New England Plant Conservation Program

Echinodorus tenellus (Martius) Buchenau
Dwarf burhead

Conservation and Research Plan for New England

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SUMMARY

The dwarf burhead, *Echinodorus tenellus* (Mart.) Buch. (Alismataceae) is a small, aquatic herb of freshwater ponds. It occurs in shallow water or on sandy or muddy pond shores that experience seasonal drawdown, where it is most evident in the fall months.

Overall, the species is widely distributed, but is rare (or only historical or extirpated) in almost every United States state in its range. This species has been documented from only four stations in New England, the northern limits of its range, with occurrences in Connecticut and Massachusetts. Connecticut possesses New England's only extant population. The species is ranked globally as G3 (rare or uncommon), regionally by *Flora Conservanda* as Division 1 (globally rare) and at the regional State levels as endangered (Connecticut) or historic/presumed extirpated (Massachusetts). Threats to this species include alterations to the natural water level fluctuations, sedimentation, invasive species and their control, and off-road vehicle traffic.

The conservation objectives for dwarf burhead are to maintain, protect, and study the species at its current site, while attempting to relocate historic occurrences. Habitat management, regular surveys, and reproductive biology research will be utilized to meet the overall conservation objectives.

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

The dwarf burhead, *Echinodorus tenellus* (Mart.) Buch. (Alismataceae) is a diminutive, inconspicuous aquatic herb. It is the only representative of the genus in New England. Only four occurrences of this taxon have been reported in New England, with three of these believed to be extirpated. The taxon currently exists at a single site in Connecticut.

In New England, this taxon has been restricted to the exposed sandy shores of ponds with marked seasonal water level fluctuations. This hydrological regime is critical to the flowering and fruiting, and thus maintenance, of the species. These ponds usually support a transient flora, whereby *Echinodorus tenellus* may appear to be absent in dry years.

The taxon is wide-ranging in the New World but exists at the northern periphery of its range in New England. This factor is partially responsible for its rarity in the region. However, other reasons for rarity and threats to the species include alterations to the natural water level fluctuations, sedimentation, invasive species, and off-road vehicle traffic.

Species of *Echinodorus* in general are important aquarium plants and garden pond ornamentals (as Amazon sword plants in aquarium trade). *Echinodorus tenellus* (usually as Pigmy Chain sword) is considered very suitable for growing in aquaria and is among the five or six most well-known species for hobbyists. Most, if not all, information about the cultivation of *E. tenellus* comes from aquarium hobbyists.

This conservation plan summarizes existing information on the ecology, taxonomy, and conservation status of *Echinodorus tenellus*. Included are threats to its survival and recommended actions for the conservation of the species in New England. The conservation objectives for *Echinodorus tenellus* in New England are to maintain the single occurrence in Connecticut at present or higher population levels, search for other occurrences in the region, and conduct species-level research.

DESCRIPTION

Echinodorus tenellus (dwarf burhead) comprises small (rarely 10 cm high) slender, glabrous aquatic herbs either submersed in water or exposed on wet shores of freshwater ponds (Haynes and Hellquist 2000). Shoots are often creeping and proliferating, often forming dense mats. Plants form rosettes with mostly submersed leaves only 2-5 mm wide. In North America, submersed plants reach 5 cm in height, their laminas sessile, narrowly linear-lanceolate in shape (up to 6 cm long; 2-3 mm wide), light green and membranous (obscurely veined).

Submersed plants from central and South America are 4-9 cm high with laminas 5-10 cm long, 1-2 mm wide and dark green, turning brownish in bright light (Kasselman 2001). Emersed plants are up to 6 cm high with leaves that are petioled (0.5-4 cm long; 1 mm thick), the laminas narrowly lanceolate or linear to elliptic (1.5-2.5 cm long; 2-4 mm wide), and of a firmer texture (venation of 1-3 nerves evident). Flowering plants are emersed summer to fall. Peduncles are round and up to 4 cm long. Bracts are up to 5 mm long and 2 mm wide. Pedicels are 0.5-3 cm long. Flowers are small (0.6-1 cm wide) with three white petals (2.5 mm long, 2 mm wide) and three green sepals (up to 4 mm long, 2.5 mm wide). Pistils are 15-20 in number and stamens are nine, with basifixed anthers (Fassett 1955, Haynes and Hellquist 2000). Two to 16 flowers are borne in 1-several simple umbels (Rataj 1975). Fruits (1-1.5 mm long; 0.8-1 mm wide) occur on a flattened receptacle as an aggregate of beakless, reddish brown achenes, typically 3-ribbed (Fassett 1955).

