New England Plant Conservation Program

Rhynchospora nitens (Vahl) A. Gray
Short-beaked bald-sedge

Conservation and Research Plan
for New England

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SUMMARY

Rhynchospora nitens (Vahl) A. Gray, Short-beaked Bald-sedge, of the sedge (Cyperaceae) family is one of several species that together form the coastal plain pondshore community, a rare globally imperiled plant community. *Rhynchospora nitens* is listed by the Massachusetts Natural Heritage and Endangered Species Program as Threatened and S2; is ranked by the Nature Conservancy as G4; and is categorized by the *Flora Conservanda*, a New England designation, as Division 2 (regionally rare).

The original range for this often-overlooked annual extends from Massachusetts to Florida west to Texas and Michigan. It is extirpated in Indiana and listed as S1 or S2 in several states (MA, NY, NJ, DE, MD, VA, NC, LA, and TX), although it appears secure in Mississippi and Florida, where it is considered weedy. In New England *R. nitens* is found currently (2002) in only thirteen sites in Plymouth to Barnstable Counties, Massachusetts, all of which are coastal plain pondshores. Approximately once or twice every seven to ten years the ponds dry down or dry up, exposing a shallow, sandy or muddy shoreline where a number of specialized herbaceous species grow and reproduce, including *R. nitens*.

Little is known about the biology and reproduction of this species. As an annual member of the Cyperaceae, it is wind-pollinated. The seeds ripen in September to October before the plants die. Populations appear to stay in more or less the same place from year to year, suggesting that the tiny achenes settle into place in the seed bank. Seeds require moist soil, light, and probably temperature fluctuations to germinate.

This rare New England taxon is unusual in that more populations and plants have been discovered recently than are known in the historical records. The first population in New England was discovered in 1925. Several new populations were found in the 1980s to early 1990s. Nine populations surveyed in 2002 had significantly more plants than those estimated earlier: hundreds to thousands instead of dozens. Threats, in Massachusetts and elsewhere, include both the direct and indirect impacts of development: destruction of shoreline vegetation by recreational activity (particularly off-road vehicles), well drawdowns that alter hydrology, and septic systems and lawn care that add nutrients. Global climate change may also affect populations in the future. Fortunately, ten out of the thirteen populations are on protected state or municipal land. Unfortunately, four populations are on ponds that are heavily developed.

The conservation goal for New England is to protect all thirteen existing populations at greater than 500 individuals each, when surveyed in low-water years. Objectives include education of abutters, users, and managers of ponds; use regulations in state forest to protect sensitive shorelines; enforcement of wetlands laws; collection for the NEPCoP seed bank; research on biology; and additional searches in low-water years. Continued and focused, cooperative efforts by state agencies and private conservation organizations to protect the coastal plain pondshore communities as a whole would protect *R. nitens*, along with other rare plant taxa and the globally threatened community.

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.

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I. BACKGROUND

INTRODUCTION

Rhynchospora nitens is one of several species that together form one of the most unusual rare species assemblages in New England: the coastal plain pondshore community (Sorrie 1994). The original range for this annual member of the Cyperaceae extended from Massachusetts to Florida west to Texas and Michigan. The Indiana population, long thought to be the most western population, was last recorded in 1899 (Swink and Wilhelm 1994). In 1999, Anton Reznicek discovered a new population in Michigan (Reznicek 1999). *Rhynchospora nitens* is listed as S1 or S2 in several states (MA, NY, NJ, DE, MD, VA, NC, LA, and TX), and S4 or secure only in Mississippi. It is considered weedy in Florida. The species' status is being reviewed in some states. In New England, *R. nitens* is found in only thirteen sites in Plymouth to Barnstable Counties, Massachusetts, all of which are coastal plain pondshores. Coastal plain ponds are shallow basins formed in glacial outwash plains and are connected to the underlying aquifer. Water is often acidic and low in nutrients. For several years at a time, the ponds are filled to the shrubby edge. In periodic drought years, the ponds dry down, exposing a shallow, often sandy shoreline and in extreme drought a silty, muddy bottom where a number of specialized herbaceous species grow and reproduce. The coastal plain pondshore is listed by the Massachusetts Natural Heritage and Endangered Species Program (MANHESP) as a S2 community. *Rhynchospora nitens* is listed by MANHESP as Threatened and S2 and is categorized by *Flora Conservanda* (Brumback and Mehrhoff et al. 1996) as Division 2, a New England rank meaning "regionally rare." However, in the southern part of its range, *R. nitens* is considered weedy and is listed overall by NatureServe as a G4 taxon.

This rare New England taxon is unusual in that more populations and plants have been discovered recently than were known in the historical records. Plants from a single population in New England were collected by Lyman B. Smith and F. E. Smith, Jr., on September 13, 1925 and determined by M. L. Fernald (Smith 1926). Bruce Sorrie, former State Botanist, rediscovered this and four other populations in 1975 (Sorrie 1977) and documented several additional populations for the MANHESP in the early 1980s. The most recently discovered population was found by Paul Somers, current State Botanist, in 1995. All but two populations surveyed in 2002 had significantly more plants than those estimated during previous dry years of 1975 and 1985: hundreds to thousands instead of dozens. Inventories are challenging as this annual germinates only in low-water years and is difficult to separate from *R. scirpoides*. Achenes must be used to distinguish them.

The range of *R. nitens* overlaps with that of *R. scirpoides*, which is found in eastern Massachusetts and Rhode Island, south to southeastern Virginia and eastern North Carolina, and northwest Indiana and southwest Michigan. The habitat of *R. scirpoides* is described as wet, sandy soil (Gleason and Cronquist 1991), although personal observations in Massachusetts

indicate that it can cover peaty soils of dried-down ponds, as well as growing on the sandier margins, where *R. nitens* is more typical. The two species intermingle in some sites. *R. scirpoides* is rare in the southern part of the United States, whereas *R. nitens* is described as weedy (Kral, unpublished communication). Thus, the relative abundance pattern appears to be reversed in the Northeast, where *R. scirpoides* appears to be much more abundant.

