltered hydrology)

C-Rank Specifications:

Condition: At least fair vigor, some non-native species may be present
Size: 50–99 plants
Landscape: Altered hydrology, development, disturbance

D-Rank Specifications:

Condition:
Size: 1–49 plants in years with suitable low pond levels
Landscape:

Justification:

A-Rank Threshold: Populations reach highest numbers in low water years following drying of the pondshore. Only two Mass EOs have had more than 500 plants under suitable conditions of naturally fluctuating pond levels.

C–D Threshold: Colonies of fewer than 50 plants are seldom found, and plants occur in low numbers, if appearing at all, in successive high water years. Since this taxon "does not appear every year" searches must be conducted during or just following low water years, before any lack of viability based on size can be presumed. Major threats are water level controls and traffic.

General Comments: Rare and local emergent perennial. Type locality is in Plymouth, MA. Occurs on peaty-boggy pondshores (also swamps and ditches [Gleason and Cronquist 2000]); with *Rhynchospora scirpoides* and *Eleocharis tuberculosa*; sometimes co-occurs with *Sabatia kennedyana*. Taxon is perennial but "does not appear every year" (L.Greene Global Ranking Form). Seldom seen except during low rainfall cycles, but seems to flower best the year after a drought. Described as drought-adapted fugitive species.

Author: Pam Polloni Revision Date: 11/3/00

Citations: T. Palmer 2000. Conservation Plan for Drowned Beakrush (*R. inundata*) in New England. NEPCoP. Global Ranking specs do not give A–D rank specs. Crow and Hellquist 2000 2:172,174. Hamilton, R.A.

Natural Heritage & Endangered Species Program
Massachusetts Division of Fisheries & Wildlife

2. An Explanation of Conservation Ranks Used by The Nature Conservancy and NatureServe

The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G (Global), N (National), or S (Subnational) as appropriate. The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

G1, for example, indicates critical imperilment on a range-wide basis -- that is, a great risk of extinction. S1 indicates critical imperilment within a particular state, province, or other subnational jurisdiction -- i.e., a great risk of extirpation of the element from that subnation, regardless of its status elsewhere. Species known in an area only from historical records are ranked as either H (possibly extirpated/possibly extinct) or X (presumed extirpated/presumed extinct). Certain other codes, rank variants, and qualifiers are also allowed in order to add information about the element or indicate uncertainty.

Elements that are imperiled or vulnerable everywhere they occur will have a global rank of G1, G2, or G3 and equally high or higher national and subnational ranks (the lower the number, the "higher" the rank, and therefore the conservation priority). On the other hand, it is possible for an element to be rarer or more vulnerable in a given nation or subnation than it is range-wide. In that case, it might be ranked N1, N2, or N3, or S1, S2, or S3 even though its global rank is G4 or G5. The three levels of the ranking system give a more complete picture of the conservation status of a species or community than either a range-wide or local rank by itself. They also make it easier to set appropriate conservation priorities in different places and at different geographic levels. In an effort to balance global and local conservation concerns, global as well as national and subnational (provincial or state) ranks are used to select the elements that should receive priority for research and conservation in a jurisdiction.

Use of standard ranking criteria and definitions makes Natural Heritage ranks comparable across element groups; thus, G1 has the same basic meaning whether applied to a salamander, a moss, or a forest community. Standardization also makes ranks comparable across jurisdictions, which in turn allows scientists to use the national and subnational ranks assigned by local data centers to determine and refine or reaffirm global ranks.

Ranking is a qualitative process: it takes into account several factors, including total number, range, and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. These factors function as guidelines rather than arithmetic rules, and the relative weight given to the factors may differ among taxa. In some states, the taxon may receive a rank of SR (where the element is reported but has not yet been reviewed locally) or SRF (where a false, erroneous report exists and persists in the literature). A rank of S? denotes an uncertain or inexact numeric rank for the taxon at the state level.

Within states, individual occurrences of a taxon are sometimes assigned element occurrence ranks. Element occurrence (EO) ranks, which are an average of four separate evaluations of quality (size and productivity), condition, viability, and defensibility, are included in site descriptions to provide a general indication of site quality. Ranks range from: A (excellent) to D (poor); a rank of E is provided for element occurrences that are extant, but for which information is inadequate to provide a qualitative score. An EO rank of H is provided for sites for which no observations have made for more than 20 years. An X rank is utilized for sites that are known to be extirpated. Not all EOs have received such ranks in all states, and ranks are not necessarily consistent among states as yet.