In the United States there are four species of *Echinodorus*: *E. floridanus* Haynes & Burkhalter, *E. cordifolius* (L.) Grisb., *E. berteroi* (Sprengel) Fassett (all of subgenus *Echinodorus*), and *E. tenellus* (subg. *Helianthium*). *Echinodorus tenellus* is the only species in New England. Their ranges overlap well south of New England, mostly in the southeastern states. Nevertheless, *E. tenellus* is easily distinguished from these other species by its small size, mat-forming habit, nine stamens (vs. usually 12+), umbelliform inflorescence (vs. racemes/panicles), flattened receptacle (vs. conical), and beakless fruits (Rogers 1983, Haynes and Hellquist 2000).

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

There are 26(-45) species of *Echinodorus* limited to waters of the Western Hemisphere from the eastern U.S. to southern South America (Cook 1990, Haynes and Holm-Nielsen 1994, Haynes and Hellquist 2000). This largely neotropical genus, noted for a high degree of endemism (Sculthorpe 1967), is partitioned into two subgenera, *Echinodorus* and *Helianthium*. Subgenus *Helianthium* contains the dwarfed species (including the wide-ranging *E. tenellus*) which are distinctive for their fewer carpels, fewer stamens, and beakless fruits (Fassett 1955). These distinctions were once considered the basis of the genus *Helianthium* (Engelm. ex Hooker f.) J. G. Smith [e.g., *H. tenellum* (Mart.) Britt.]. Contemporary molecular studies by Soros and Les (2002) have supported the segregation of these subgenera at the generic level [hence *H. tenellum*], but this interpretation is not adopted in this plan.

Taxonomic opinions have varied concerning the limits of *Echinodorus tenellus*. On the basis of fruit features, some authors have separated the species into two; one in North America (*E. parvulus* Engelm.) and one in the neotropics (*E. tenellus sensu stricta*). The recognition of just a single species (i.e., *E. tenellus sensu lato*) generally has been accepted since morphological distinctions intergrade where geographic ranges overlap (Robinson 1905, Rataj 1975, Haynes and Hellquist 2000). While recognizing *E. tenellus* in the broad sense, however, Fassett (1955) acknowledged four varieties based largely on achene variation: var. *parvulus* of

North America, and vars. *latifolius*, *ecostatus*, and *tenellus* of Central and South America. Accordingly, New England plants are referred to as *E. tenellus* [var. *parvulus* (Engelm.) Fassett]. Other nomenclatural novelties affecting North American *E. tenellus* have notably been based on a New England population. A submersed form of Massachusetts plants was named as forma *randii* by Fassett (1955), with the remaining North American plants referred to f. *parvulus*. Putative hybrids between *E. tenellus* var. *parvulus* and var. *tenellus* have been reported (Rataj 1975). *Echinodorus tenellus* was originally described as *Alisma tenellum* Martius (1830). It is sometimes known as "*Sagittaria microfolia*" (trade name) in trade, but this is not a legitimate name.

Some authors have speculated that the North American *Echinodorus tenellus* (var. *parvulus*) evolved from refugial populations in the Ozarks region of central U.S. and later invaded the Coastal Plain (Fassett 1955; Lipscomb 1977). The species is perhaps most closely related to *E. bolivianus* (Rusby) Holm-Niels. (which now includes Fassett's *E. tenellus* var. *latifolius*). *Echinodorus bolivianus* is distributed from Mexico through Central America to Argentina (lacking in Amazon region). No phylogenetic reconstruction of the entire genus exists, however.

SPECIES BIOLOGY

Unlike most species of *Echinodorus*, *E. tenellus* grows submersed, but is found emersed on wet substrate (as currently in New England). As with many aquatic plants, this reaction to the environment influences the morphology of the foliage whereby the exposed leaves are relatively shorter, broader and thicker. As water levels drop in *E. tenellus* habitats, the emersed foliage replaces the submersed foliage. It is apparent that the most noticeable stage of these diminutive, inconspicuous plants is during late seasonal drawdown.