The conservation goal is to protect all thirteen existing populations by protecting shoreline vegetation from trampling and off-road vehicle (ORV) use; maintaining natural water fluctuations; and protecting ponds from nutrient inputs. Fortunately, ten out of the thirteen populations are on protected state or municipal land. Unfortunately, four populations are on ponds that are heavily developed. Threats include both the direct and indirect impacts of development: destruction of shoreline vegetation by walking, boating, and swimming; well drawdowns; and added nutrients from septic systems and lawn care. ORVs are a major and pervasive physical threat. The Massachusetts Division of Fisheries and Wildlife, the Massachusetts Chapter of The Nature Conservancy, and the Wildlands Trust of Southeastern Massachusetts have been focusing on coastal plain ponds as a priority in land protection, management, and public education for several years. Continued and focused, cooperative efforts to protect the coastal plain pondshore communities as a whole would not only protect this taxon, but also several other rare plant species and the globally threatened community.

DESCRIPTION

Rhynchospora nitens is a member of the Cyperaceae. It is a tufted annual growing 10-100 cm tall. The leaf blades are 1-3 mm wide. The spikelets are ovoid to cylindric, 3-7 mm long, and clustered at the ends of the stem and branches (Gleason and Cronquist 1991). The inflorescence is cymose, umbel-like (Godfrey and Wooten 1979, Brown and Brown 1984), terminal and axillary; the peduncles are glabrous. Spikelets are many-flowered with spirally imbricate scales (Radford et al.1968). The scales are numerous, thin, 1-nerved, ovate, acute, 3 mm long, each subtending a perfect flower. The perianth is wanting and there are only 1or 2 stamens. The achenes measure 0.7-1.0 mm long, are rotund (Gleason and Cronquist 1991) or lenticular (Godfrey and Wooten 1979, Brown and Brown 1984), a little wider than long, and contract to a short broad stipe. In this species, the achenes are scarcely stipitate, transversely conspicuously rugose, and only inconspicuously margined. The tubercle is very short and closely appressed, looking "melted." The achenes are pale brown, becoming nearly black. The features of the achenes of *R. nitens* contrast with those of the look-alike *R. scirpoides*, which is similar in all respects except that the achenes are longitudinally finely striate and sometimes obscurely cross-rugulose, with raised pale margins. The tubercle of *R. scirpoides* is flat in cross-section, triangular subulate, nearly or quite as long as the achene. (Gleason and Cronquist 1991). *Rhynchospora scirpoides* also has a usually persistent style and persistent filaments, while the style and filaments of *R. nitens* do not persist (Godfrey and Wooten 1979).

Field observations in Plymouth, Massachusetts, of hundreds of plants of both *R. nitens* and *R. scirpoides* reveal that the two species cannot be consistently separated by habitat or habit. The height of both species is typically 4-12 cm, much smaller than more southern samples as indicated by herbarium specimens in the Gray Herbarium and the 60-100 cm of the descriptions. While the herbarium specimens of the southern plants show a denser appearance to the spikelets in *R. scirpoides*, this is not apparent in the northern plants, probably due to their smaller number. The smaller number is likely, in part, due to the shorter growing season and perhaps differences among habitats. The southern habitat of limesink depressions may have richer soils or more nutrients available than the relatively low-nutrient coastal plain pondshores. Sorrie (1977) notes that the scales of *R. scirpoides* are rufous brown and those of *R. nitens* gray brown; however, this is not always a discernable trait. The achenes are diagnostic and must be observed to verify the *R. nitens* from *R. scirpoides* for identification in Massachusetts.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

The taxon has been placed in the genus *Psilocarya* (Torrey) (Radford et al.1968, Fernald 1950, Godfrey and Wooten 1979, Brown and Brown 1984); however, several more recent authors place it in the genus *Rhynchospora* (Gleason and Cronquist 1991, Kartesz 1994, Crow and Hellquist 2000, Flora of North America Editorial Committee 2002, Missouri Botanical Garden 2003).

Some authors separate *Psilocarya* from *Rhynchospora* using multiple features: in *Rhynchospora* the spikelets have 2-many empty basal scales and are mostly 1-4 flowered. The perianth usually has bristles. *Psilocarya* spikelets have one empty basal scale and are mostly more than 4-flowered. The perianth bristles are absent (Radford et al. 1968, Godfrey and Wooten 1979, Brown and Brown 1985).

Several other synonyms are listed for the species. Kartesz (1994) notes *Psilocarya nitens* (Vahl) Wood and *P. portoricensis* Britt. *Flora of North America*, Volume 23, 2002, includes *Scirpus nitens* Vahl (1805); *Isolepis nitens* (Vahl) Roemer and Schultes (1817); *Psilocarya nitens* (Vahl) Alph. Wood (1876); and *P. rhynchosporoides* Torrey (1836). Asa Gray described *Rhynchospora nitens* in his *Manual* in 1867 (Missouri Botanical Garden 2003). Despite these several synonyms, *R. nitens* appears now to be an accepted species.

SPECIES BIOLOGY

Very little is found in the literature on the species biology of *Rhynchospora* or *Psilocarya*. The genus is wind-pollinated, as are most species in the Cyperaceae. While the flowers are perfect, it is unknown if they are self-compatible. Based on observations made by the author in 2002, plants fruit even though many of the plants are only 6 cm high. According to MANHESP field forms and personal observations, plants are still in flower in the late summer

and the achenes mature from September into early October in Massachusetts. The achenes tend to change from a white to light brown to almost black as they mature. The culms and leaves of most plants brown and deteriorate in early October, presumably releasing their seeds onto the surrounding substrate. Plants often grow in clusters, occasionally in slight depressions; at other times, they are more scattered along a sandy stretch. Densities of the Massachusetts populations in 2002 varied from estimated 24 plants per 0.10 square meter to only 1-7 plants per square meter.

