New England Plant Conservation Program

Eleocharis tricostata Torrey
Three-angled spikerush

Conservation and Research Plan for New England

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SUMMARY

Eleocharis tricostata Torrey, Three-angled spikerush, is a long-lived perennial in the sedge family (Cyperaceae). It is distributed from Massachusetts and New York, south to Florida along the Atlantic Coast with disjunct populations in Michigan. It is reported from 14 states, but is considered to be rare in seven states, and is known only from historical records in Maryland and Pennsylvania.

In New England, *Eleocharis tricostata* has been collected at a total of six sites in Massachusetts and Rhode Island. Two of the sites, both in Massachusetts, are extant. Before 1988, there was only one population considered to be extant, but it had not been seen for many years. During the early Natural Heritage Network effort to document globally rare species in the late 1980's and early 1990's, *E. tricostata* was listed as a G3 species (vulnerable to extirpation or extinction), because of its limited range and low number of known occurrences. The single known site in New England was relocated and a second, much larger population was discovered. *Eleocharis tricostata* was reranked to a G4 (apparently secure), based mainly on survey results in New Jersey and the Southeast. *Eleocharis tricostata*, however, remains rare in New England and is listed in *Flora Conservanda* as a Division 2 species, regionally rare.

Eleocharis tricostata is distinctive, but difficult for many botanists to identify. It may not always be evident at sites, particularly during periods of high water. There are probably more occurrences to be located in New England with additional searches.

In the Southeast, *Eleocharis tricostata* occurs in long-leaf pine savannahs and sandy and peaty soils near the coast. In New Jersey, it is found in pine barrens ponds. In New York and New England, *E. tricostata* occurs in mucky sections of coastal plain ponds. It is most evident during low-water periods. Coastal plain ponds have been well inventoried for pondshore species in New England, but less well inventoried for the species that occur in deeper organic deposits that are only rarely without water and support mainly sedges and grasses. There are numerous coastal plain ponds in Southeastern Massachusetts and dozens in Rhode Island that could support habitat for *E. tricostata.* Threats to *E. tricostata* include eutrophication of ponds, competition from other wetland species, hydrological alterations, succession, and physical disturbance. Little is known about the life history of *E. tricostata*. In one study, it was noted to germinate only under flooded conditions. It is believed to be long-lived, to form seed banks, and to be able to persist at sites through a range of water levels.

The conservation objectives for *Eleocharis tricostata* include: searches for new populations; the protection of six populations, if new populations can be found, including four in Massachusetts and two in Rhode Island; the development of an improved understanding of habitat use by *E. tricostata*; the investigation of life history events; and the maintenance of an *ex situ* seed bank. A monitoring protocol is recommended. Introductions/reintroductions are not recommended at this time.

PREFACE

This document is an excerpt of a New England Plant Conservation Program (NEPCoP) Conservation and Research Plan. Because they contain sensitive information, full plans 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.

NEPCoP 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. If you require additional information on the distribution of this rare plant species in your town, please contact your state's Natural Heritage Program.

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I. BACKGROUND

INTRODUCTION

Eleocharis tricostata Torrey, Three-angled spikerush, is a rhizomatous perennial in the sedge family (Cyperaceae). It is distributed from Massachusetts south to Florida along the Atlantic Coast with disjunct populations in Michigan. It has been collected in 14 states, but is now known only from historical records in two states and is rare in seven other states. During the 1980's, *E. tricostata* was ranked G3 (vulnerable to extirpation or extinction) and was the subject of significant inventories throughout its range. Two sites were located in Massachusetts. There are three additional historical records in Massachusetts and Rhode Island. *Eleocharis tricostata* was reranked to G4 (apparently secure), based on numerous sites located in New Jersey and Florida. It remains rare throughout the northern part of its range, including New England. *Eleocharis tricostata* is listed in *Flora Conservanda* as a Division 2 species, regionally rare (Brumback and Mehrhoff et al. 1996). This conservation plan is developed to assemble the current information available on *E. tricostata* in New England, to review the biology, ecology, and habitat needs of *E. tricostata* from throughout its range, to assess the reasons for its rarity in New England, and to inform the development of a conservation strategy for its protection.

Eleocharis tricostata is morphologically distinct, but can be confused with several other species of *Eleocharis* that are 20-60 cm tall and grow in organic soil in shallow water. In the Southeast, it occurs in long-leaf pine savannahs and, in New Jersey, it is found in pine barrens ponds. In New England, *Eleocharis tricostata* is found in coastal plain ponds in areas where the water level can fluctuate dramatically from year to year. *Eleocharis tricostata* can look very different with changes in water level. It may have been overlooked at some sites in New England.

It is unknown why *Eleocharis tricostata* is rare in New England. There is little known about its life history. In one study, it was noted that *E. tricostata* germinated only under flooded conditions (Kirkman 1992). It is known to persist at sites for many years.