Echinodorus tenellus is considered an annual (Haynes and Hellquist 2000) or delicate perennial (Gleason and Cronquist 1991) species with population numbers fluctuating yearly. Flowers (ca. 3-16 per umbel) are produced by emersed plants only (Rataj 1975), but there is a report of flower production in shallow water (Rand 1903). Plants flower and fruit from late summer to fall. Achenes (up to 20 per flower) are produced seemingly in abundance. All species of *Echinodorus* are believed to have floral nectaries, where nectar is secreted from the stamen bases (Watson and Dallwitz 2002). There are no reports of specific pollinators or breeding system details for *E. tenellus*. Studies of the distantly-related *E. grandiflorus* have shown insects, particularly bees, to be important pollinators and that self-compatible and self-incompatible breeding systems can exist in a single species (Viera and de Souza Lima 1997). The chromosome number of *E. tenellus* is $2n = 22$ (Kasselman 2001) probably indicating the diploid level as in the related genus *Sagittaria* (Jiakuan 1989). No information is available on seed dormancy or germination requirements, although Baskin and Baskin (1999) report in another *Echinodorus* species that cold stratification may be required. The small size of seeds,

lack of hairs or other modifications, and close proximity to the ground would seem to limit dispersal.

Like other species in subgenus *Helianthium*, *Echinodorus tenellus* also produces modified inflorescences on submersed plants (Wilder 1975, Rogers 1983). These prostrate runner-like "pseudostolons" (Charlton 1968) represent sterilized inflorescences; however, they only produce vegetative buds followed by clonal plantlets (never flowers). The prolific production of these indeterminately growing pseudostolons allows for the species to spread rapidly and asexually colonize an area. Individuals are often found with 3-4 plantlets attached. It is this mat-forming trait that makes the species a desirable "foreground" aquarium plant (Gray 1994, Randall 1998, Kasselman 2001).

As evidenced from aquarium hobbyists, *Echinodorus tenellus* (as Pigmy Chain Sword in trade) is apparently not difficult to cultivate and, due to its prolific vegetative reproduction, will regularly need to be "thinned" (Randall 1998). General cultivation requirements include a sandy substrate and high light levels (Rataj and Horeman 1977, Stodola 1987, Smith 1994). *Echinodorus tenellus* can not be grown in aquaria more than 60 cm high due to the lack of sufficient light. It is recommended to be grown in soft to medium-hard water with weakly acidic pH values (Kasselman 2001). The optimum temperature is between 18^{o} and 28^{o}C; however, the plants also temporarily withstand higher or lower values. Depending on the origin of populations, the plant will flower under conditions of long or short day length. The emergent form can be grown in greenhouse culture without any difficulty.

The phycomycete *Aphanomyces euteiches* Drechsler has been documented to infect and destroy large numbers of cultivated *Echinodorus longipetalus* Micheli in A. & C. de Candolle plants (Ridings and Zettler 1973). Experimental inoculations on other species of *Echinodorus* (not including *E. tenellus*) failed to infect the specimens and affect their health. It is not known if fungi or other pathogens affect *E. tenellus*.

HABITAT/ECOLOGY

Like all Alismataceae, *Echinodorus tenellus* is adapted and confined to aquatic habitats. Throughout its North America range, the species is described as occurring in permanently shallow water (< 1m deep) or periodically wet areas along the margins of small freshwater streams, lakes, or ponds (Gleason and Cronquist 1991, Haynes and Hellquist 2000). The substrate is described as sandy soil, mud, or peat. South American habitats of naturally occurring *E. tenellus* populations are described further in Kasselman (2001).

In extant and historic New England occurrences, *E. tenellus* is known to colonize areas with notably fluctuating water levels. Stations exist along the lower shores of ponds that experience seasonal inundation. Consequently, plants (or their propagules) are presumably submerged for a significant part of the year but then during the late-season low water periods,

plants are emergent and able to flower. If the fall months follow a rainy summer, the water-table is high and the shores will be wet and saturated. Following a dry summer, the shores are more sandy and dry. This latter condition does not appear conducive to *E. tenellus*, as plants are not found during extended drought conditions with its associated drier soils (Fernald 1918, Godfrey and Wooten 1979). It is currently not known if the drier conditions actually kill the plants or merely make them go dormant.

High light levels appear to be a requirement for *Echinodorus tenellus*. All New England stations, current or historic, have been highly exposed ponds with no potentially shading woody plants in close proximity. A high light prerequisite is also evident from the consensus of aquarium growers, who report effortless cultivation but note that plants demand high light levels (e.g., Rataj and Horeman 1977, Kasselman 2001).