Seed dispersal is likely to be limited as the achenes are very small and do not exhibit any dispersal features, unlike most other *Rhynchospora* species that have bristles that may facilitate dispersal. Wind and wave action may be dispersal mechanisms as they appear to be with other coastal ponds species (Keddy and Wisheu 1989); however, in the fall, the plants are usually far from the water edges, preventing or delaying distribution of dying plants, spikelets, or seeds by water. Most of the populations surveyed in the early 1980s by Bruce Sorrie and Richard LeBlond were observed in the same locations around the ponds in 2002. The plants do not appear to disperse very far.

The seeds are able to be dormant for several years until the conditions are favorable for growth (Sorrie 1982). One study in New York noted that in the first drought year in 1986, *R. nitens* was not located; however, in the second year it was found. It may have been undetected the first year due to low numbers or it may not have been present. It was abundant for several subsequent low-water years (Zaremba and Lamont 1993).

Specific information on conditions for seed germination of *R. nitens* is limited. As part of the New England Plant Conservation Program (NEPCoP) seed banking experiments, seeds of *R. nitens* were collected in early September 1991 from sites MA .008 (Plymouth) and MA .009 (Plymouth) and provided different germination treatments. The highest percent germination (20%) occurred for seeds that were dried in a drier over silica gel, sowed on a sterile medium with no cover, placed in a warm 65 degree Fahrenheit greenhouse for 12 weeks, and then placed in a refrigerator for 12 weeks. Seeds then germinated outside in May and fruited in October. Seeds from the same collection that were dried, sowed, and placed in a refrigerator and then placed in warm greenhouse and later outside had a 0% germination rate. Seed sowed without drying and placed outside for the winter had only a modest germination of 4% the following year. Dried seed with both warm then cold treatment — or fluctuating temperatures — appear to have the best results. Note only about 25% of the seeds were dark colored indicating that the remaining 75% may not have been mature (William Brumback, New England Wildflower Society, personal communication). Further experiments with mature seed, perhaps mimicking the conditions of submergence, might reveal the species tolerance of inundation over a period of years.

In a single test, *R. scirpoides* germinated more readily than *R. nitens* in cultivation. In 1981, fresh seed collected in September by the New England Wild Flower Society was sowed in flats (no count of seeds sown) which were placed outside for the winter. Plants germinated

by May 1982. Eighteen plants bloomed in July 1982 and died that year. The following July 1983, there were hundreds of new seedlings, indicating that indeed the plant is an annual and produces plentiful seed in cultivation (Brumback, personal communication).

Most wetland members of the Cyperaceae in New England require damp exposed soil to germinate (Melissa Dow Cullina, Massachusetts Natural Heritage and Endangered Species Program [MANHESP], personal communication). These species may require light or temperature fluctuation or both. As the seeds are small and, therefore, have limited food reserves, it is likely they germinate at or near the soil surface. Other research indicates that many wetland plants require temperature fluctuations to germinate as well (Thompson and Grime 1983, Maas 1989).

Rhynchospora nitens is found where there are gaps in the vegetation, indicating intolerance to shade or perhaps to competition from other plants. Keddy and Wisheu (1989) note that rare coastal plain pondshore species are stress-tolerators and poor competitors and that competition intensifies from infertile beaches to sheltered bays. It is important to note that vegetation varies dramatically from year to year depending on hydrology as well as the response of individual plants, seed or vegetative parts, in the soil (Schneider 1994). Steinauer suggests that *R. nitens* is tolerant of high soil nutrient content as long as the reproductive sites are maintained, indicating that bare soil could be artificially maintained around ponds as propagation sites if necessary (Ernest Steinauer, Massachusetts Audubon Society, personal communication).

The populations of *R. nitens* appear to persist for many decades despite the sporadic appearance of the plants. Much of the population is represented in the seed bank. Only in low-water years are plants present. In New Jersey, a population discovered in 1913 is still extant (David Snyder, New Jersey Natural Heritage Program, personal communication). The first population found in Massachusetts in 1925 was rediscovered in 1975 (Sorrie 1977). Long absence should not be the sole reason to rank a population as extirpated (Snyder, personal communication).

A smut fungus was observed by the author in most populations where both *R. nitens* and *R. scirpoides* grew. The spikelets were deformed, appearing slightly larger and more rounded, and the axils of the scales were filled with black material. No achenes were present. Because of the similarity of the two species and the fact that the smut aborted any seed development, it is unclear whether the plants observed were *R. nitens*, *R. scirpoides*, or both. Consequently, it was difficult to estimate the percent of smut affecting *R. nitens*. The smut also appeared on a few herbarium specimens for *R. scirpoides* at the Gray Herbarium. Many members of *Rhynchospora* are susceptible to infection by smut fungi. *Cintractia* and *Trichocintractia* infect tropical *Rhynchospora* and inhibit floral development and inflorescence development, respectively (Piepenbring 1995). Fischer (1953) reports that both *R. nitens* and *R. scirpoides* are prone to smut infection along with *R. alba, R. capitellata, R. fusca*, and *R. macrostachya*. Several of these species associate with *R. nitens* in coastal plain pondshores. Otherwise, there were no signs of predation or disease on the plants.

HABITAT/ECOLOGY

Rhynchospora nitens is a member of the coastal plain pondshore community found in southeastern Massachusetts. This community type includes a number of rare and endangered plant species. Associates found in ponds with *R. nitens* include several state- listed species, such as *Eupatorium leucolepis* var. *novae-angliae* (G5T1, S1), *Lachnanthes caroliana* (SC, G4, S3), *Sabatia kennedyana* (SC G3, S3), and *Sagittaria teres* (SC, G3, S3). Several other state watch-listed species include *Drosera filiformis*, *Eleocharis melanocarpa*, *Fuirena pumula*, *Scleria reticularis* var. *reticularis*, and *Stachys hyssopifolia*. Management concerns for these species are similar to those for *R. nitens*.