The conservation objectives for *Eleocharis tricostata* include survey work to locate additional populations and, if new populations can be located, the protection of six populations, including four in Massachusetts and two in Rhode Island. Each population should have at least 500 culms and occur in multiple patches. All populations should be monitored annually for at least ten years and subsequently assessed at an interval sufficient to assess environmental change and the need for management. A monitoring protocol is proposed. Additional information should be collected to describe life history events, particularly related to the condition of the species during different water levels. Through field studies, habitat use for *E. tricostata* should be characterized to facilitate searches for new populations and to direct management. The current *ex situ* seed bank should be improved. Introductions or reintroductions are not recommended at this time.

DESCRIPTION

The following description of *Eleocharis tricostata* is adapted from Svenson (1934), Fernald (1950), Godfrey and Wooten 1979, Gleason and Cronquist (1991), and Smith et al. (2003). Nomenclature follows Mitchell and Tucker (1997). *Eleocharis tricostata* is a tufted perennial with a distinctive white, 1.5-3 mm diameter, scaly rhizome, with internodes 1.5-3.0 mm. Culms are 20-60 cm tall, compressed or subterete, and slightly grooved; they have been described as "spongy." The spikelet is cylindrical, 6-16 mm long and 2.5-3 mm broad, clearly differentiated from the culm. The spikelet is symmetrical and rounded at the summit. Sheaths are reddish and truncate at the summit with a mucronate tip that is an extension of the midrib. Scales are tan and ovate with scarious margins. Achenes are smooth and trigonous and slightly winged, obovoid, 0.6-0.8 mm long and 1.0-1.5 mm broad, and bristle-less. The tubercle is much smaller than the achene, spongy, and depressed, with a white rim.

The most significant features to use for field identification in New England include the clumped character of the plants, the somewhat flattened culms, the symmetrical, long spikelets, and the truncate sheath summit and its mucronate tip (personal observation). If plants are in fruit and they are ripe, the achenes are distinctive with their winged, trigonous edges, tiny tubercule, and lack of bristles. *Eleocharis tricostata* is also definitively identified in sterile condition. The rhizome is scaly or knotty with closely arranged nodes. When handled, the scales are easily removed, exposing the white, wiry rhizome. Plants can be found growing in a few closely scattered clumps or can be dense and cover large areas. Plants can be erect or unsupported and decumbent, probably depending on changes in water levels during the growing season (personal observation).

There are several other co-occurring, New England species of *Eleocharis* that can be mistaken for *E. tricostata*. *Eleocharis smallii, E. palustris,* and *E. erythropoda* can occur in shallow water, are rhizomatous, have a long spikelet, and are moderately large for the genus, 20-60 cm tall. They differ from *E. tricostata* in having biconvex achenes with bristles, round culms, an oblique sheath summit, and a rhizome that is not white. *Eleocharis tenuis* can also grow in shallow water, has a similarly thick rhizome to *E. tricostata*, a truncate sheath, and a trigonous achene. *Eleocharis tenuis* differs from *E. tricostata* in that it has slender culms, spikelets less than 6 mm long, and a rhizome that is not white. *Eleocharis robbinsii* often co-occurs with *E. tricostata.* It is rhizomatous and can be up to 70 cm tall. It is very distinctive, with a spikelet scarcely differentiated from the three-sided culm. It has biconvex achenes with a tall tubercle and bristles. *Eleocharis elliptica*, like *E tricostata* is rhizomatous, has trigonous achenes, and a flattened culm. It differs from *E. tricostata* by lacking keel-like angles to the achene, having bristles most of the time, and having slender rhizomes that are not white. *Eleocharis engelmannii* also can be found in shallow water and superficially looks like *E. tricostata.* It is a tall, cespitose plant with spikelets that look similar to those of *E. tricostata*. It differs from *E. tricostata* in that it is an annual, has obliquely truncate sheath summits, biconvex achenes, a broad flattened tubercle, and bristles. The main characters that distinguish *E. tricostata* from all other *Eleocharis* species in New England

is the white wiry rhizome. A review of distinguishing features for species superficially similar to *E. tricostata* appears in Table 1. The general description of the genus *Eleocharis* in the *Flora of North America* (Smith et al. 2003) includes a useful description of characters that are not well interpreted for the genus in the field and ways to avoid confusion during the use of keys.

The common names for *Eleocharis tricostata* include three-angled spikerush and three-angled spike-sedge. There is a good illustration of the rhizome, spikelet, sheath summit, and achene of *E. tricostata* in Crow and Hellquist (2000: 198).

Table 1. Review of field characters that differentiate *Eleocharis tricostata* from other tall species of *Eleocharis* in New England.

Species	Characters					
	Bristles	**Rhizome**	**Spikelet size (mm)**	**Sheath Summit**	**Achene Shape**	**Culm Cross-section Shape**
Eleocharis tricostata Torrey	None	White	5-20	Truncate	Trigonous	Somewhat flattened
Eleocharis smallii Britton	3-6	Not white	6-12	Oblique	Biconvex	Terete
Eleocharis palustris Roemer & Schultes	306	Not white	5-40	Oblique	Biconvex	Terete
Eleocharis erythropoda Steudel	5 or 6	Not white	3-18	Oblique	Biconvex	Terete
Eleocharis tenuis (Willd.) J.A. Schultes	None	Not white	2-6	Truncate	Trigonous	Terete
Eleocharis robbinsii Oakes	6	Not white	9-33	Oblique	Biconvex	Triangular
Eleocharis elliptica Kunth	0-5	Not white	4-8	Truncate	Trigonous	Flattened
Eleocharis engelmannii Steudel	6	None	5-13	Oblique	Biconvex	Terete

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

There are about 100 genera in the Cyperaceae worldwide, with 27 genera in North America (Smith et al. 2003). There are about 200 species of *Eleocharis* worldwide and 67 in North America. The name is derived from the Greek: *helos* for marsh and *charis* for grace. All species of *Eleocharis* are found in wetlands and have some variation in habit, probably related to water level (Gleason 1952).

The taxonomy of *Eleocharis* was studied by Svenson (1932) who placed *Eleocharis tricostata* in Series 6, the Palustriformes, and Subseries Truncatae. The Truncatae is characterized by achenes 0.7-1.5 mm long and the upper sheath truncate, indurate with a mucronate tip. The only other member of this sub-series in New England is *E. elliptica* which is similar in appearance to *E. tricostata*, but has more highly flattened culms, is not rhizomatous, and has bristles. The genus *Eleocharis* has recently

been reviewed by Roalson et al. (2001). Most of the relationships among subsections of *Eleocharis* are not substantiated by genetic assessment and represent evolutionary convergence. Relationships within the genus have undergone significant revision. *Eleocharis tricostata* is now considered to be a part of the subgroup *Eleocharis*.

Eleocharis tricostata is a distinct species, first named by John Torrey in 1836 as *Scirpus tricostatum*. Synonyms include (International Plant Name Index 2004):

Scirpus tricostatum Torrey
Scirpus tricostatus (Torr.) Kuntze
Trichophyllum tricostatus (Torr.) Kuntze
Trichophyllum tricostatum (Torr.) House

SPECIES BIOLOGY

There is little information on the biology of *Eleocharis tricostata.* In one study of Carolina Bays, *Eleocharis tricostata* germinated in an experimental seed bank project only under flooded conditions (Kirkman 1992). Efforts to germinate seeds were unsuccessful at the Garden in the Woods, Framingham, Massachusetts (William Brumback, New England Wild Flower Society, personal communication). Seeds were, however, sown on standard medium and watered, but not held under flooded conditions. Seedlings of *E. tricostata* have not been observed in the field.

Collections of *E. tricostata* have been made as early as June 17 with ripe achenes. However, one collection from August 14 was noted as having immature fruits. Flowering phenology in *E. tricostata* may be related to water level at the beginning of the growing season (Bicknell 1908). If water levels are high, plants either do not flower or they flower in July or August and have mature fruit later in the season. It appears that the best time to see ripe fruit is from late July to the end of September. Fruit appear to be held on the plant until mid-fall.

It is unclear if *E. tricostata* remains dormant during periods of high water. At several sites on Long Island, numerous plants were seen during a low-water year, but none were evident during other years when water levels rose (personal observation). The depth of water at the location of the plants at one pond was estimated at one meter when plants were not found. At another pond, plants were abundant on a dry pond bottom one year, but were not seen a second year, when the water was about one meter deep and was dark, presumably from tannins from the surrounding scrub oak thicket. It is possible that *E. tricostata* remains dormant some years during high-water periods.

At one New York site that has been documented as *Eleocharis tricostata,* a small stand of tall, sterile, spongy-leafed *Eleocharis* located along a disturbed border of a pond was examined for three years in a row (personal observation). Plants did not flower during this period. During the third year, the border of the plant clump was excavated,

exposing the white, wiry rhizome characteristic of *E. tricostata*. The plants also had a truncate sheath.

There are no data available on the longevity of *Eleocharis tricostata* individuals or populations. None of the extant populations in New England or New York have clear historical records that document that a population has likely been present at the site for many years. Long Island has four historical records for sites that no longer support *E. tricostata*. There are six recently located, extant populations in New York that have no earlier records. One of these six sites could have an historical record which bears a generic site name, Wading River, which could be any one of many ponds. Given its habit and the pondshore community in which it lives, it is likely that *E. tricostata* is a long-lived perennial, but it is not clearly demonstrated in the historical records.

HABITAT/ECOLOGY

Eleocharis tricostata is an obligate wetland species. It grows in a range of wetland conditions along the coast. In the Southeast, it occurs in long-leaf pine savannah swales and in other wet sandy acid sites (Radford et al. 1968). In New Jersey, it is found in wet pine barrens swales and on pond borders (Stone 1973).