The coastal plain pondshore community is ranked S2 by MANHESP; however, while generally considered globally rare, there is no global rank as such for the coastal plain pondshore community in Massachusetts. NatureServe (2001) has divided the pondshore communities into several associations with individual ranks. One coastal pond in Massachusetts may feature several of these associations. MANHESP has not yet assessed each pond for this variation (Patricia Swain, MANHESP, personal communication) and, therefore, it is difficult to place a rank on the community subtypes.

Sorrie (1994: 225) succinctly describes coastal plain ponds of New England, which are more or less similar to ponds further south to Georgia, north to Nova Scotia, and disjunct in Michigan. The coastal plain ponds where *R. nitens* is found in Massachusetts are freshwater kettlehole depressions or periglacial outwashes. Sorrie goes on to say:

> These wetlands lie in gently sloping basins with no inlet or outlet and are intimately linked with the underlying groundwater or aquifer. Thus, their water levels rise and fall naturally with the seasons, depending on cycles of rainfall and evaporation. When water levels drop during summer, a shore of variable width may be exposed and thus be able to be colonized by species adapted to this seasonally inundated habitat. During a typical year, a pond's basin will be filled with water up to the shrub/tree line…during late fall, winter, and spring. At this time the rootstalks and basal portions of virtually all pondshore plants will be covered by water or ice. Water levels drop during summer and early fall as decreased rainfall and increased evaporation cause the water table to be depressed. This is termed the annual drawdown and is a natural phenomenon, not be confused with withdrawal for human use or pond management.

During severe drought, water levels may be low for several consecutive years, even during winter. No two ponds respond in the same manner (Zaremba and Lamont 1993, Sorrie 1994). Water depth ranges widely, but in the ponds observed by the author in 2002 changes appeared to be 1-2 meters maximum. The cycle of low- and high-water years is estimated as one in seven years or one to three out of ten years (Sorrie 1994). In the late summer of 2002 when many of the populations were confirmed, the smaller ponds and lobes of larger ponds dried down completely.

Specific information on chemical characteristics of the Massachusetts ponds is lacking due to the shortage of long-term studies. Sorrie (1994) cites a 1988 study (Layzer et al. 1988) that showed that the coastal plain ponds in southeastern Massachusetts are highly acidic, with typical values of pH ranging from 5.2-6.5, rarely as high as 7.8, but frequently down to 4.4. Alkalinity, a measure of a pond's acid neutralization capability has values ranging from .40-4.0 mg/liter (most measurements in April), and rarely as high as 6.70. Coastal plain ponds are considered acidic and nutrient-poor (Swain 1996), but few data are available for New England (Sorrie 1994).

The distribution of plants is affected by drawdowns. Typically, pondshore vegetation is stimulated to grow in bands along the exposed shores, rather than in large patches across a more-or-less uniformly exposed bottom. However, in shallow lobes and cutoffs of the larger ponds, emergent or stranded vegetation may extend across from shore to shore (Sorrie 1994). On Long Island, New York, *R. nitens* occurs in a lower band described by Zaremba and Lamont (1993) as sandy, exposed pond bottom. This is the outermost of three pond bottom bands and is exposed during droughts, is often very sandy, and is dominated by annual species. (The other two pond-bottom bands include the organic exposed pond bottom, which is more frequently flooded than the sandy zone, and the permanently flooded zone.) The exposure during droughts allows accumulated organics to decompose leaving the sandy substrate. In years when the pond levels are particularly low, the sandy zone may be sparsely vegetated. Zaremba and Lamont (1993) describe it as being dominated by *R. capitellata, R. nitens,* and *Scleria reticularis* var. *reticularis*. This description is very similar to conditions and associates observed in Massachusetts.

In Massachusetts, substrate character is largely dependent on parent materials but is influenced by waves that sort the organic matter and deposit nutrients. While some pond shores are quite uniform, substrates around several ponds vary from sandy to cobbly to peaty (Sorrie 1994). Organic sediments accumulate where wave action is not strong. However, organic build-up may be reversed to some degree during drought cycles — when the bottom sediments are exposed and tend to oxidize, leaving a sandier, more nutrient-poor substrate (Sorrie 1994).

Rhynchospora nitens is found in variety of pond sizes in Massachusetts, from less than two acres to almost forty acres. Some of the ponds dried down completely in the year 2002, while others still held water. However, in the larger ponds, the plants were found in protected shallow coves. Typically, the plants were recorded on sandy shores of 1-3% grades with sparse vegetation. In 2002, the sandy shores extended up to 15-meters wide before they became peaty bottoms. *Rhynchospora nitens* grew more or less in the lower half of the exposed shoreline between the upper shrubby edge and the mucky basin. *Rhynchospora nitens* and associates formed scattered vegetative bands 3-5 meters wide in areas where the shoreline was only exposed in drought years. Some of the colonies of *R. nitens* were15 meters long, others only 1.5-3 meters long, more or less. Occasionally, there were isolated individuals. Plants sometimes grew in low depressions with some debris or a very thin layer of peat.

Rhynchospora nitens did not grow where the vegetation was dense, such as areas where *Juncus militaris* or *R. capitellata* dominated. Nor were they found on cobble shores or on exposed peaty pond basins.

MANHESP field forms and observations by the author in 2002 reveal associates of *Rhynchospora nitens*. Typical associates include sparse *R. capitellata, Hypericum canadensis, H. mutilum, Panicum verrucosum*, *Scleria reticularis* var. *reticularis*, *Rhexia virginica, Cyperus dentatus, Fimbristylis autumnalis, Eriocaulon aquaticum*, a low-growing *Eleocharis* c.f. *olivacea*, and *Drosera intermedia*. Other nearby species include *Gratiola aurea*, *Coreopsis rosea*, *Eleocharis robbinsiana*, and *Juncus pelocarpus*. *Rhynchospora nitens* does not grow where *Rhynchospora capitellata, Juncus militaris, Rhynchospora macrostachya,* or *Dichanthelium meridionale* are dense.