In New England and New York, *Eleocharis tricostata* occurs in coastal plain ponds, which are found on glacial moraine or outwash deposits. The water level in these ponds is related to the general level of the groundwater, which varies in relation to rainfall over long periods of time. While these ponds do draw down during the summer, their general water level can be high or low all year long, related to the overall trend in rainfall. A distinctive suite of species is associated with the gradually-sloping margins of these ponds (Sorrie 1994, Zaremba and Lamont 1993). The plant diversity in these ponds is regulated by significant shifts in water level, combined with acid soils and low-nutrient conditions. During high-water periods, the vegetation is dominated by emergent species, and depending on water levels, floating species. Those plants that cannot tolerate flooding die or remain dormant as roots and rhizomes or seeds. During low-water periods, species that grow best under deep-water conditions die back or survive as rhizomes and roots or seed. Seeds germinate on exposed pond shores, and dormant rhizomes break dormancy and grow. Neither the deep-water species nor the dry shoreline species are able to dominate over time. The key to surviving in this variable environment is having the capacity to persist during adverse conditions.

Eleocharis tricostata occurs within coastal plain ponds in areas that dry out infrequently, where organics accumulate and persist during low-water conditions. Most often, *E. tricostata* is observed during low-water periods; searches for the species at the same sites during high water have been unsuccessful. Several of these sites have dark water and it is not possible to see submerged plants easily. It is unclear if *E. tricostata* survives high-water periods and produces biomass below water, or if the plant remains dormant and continues to produce aboveground biomass only when water levels are low or the pond bottom is partially dry.

All six of the extant populations in New York are located in ponds in a pine barrens landscape with a history of fire (personal observation). The ponds are shallow and dry during extended droughts, and are full of water during years with normal rainfall. Water depths during high-water periods range from 75 to 150 cm. The substrate consists of fine organics mixed with sand. Associated species in New York, with a distinct bias toward rare species, include: *Calamagrostis canadensis, Coreopsis rosea, Eleocharis melanocarpa, E. olivacea, Sagittaria teres, Agalinis purpurea, Polygonum* spp., *Stachys hyssopifolia, Panicum rigidulum, Gratiola aurea, Rotala ramosior,* and *Cyperus* sp.

During one extended period of drought, *Eleocharis tricostata* was abundant with hundreds of flowering culms at one site in New York during the first year that the pond was dry. During a second and third year of drought, when the cover of *Calamagrostis canadensis* increased at the location to nearly 100 percent, *E. tricostata* was less abundant and had very few flowering culms. *Eleocharis tricostata* may survive at a site for long periods of time with total cover and fertility fluctuating in relation to water level and competition from other species.

Under at least some circumstances, *E. tricostata* appears to be tolerant of some level of disturbance. Two of the New York populations occur in natural ponds that have been used as roadside catch basins for at least 30 years. The ponds are littered with styrofoam and colorful toy fragments amidst *Phragmites* at the pipe outlet, but support native species, including *E. tricostata* at more distant points.

In New England, *Eleocharis tricostata* occurs with *Dulichium arundinaceum, E. obtusa,* and *Euthamia graminifolia* with scattered individuals of *Scirpus cyperinus*. At the pond with the largest population in New England (MA .002 [Taunton]), the pond bottom is dominated by *Euthamia tenuifolia, Coreopsis rosea, Eleocharis tricostata, Fimbristylis autumnalis, Juncus pelocarpus, Panicum verrucosum, Rhexia virginica, Hypericum canadense, H. boreale, Drosera intermedia,* and *Sabatia kennedyana.*

Many rare plant species are associated with *Eleocharis tricostata* in New England and New York: *Sabatia kennedyana, Coreopsis rosea, Hypericum adpressum, H. hypericoides, Rotala ramosior, Polygonum careyi, Sagittaria teres, Utricularia radiata, Eleocharis melanocarpa, Stachys hyssopifolia,* and *Hedyotis uniflora.*

THREATS TO TAXON

Competing Species Displacing Habitat

Changes in species composition in coastal plain ponds often accompany changes in nutrient dynamics. Several of the sites in New York that supported *Eleocharis tricostata* are now dominated by wetland species that thrive in high-nutrient conditions (personal observation). *Phragmites australis, Calamagrostis canadensis, Euthamia tenuifolia, Cyperus* spp., and *Bidens* spp. appear to be good indicators of nutrient

enrichment in coastal plain ponds. One historical site in Massachusetts (MA. 001 [Nantucket]) is now dominated by *Calamagrostis canadensis* and *Euthamia tenuifolia*. Many of the characteristic species of coastal plain ponds, including *E. tricostata*, can be displaced by these species.

Natural Succession

In some cases, coastal plain ponds undergo succession that may be driven by natural processes and may not always be cyclic (personal observation). Ideal habitat for *Eleocharis tricostata* occurs in areas where organics accumulate, but are partly decomposed during low-water exposures. *Eleocharis tricostata* occurs in sections of coastal plain ponds that may not dry out completely for many years. If, during low-water periods, shrubs and trees can become established in *E. tricostata* habitat and grow tall enough to survive periods of high water, the character of a site could change, reducing habitat for *E. tricostata.* Many of these ponds occur in landscapes with vegetation types, such as pine barrens and scrub oak thickets, that periodically burn. Some of the ponds that have supported *E. tricostata* on Long Island in the past are now wooded. In contrast, fires that occur during low-water periods when ponds are dry may carry across the pond basin and eliminate wetland shrubs and trees and even burn soil organics, creating habitat for *E. tricostata.*

Eutrophication

Coastal plain ponds are typically acidic and low-nutrient environments. Several of the ponds on Long Island that historically supported coastal plain pondshore species, including *E. tricostata*, have been altered by road runoff, septic systems, golf courses, or tilled fields that increase nutrient availability and change species composition (Zaremba and Lamont 1993).

Physical Disturbance

There are several types of physical disturbances in coastal plain ponds that could impact or eliminate habitat for *Eleocharis tricostata*. Off-road vehicles use has been noted at MA .002 (Taunton). During low-water periods, the margins of coastal plain ponds can be exposed or even the whole pond can be dry. These usually flat, open areas are often subject to recreational off-road vehicle use, particularly in remote regions. Excessive vehicle activity is not always limited to sandy areas. Sections of some of these ponds with wet organic soils can look like they have been plowed after a weekend of off-road vehicle use.

At one site that supports *Eleocharis tricostata* (MA .001 [Taunton]), peat has been extracted, altering the substrate in the pond. Peat removal has not occurred at this site for several years. There are also instances of purposeful excavation of some types of

coastal plain ponds, particularly small ponds to create open-water environments. Ponds with organics and emergent vegetation may be dredged to create a more landscaped setting, eliminating habitat for some long-lived species, such as *E. tricostata*, that require stable substrate for long periods of time.

In New York, grass carp are also used in some coastal plain ponds to control nuisance vegetation. Grass carp grow to be very large and are voracious eaters that can devegetate ponds quickly, also changing nutrient availability and creating substrate disturbances that may be colonized by invasive species.

One of the most frequently cited threats to coastal plain ponds in New England is the alteration of hydrology, often from the withdrawal of water for municipal water supplies (Barbour et al. 1998). Many coastal plain ponds occur in areas that are undergoing rapid residential development. Groundwater is withdrawn, particularly during summer months, at rates far in excess of rainfall, resulting in water levels in ponds that are lower than during normal conditions. Long-term changes in water levels can alter species composition in these communities. Natural fluctuations of water levels in ponds may be critical to maintain habitat for *Eleocharis tricostata*.

DISTRIBUTION AND STATUS

General Status

Eleocharis tricostata is known from Massachusetts to New York south to Florida and Alabama along the coast with disjunct populations in Michigan. Within this range, there are no known collections from Connecticut or the District of Columbia. It is believed to be extirpated from Pennsylvania and Maryland. Data available through NatureServe (2004) indicates that *E. tricostata* has occurred in Louisiana. During the review of the taxon in the *Flora of North America* treatment (Smith et al. 2003), specimens were not located for Louisiana. The species is listed as S1 or S2 in seven states and is listed as S3 or S4 in two states, New Jersey and Georgia. *Eleocharis tricostata* is listed as SR in South Carolina, but is referred to as rare in Radford et al. (1968) and noted as occurring in only four counties. In Florida, it is ranked as SR and is known from 14 counties in the northern part of the state. The status in Alabama is S?. Magee and Ahles (1999) list *E. tricostata* as occurring in Maine. There are no known collections of *E. tricostata* from Maine and there is no indication in the treatment of *E. tricostata* in the *Flora of North America* (Smith et al. 2003) that it has ever occurred in Maine. It is likely that the Magee and Ahles (1999) report is inaccurate. *Eleocharis tricostata* is known from 14 states, but is probably common or secure in only five states.

Eleocharis tricostata is listed as a Division 2 species in *Flora Conservanda* (Brumback and Mehrhoff et al. 1996), which is defined as a Regionally Rare taxon with fewer than 20 occurrences within New England. Its global rank is G4 (apparently secure); its U. S. national rank is N? (NatureServe 2004). Data on the North American distribution and status of the taxon are available from NatureServe (2004). Data

concerning county distribution within states were obtained from the PLANTS National Database (United States Department of Agriculture 2004). Data are summarized in Table 2 and Figure 1.