Of particular note, the look-alike *R. scirpoides* is a common associate and can confound censuses of *R. nitens*. *Rhynchospora scirpoides* prefers the mucky bottoms of the dried down ponds and can grow in mats of thousands. However, it can also grow into the sandy shoreline, intermixing side by side with *R. nitens*.

Further south, the growth habit, habitat, and population size of *R. nitens* are very different from those observed in the Northeast. In New Jersey, *R. nitens* occurs on intermittent coastal plain habitat where the plants grow on mud of dried-down coastal plain ponds or in dense turf with sedges, grasses and herbs (Snyder, personal communication). *Rhynchospora nitens* grows in savannahs and ditches (Radford et al. 1968); wet sands, sandy peats, and peats; clearings and borders of wet woodlands; marshy shores; ditches and drainage canals (Godfrey and Wooten 1979). Edwin L. Bridges, botanical and ecological consultant familiar with both Florida and Texas (personal communication), reports that *R. nitens* is extremely common in peninsular Florida. Here, it tends to occur in situations of seasonal inundation on almost pure sand, germinating when the soil is moist but not inundated. The species continues to grow as the areas fill with water, often to the point of growing over one meter tall if necessary to stay above the rising water and developing copious adventitious roots. As an annual, it occupies communities where there is space for annuals to fill in gaps between perennials and shrubs. It is most commonly found in shallow depressions and marshes that are more or less analogous to areas in southeast Texas. There are thousands of these ponds in peninsular Florida and, therefore, there are hundreds of sites for *R. nitens*. It also occurs in wet wiregrass prairies, marl prairies, and wet flatwoods/pine savannas. In the Florida panhandle, it is more restricted. It is found mostly in coastal interdunal depressions (similar to habitat found in Texas Coastal Bend) and on sandy margins of limesink depression ponds. It is also occasionally found in seepage slopes. The largest populations are in disturbed, not natural, areas: roadside ditches, low embankments, and clear-cut, scraped or otherwise highly disturbed pine flatwoods and savannas. This description by Bridges indicates that *R. nitens* varies dramatically in size and can adapt to a range of both natural and disturbed conditions in the Southeast, whereas in the Northeast, the species appears to be much more stenotropic.

THREATS TO TAXON

The threats to the taxon in New England are several. The plant depends on a unique set of hydrological conditions, has very small seeds that probably need light to germinate, and only emerge sporadically within any given decade. Overall, the species in Massachusetts is considered ecologically fragile; it may not readily come back if an area is heavily disturbed because it appears to have low dispersal capability (Sorrie 1982) and there are no seed sources nearby for natural re-establishment.

Development

Shoreline development for summer homes has been a growing threat around unprotected ponds. In some cases, the houses are built right to the pond edge and the owners have dredged the ponds for deeper water, raked the beach of vegetation, and stored their boats and floats on the shore (MA .001 [Plymouth], MA .002 [Plymouth], MA .012 [Plymouth]). Septic systems and lawns leach nutrients to the groundwater. Groundwater is responsible for up to 75% of the water budget for coastal ponds in Plymouth (Theall 1983). Nutrients in the pond water increase aquatic weeds and add organic matter (MA .001 [Plymouth], MA .005 [Plymouth]). Nutrient enrichment of the infertile shores can encourage the development of common, more competitive species (Keddy and Wisheu 1989, Schneider 1994). Landowners feed geese and ducks that then rest and defecate in ponds (MA .001 [Plymouth]). This not only increases the nutrients in the ponds, but also can increases shoreline grazing (Sorrie 1994, Swain 1996).

Off-Road Vehicles (ORVs)

ORVs are a major disruption to shorelines of coastal ponds on both protected state land and private land not only in Massachusetts (Sorrie 1994, Swain 1996), but also in other states as well (Keddy and Wisheu 1989, Zaremba and Lamont 1993, Schneider 1994). This activity can be particularly acute in low-water years when the shorelines are most exposed (Keddy and Wisheu 1989, Zaremba and Lamont 1993). The vehicles not only destroy existing plants and seeds, but also drastically alter shore micro-topography, changing the gradual, relatively smooth grade to one with ruts and dry ridges (Swain 1996), churning up the organic matter, and exposing seeds to drying (Zaremba and Lamont 1993). Research indicates that the seed bank is diminished, organic matter is distributed differently, and more ruderal species such as *Juncus* spp. can gradually replace the rare flora if disturbance from all-terrain vehicles continues (Keddy and Wisheu 1989, Zaremba and Lamont 1993). In more isolated sites where there are few houses, access points have eroded due to vehicles and foot traffic, thereby washing sand onto the shores and into the ponds (MA .012 [Plymouth], MA .013 [Plymouth], MA .014 [Plymouth]).

Hydrological Alterations

Municipal and private wells are perhaps the most insidious and politically difficult threats as artificial withdrawals for public water supply change the natural hydrology of the ponds in order to meet the ever increasing domestic and commercial water demand. Some of the most protected ponds on state land are subject to significant drawdowns. Several of the ponds (MA .001 [Plymouth], MA .004 [Plymouth], MA .006 [Falmouth], MA .010 [Plymouth]) are within zones of contribution of municipal wells, not to mention individual wells. Changes in hydrology can cause longer periods of drawdown, allowing encroachment of upland plants around the perimeter and preventing a resting period that may be essential for the species (Swain 1996). Also, wave action, substrate, and nutrients can be altered by this exposure (Keddy and Wisheu 1989, Sorrie 1994, Swain 1996). Long-term withdrawals can permanently lower the water table throughout a region, thereby drying out shallow coastal ponds. This has been the case in Long Island where the lowering of the local water table by three meters has caused a conversion of wetlands to uplands (Zaremba and Lamont 1993). This permanent lowering of the water table is also a concern in Massachusetts where both Plymouth and Cape Cod are underlain by sole-source aquifers. Excessive draw down by cranberry operators has resulted in the colonization of one pond by undesirable ruderal species such as *Echinochloa crus-galli* (Tim Simmons, MANHESP, personal communication).