Table 2. Occurrence and status of *Eleocharis tricostata* 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)
Massachusetts (S1, E): 2 extant occurrences and 1 historical occurrence	Alabama (S?)	South Carolina (SR): 4 counties	Maryland (SH)
Rhode Island (S1, E): 2 historical occurrences in 1 county.	New Jersey (S4)	Florida (SR): 14 counties	Pennsylvania (SX)
Delaware (S1)	Georgia (S3/S4): 5 counties		
Michigan (S2, T): 1 county			
New York (S1, E): 6 extant occurrences in three counties			
North Carolina (S2): 6 counties			
Virginia (S1): 4 counties			

Status of All New England Occurrences — Current and Historical

Eleocharis tricostata has not been collected in Maine (Don Cameron, Maine Natural Areas Program, personal communication), New Hampshire (Sara Cairns, New Hampshire Natural Heritage Bureau, personal communication), Vermont (Bob Popp, Vermont Nongame and Natural Heritage Program, personal communication), or Connecticut (Nancy Murray, Connecticut Natural Diversity Data Base, personal communication). Consequently, there have not been any efforts to survey for *E. tricostata* in these states.

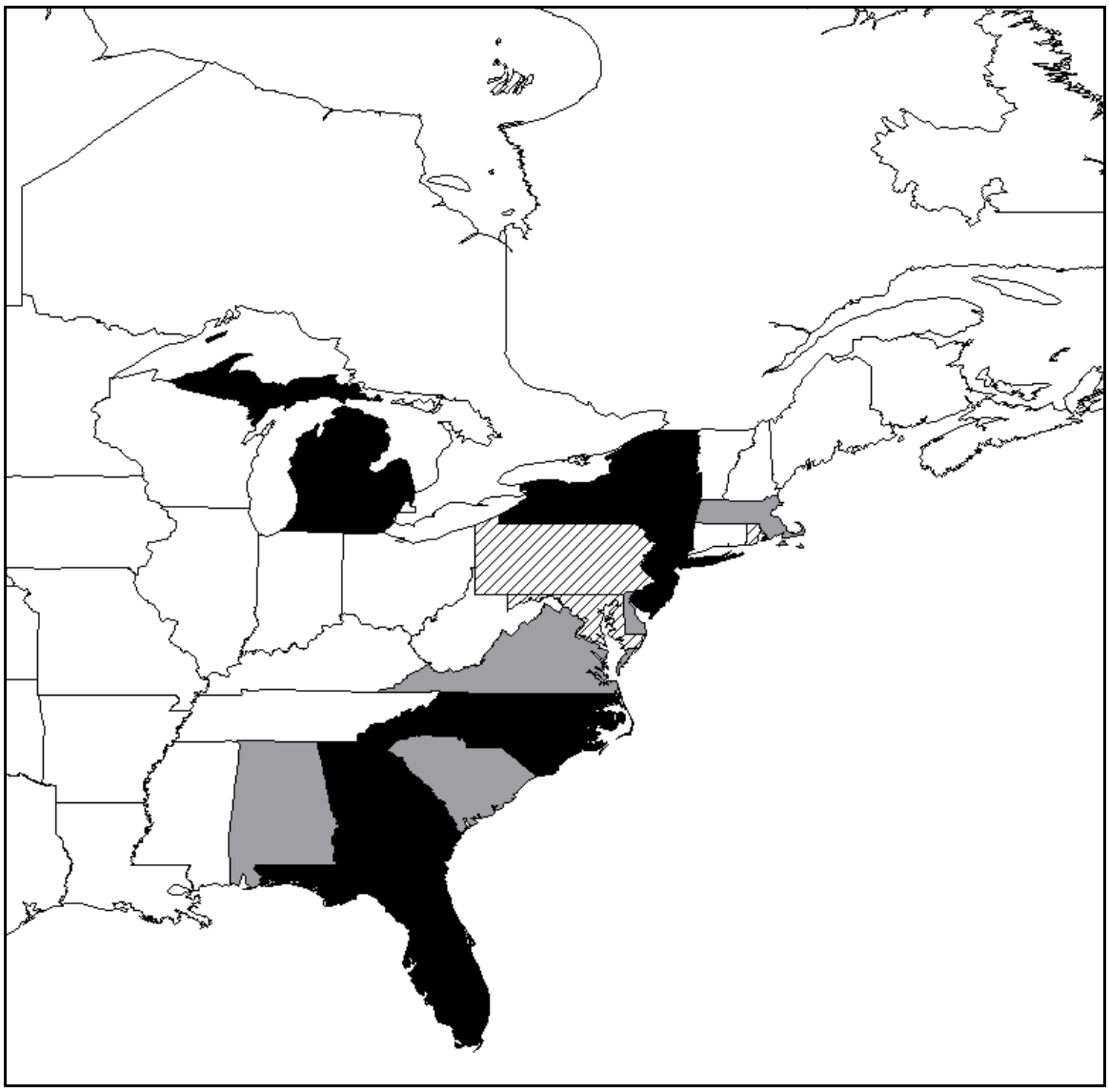

Figure 1. Occurrences of *Eleocharis tricostata* in North America. States and provinces shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences. The states with diagonal hatching are designated "historic," where the taxon no longer occurs. See Appendix for explanation of state ranks.