Recreational Use

Swimming, boating, horseback riding, and walking by abutters are frequent activities (Sorrie 1994, Swain 1996). Also, visitors are attracted to public beaches on the larger ponds or to isolated ponds in the state forest. Even occasional foot traffic can create trails that can be visible a year later (Swain 1996). Recreational threats were observed at several populations in 2002: MA .001 (Plymouth), MA .002 (Plymouth), MA .003 (Plymouth), MA 010 (Plymouth).

DISTRIBUTION AND STATUS

General Status

Rhynchospora nitens is listed by MANHESP as Threatened in Massachusetts and S2; by *Flora Conservanda* as Division 2; and by NatureServe as G4. It is found currently only at thirteen coastal ponds in Plymouth and Barnstable Counties in all of New England, is sporadic farther south, and disjunct in Michigan. *Rhynchospora nitens* is listed as S1 or S2 in several states (Massachusetts, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, Louisiana, and Texas) and S4 or secure only in Mississippi, while its status is "reported" in three southern states (South Carolina, Georgia, and Alabama) (NatureServe 2001). Radford et al. (1968) notes *R. nitens* in seven mostly coastal counties in North Carolina, and three in South Carolina. It also notes it in Virginia, Georgia, and Florida. In the southern states, *R. nitens* is

described in 1981 by Professor Robert Kral of Vanderbilt University (unpublished communication) as weedy: "coming in readily on moist sandy, disturbed ground along with a host of other *Rhynchospora*, *Cyperus*, *Fimbristylis*, and *Xyris*. It can form good stands in shallows and around borders of limesink ponds, is frequent in broad marshes just in from the coast of Florida. In north Florida, *R. scirpoides* may also appear locally around limesink ponds, but there is no question that its occurrence is scarce." *R. scirpoides* in contrast to *R. nitens* is "plumb scarce." This information has been complemented and in some respects contradicted by recent correspondence with botanists in several states.

The New Jersey Natural Heritage Program ranks *R. nitens* as S2. Of the nine populations, seven have recently been confirmed with two others most likely extant. Only two occurrences are on protected land (state and TNC property). The threats are minimal with three to four sites impacted by ORVs (Snyder, personal communication).

The North Carolina Natural Heritage Program ranks *R. nitens* as S3. Richard LeBlond (Botanist, personal communication) is recommending that it be removed from the watch list. He has found 58 occurrences in southeastern North Carolina since 1990. The taxon is extant in seven counties and historical in two.

South Carolina's Natural Heritage Program does not list *R. nitens* (A. Pittman, South Carolina Natural Heritage Program, personal communication).

Rhynchospora nitens is ranked as S3? in Georgia. The Natural Heritage Program Botanist, Tom Patrick (personal communication) is uncertain of how common it actually is. There are a total of seven reports in six counties, mostly from before 1985. Given the variety of habitats it is known to occur in, he thinks *R. nitens* is undercollected. However, he goes on to cite a 1949 draft flora of southeastern Georgia that indicates *R. nitens* as rare and only seen in two places: one in a shallow grassy limesink pond and one in a small desiccated pond in the pineland. There is no further information.

The Nature Conservancy Botanist in Texas, Bill Carr (personal communication) would unofficially rank this species as S1 or S1S2, rather than the official listing of S2. However, *R. nitens* is not tracked by the Texas Natural Heritage Program due to limited resources. The only part of Texas in which *R. nitens* is consistently encountered is in a system of Pleistocene barrier islands in Aransas, Nueces, and San Patricio counties (all in the vicinity of Corpus Christi). In that area, *R. nitens* occurs in ephemeral freshwater potholes among more or less stabilized low sand dunes, often in the company of other state-rare sedges such as *Fuirena longa*, *R. divergens*, and *R. microcarpa*. There are also a few, mostly historical, records in eastern Texas, specifically in Hardin, Jefferson, and Robertson counties. Although it has received little attention in Texas, Carr's sense is that it is not doing well as most of the freshwater potholes in the Corpus Christi area are being lost to development.

Rhynchospora nitens is disjunct in the Great Lakes region (Reznicek 1994). The NatureServe website indicates *R. nitens* as extirpated in Indiana. The last documented collection for *R. nitens* in Indiana was in 1899 in Porter County (Swink and Wilhelm 1979), although Floyd Swink may have collected a specimen from Dune Acres, Porter County, Indiana in the 1940s (Anton Reznicek, University of Michigan, personal communication.) Anton Reznicek collected a state record in Michigan in 1999 (Reznicek 1999).

Several factors may contribute to the sporadic distribution of *R. nitens*, not only in Massachusetts, but also throughout its range. The distribution of lakeshore species in the Great Lakes region is based on three ecological factors that influence variation in species composition between ponds (Keddy and Reznicek 1982). Water chemistry, including pH and conductivity, has a marked influence on shoreline and aquatic species composition. Geological history has influenced dispersal among post-glacial lakes. Chance will play a role in dispersal, colonization, and extinction of shoreline species as ponds are isolated islands in a terrestrial ocean. In the Great Lakes, the disjunct populations of pondshore species may have occurred by short- to moderate-distance dispersal by birds of seeds into areas of suitable habitat (Reznicek 1994). These factors may similarly influence the species composition of smaller, glacially-formed ponds of southeastern Massachusetts. In addition, as has been the experience in Massachusetts, populations may be overlooked and unrecorded. The grass-like plants are not easy to see or identify and they only appear to emerge in drought years, which may be once every ten years. The scarcity of scientific literature covering this taxon indicates that this has not been a popular plant to study.

Table 1 and Figure 1 summarize the status and distribution of *Rhynchospora nitens* in North America.