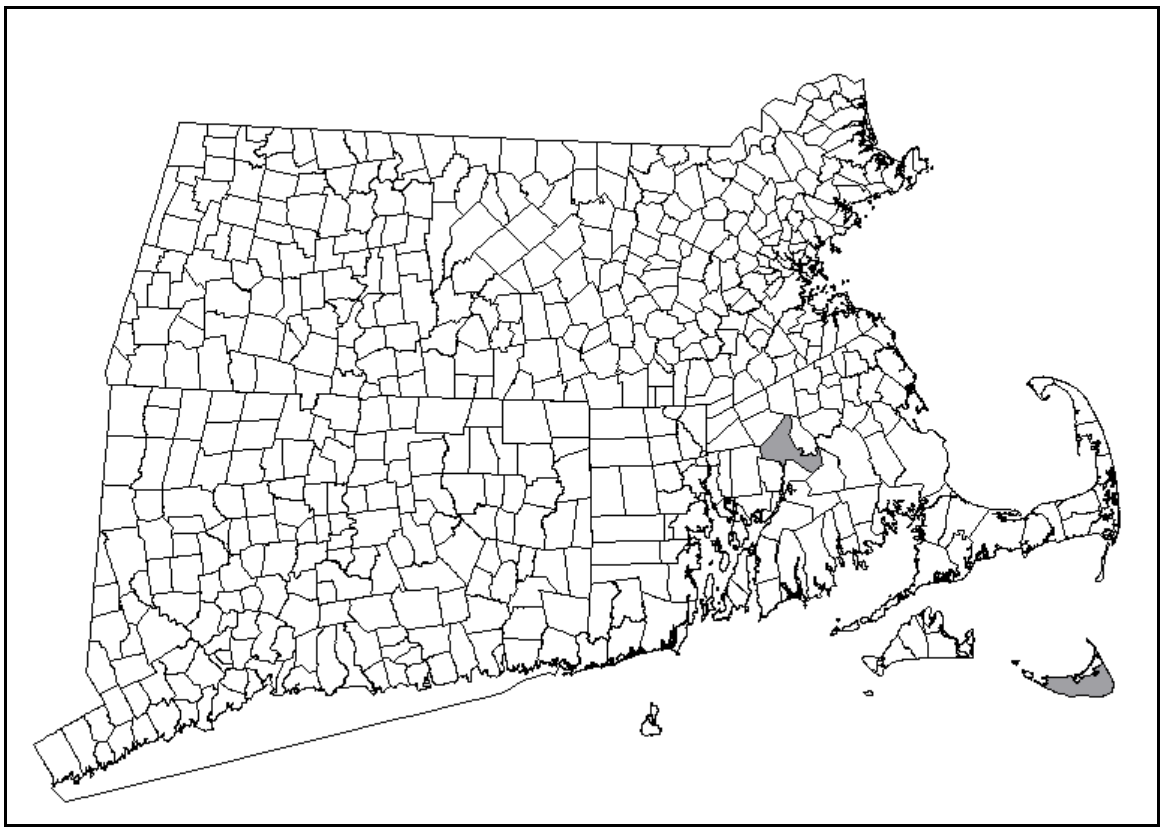

Figure 2. Extant occurrences of *Eleocharis tricostata* in New England. Town boundaries for southern New England states are shown. Towns shaded in gray have one to five extant occurrences of the taxon.

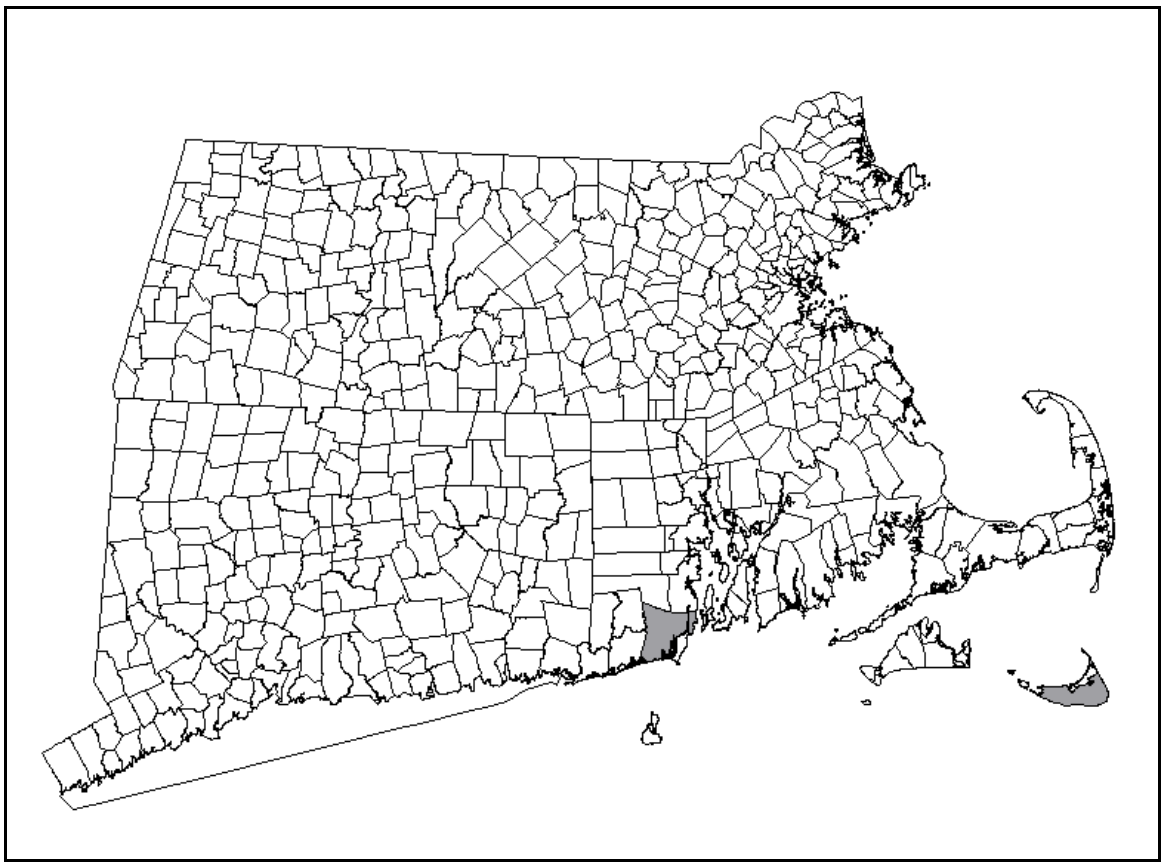

Figure 3. Historical occurrences of *Eleocharis tricostata* in New England. Towns shaded in gray have one to five historical records of the taxon.

Table 3. New England Occurrence Records for *Eleocharis tricostata.* Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
MA	.001	Nantucket	Nantucket
MA	**.002**	**Bristol**	**Taunton**
MA	**.003**	**Nantucket**	**Nantucket**
RI	.001	Washington	Narragansett
RI	.001	Washington	South Kingstown

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

The primary conservation objective for *Eleocharis tricostata* is to protect, through conservation action, six populations in New England; four in Massachusetts and two Rhode Island, all in natural habitat settings. There are currently two extant populations in Massachusetts and significant amounts of potential habitat that have not been surveyed for *E. tricostata.* The best opportunity to locate new populations and protect *E. tricostata* is in the vicinity of the two extant populations. There is potential habitat at other Massachusetts locations, particularly on Cape Cod and in Plymouth and Bristol Counties. All Rhode Island coastal plain ponds should be considered and searched for *E. tricostata*. It will be necessary to locate additional populations of *E. tricostata* in both Massachusetts and Rhode Island to achieve this objective.

Each occurrence should be managed to maintain a population of at least 500 culms annually in two or more patches with a total area of at least five square meters. The minimum viable population size for *Eleocharis tricostata* in New England, or anywhere in its range, is not known. The two Massachusetts populations consist of 200 culms and more than 10,000 culms. In New York, populations vary from 50 to 500 culms. Populations can occur as patches of plants. It seems advisable to have more than one patch of plants to avoid loss of the entire population due to some localized disturbance.

A third objective is to understand the causes for rarity and conservation needs of *Eleocharis tricostata* better by conducting site and population monitoring and life history studies. A clear understanding of the biological and ecological limitations of *E. tricostata* in New England will inform conservation actions over time.

A fourth conservation objective is to improve the existing *ex situ* seed bank. Germination studies should be conducted to assess seed viability in New England and develop methods to grow plants from seed. Rhizome propagation should also be considered. The conservation *ex situ* seed bank or rhizome bank should preserve the gene pool of *Eleocharis tricostata* in New England. If all natural populations are lost at some point in the future, seeds will be needed to supply material for additional studies and reintroduction efforts, if called for in future iterations of this plan. With only two currently known populations in New England, both within a small geographic area, it is desirable to retain New England seed in an *ex situ* seed bank. Reintroductions or introductions are not recommended at this time.

Site and population monitoring should be conducted for ten years to establish baseline information and characterize population trends and life history details. Searches for new populations should also be conducted for ten years under a range of different water levels. If, after ten years, additional populations of *E. tricostata* are not located and there is not an adequate number of sites to achieve the primary conservation objective of the protections of six populations, then the conservation objectives for *E. tricostata* should be revised to reflect the new data obtained during the implementation of this plan.

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IV. APPENDICES

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.