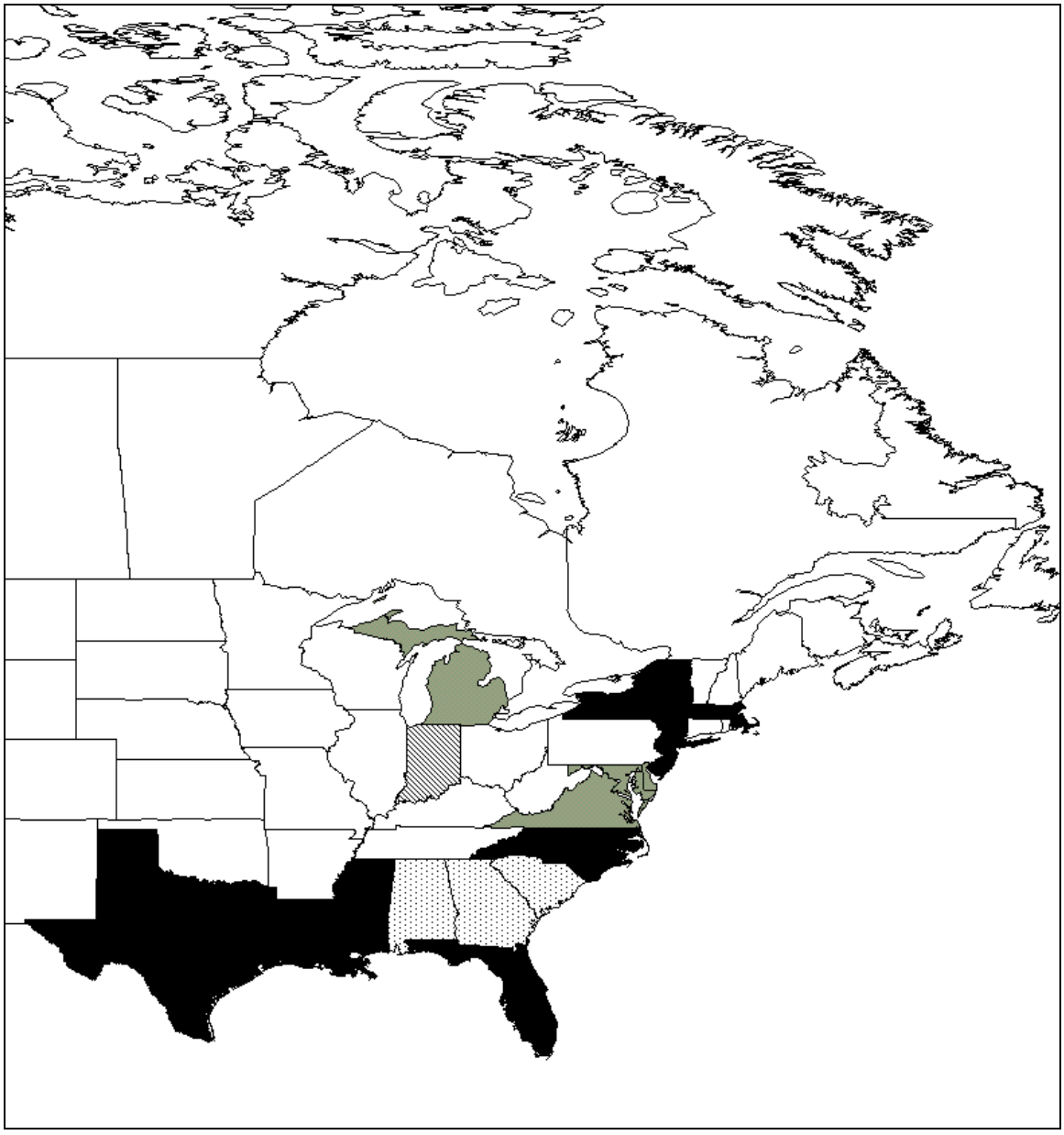

Figure 1. Occurrences of *Rhynchospora nitens* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. The state (Indiana) with diagonal hatching is designated "historic," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified). See Appendix for explanation of state ranks.

Table 1. Occurrence and status of *Rhynchospora nitens* in the United States and Canada based on information from Natural Heritage Programs.			
OCCURS and LISTED (AS S1, S2, OR T and E)	**OCCURS and NOT LISTED (AS S1, S2, OR T and E)**	**OCCURRENCE REPORTED OR UNVERIFIED**	**HISTORIC (LIKELY EXTIRPATED)**
Delaware (S1)	Florida (S?): reported as common in much of Florida	Alabama (SR)	Indiana (SX)
Louisiana (S2S3)	Mississippi (S4)	Georgia (SR)	
Massachusetts (S2, T): 13 current occurrences	North Carolina (S3): 58 populations have recently been documented	South Carolina (SR)	
Maryland (S1, E)	Michigan: new state record by A. Reznicek		
New Jersey (S2)			
New York (S2)			
Texas (S2): not currently tracked by Natural Heritage, many sites being lost to development			
Virginia (S1)			

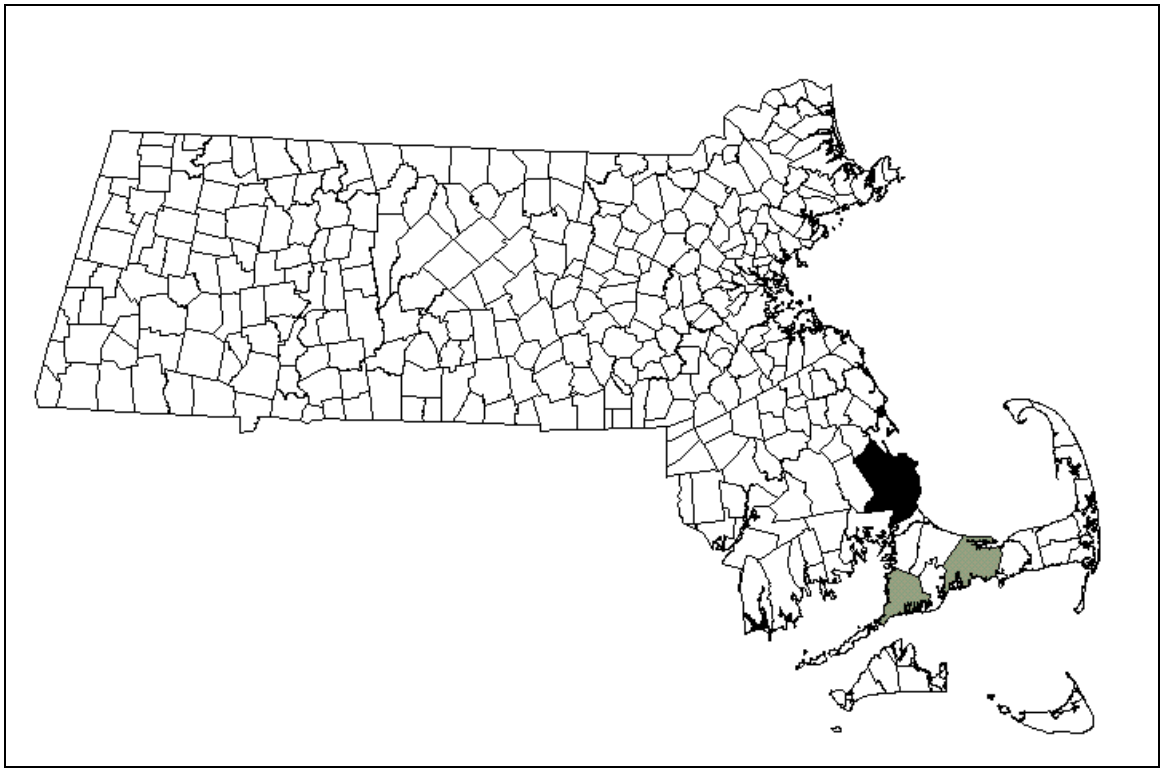

Figure 2. Extant occurrences of *Rhynchospora nitens* in New England. Town boundaries for Massachusetts (the only New England state in which the taxon occurs) are shown. Towns shaded in gray have one to five extant occurrences of the taxon. The towns shaded in black have 6 or more occurrences. Historical records coincide with towns containing extant occurrences.

Table 2. New England Occurrence Records for *Rhynchospora nitens.* Shaded occurrences are considered extant.

State	EO Number	County	Town
MA	.001	Plymouth	Plymouth
MA	.002	Plymouth	Plymouth
MA	.003	Plymouth	Plymouth
MA	.004	Plymouth	Plymouth
MA	.005	Plymouth	Plymouth
MA	.006	Barnstable	Falmouth
MA	.007	Plymouth	Plymouth
MA	.008	Plymouth	Plymouth
MA	.009	Plymouth	Plymouth
MA	.010	Barnstable	Barnstable
MA	.011	Plymouth	Plymouth
MA	.012	Plymouth	Plymouth
MA	.013	Plymouth	Plymouth
MA	.014	Plymouth	Plymouth

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Goal: Protect all thirteen extant Massachusetts occurrences in context of globally rare coastal plain pondshore communities, with a minimum of 500 plants each in dry years. All thirteen occurrences should be sustained.

- This species is state-listed in eight of the states within its range and is believed extirpated in Indiana. Status in many states is uncertain. Only in Mississippi and Florida is it deemed secure at this time. All New England populations warrant protection.

- Massachusetts has the only thirteen occurrences in New England.

- It is feasible to do. While the developed ponds may be thought to be particularly vulnerable over the long term, two ponds on Long Island that have been surrounded by houses for forty and ten years still support good examples of the coastal plain pondshore community (Zaremba and Lamont 1993). Furthermore, the populations that were found over 25 years ago are still present, and these are all growing around developed ponds.

- Four of the developed ponds are clustered and, therefore, may provide opportunities for genetic transfer between metapopulations. They should not be lost.

Rhynchospora nitens is one of several rare species of a globally-threatened coastal plain pondshore community (Sorrie 1994). As such, it should be managed in conjunction with efforts to protect the entire coastal pondshore community.

- Protecting the whole pondshore community increases the probability that the protected system will be self-perpetuating and more resistant to occasional perturbations. It also maximizes efficiency by allowing many species to be protected at once (Keddy and Wisheu 1989).

- A holistic protection plan is appropriate because there is already significant focus, protection activity, and research by several organizations (TNC and others) and the state to protect coastal plain pondshore communities and associated rare plants in southeastern Massachusetts.

- The threats are the same for several rare species including water withdrawals, increased nutrients due to nearby development, ORVs, and trampling by walkers, fishermen, etc.

- The protection measures for this species are similar to other rare coastal plain pondshore plants; namely, protecting the pond shores, minimizing water withdrawals and nutrient inputs, blocking ORV access, and minimizing recreation, such as walking, fishing, boat storage, and beach use.

- The other coastal plain pondshore species, such as *Sabatia kennedyana*, are much more "charismatic" than this inconspicuous sedge and, therefore, likely to garner increased public support for conservation. Therefore, concentrating on the entire community and other associated plants will indirectly benefit *R. nitens*.

The population goal of a minimum of 500 plants in a low-water year is difficult to determine and monitor. Five hundred plants seems a logical number as most of the populations surveyed in 2002 had at least this number and were greater in size than the previous surveys, which were in the dozens and low hundreds. However, populations of this and other coastal plain pond annual species are known to fluctuate dramatically and their biology is little known, making it difficult to set guidelines. As more data accumulate by regular monitoring of populations, more specific thresholds can be determined. A steady or precipitous decline should trigger conservation action.

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IV. APPENDICES

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1. An Explanation of Conservation Ranks used by The Nature Conservancy and NatureServe

1. 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.