Plant species associated with *Echinodorus tenellus* in New England are completely herbaceous, and markedly change over the season due to the water level fluctuations (Fernald 1918). Species composition in New England includes *Gratiola aurea*, *Bidens connata*, *Eleocharis acicularis*, *Penthorum sedoides*, *Lysimachia terrestris*, *Polygonum hydropiperoides*, and *Mentha* sp. Notable associates include the regionally rare *Rotala ramosior*, *Stachys hyssopifolia*, and *Hemicarpha micrantha*.

THREATS TO TAXON

Echinodorus tenellus is most likely rare in New England because its occurrence represents the upper limits of its geographic range. Direct threats to *Echinodorus tenellus* are limited in number but significant. Despite fluctuating population numbers, the lone extant New England occurrence, in Connecticut, seems to be generally secure and monitored by NEPCoP schedules and occasional visits. However, factors that threaten this status include:

Alterations to natural water level fluctuations. Given that the life history of this annual species requires late season drawdown to achieve reproduction, this factor represents a serious threat to New England occurrences. Spring high water levels prevent encroachment of woody shrubs and trees, and late summer drawdown allow for the characteristic herbaceous community. Plants require high light levels and are normally known to flower only when exposed on wet shores. Hydrologic alterations must have contributed to the demise of MA .001 (Cambridge), where that pond is now a municipal water reservoir. It should be noted that the natural water level fluctuations at CT .001 (Glastonbury) are due to ground water flow and known not to be influenced materially by surface water flow.

Sedimentation. Sedimentation appears to be a potential threat to this species. The site of the single extant occurrence (CT .001 [Glastonbury]) is being impacted by sedimentation (David Gumbart, The Nature Conservancy, personal communication).

An inlet stream to the pond is known to deposit sand from a nearby highway. Historically, this inlet was channeled, which increased natural erosion levels and the accretion of sand and gravel. More recent road construction nearby has also contributed to this build up.

Invasive species. The invasive plant *Lythrum salicaria* may pose a threat to the continued occurrence of *E. tenellus* in New England. Other invasive species could also pose a threat in this habitat. *Lythrum salicaria* is reported at both extant (CT .001 [Glastonbury]) and extirpated New England occurrences (MA .003 [Winchester]), heavily infested at the latter.

Chemical treatment. An historic site of this species in Massachusetts (MA .003 [Winchester]) is reported to have been "chemically treated" to control vegetation (Massachusetts Natural Heritage and Endangered Species Program unpublished data). While no other information is available on the type(s) of herbicide or the application, the use of chemicals to treat invasive species presents an associated threat to the species.

Damage from off-road vehicles. Off-road vehicle (ORV) traffic could be a serious threat to *E. tenellus* populations. ORV use has been noted at CT .001 in Glastonbury (Connecticut Natural Diversity Data Base, unpublished data) in the fall season when the pond shores are dry. It is this period of time when the plants are normally setting fruit.

DISTRIBUTION AND STATUS

General Status

Echinodorus tenellus is primarily a coastal plain species in North America, distributed irregularly from Connecticut south to Florida, Texas, and Mexico, and up the Mississippi embayment to Illinois (Crow and Hellquist 2000). The species occurs locally along the Atlantic and Gulf coasts with very few inland stations. It is rare throughout its North American range (Table 1). Globally, this taxon is ranked either G3 (based on its synonym *E. parvulus*; Brumback and Mehrhoff et al. 1996) which indicates it is vulnerable, or G5 (*E. tenellus sensu lato*), which indicates it is secure but may be rare in parts of its range, particularly on the periphery (NatureServe Explorer 2002). Abundance in its neotropical range (Mexico, West Indies, Central and South America) is lesser known (Haynes and Holm-Nielsen 1994). Figure 1 shows the North American distribution of the taxon.

Table 1. Occurrence and status of *Echinodorus tenellus* in the United States and Canada based on information from Natural Heritage Programs. See Appendix 3 for specimen citations.			
OCCURS & LISTED (AS S1, S2, OR T &E)	**OCCURS & NOT LISTED (AS S1, S2, OR T & E)**	**OCCURRENCE REPORTED OR UNVERIFIED**	**HISTORIC (LIKELY EXTIRPATED)**
Connecticut (S1/endangered): 1 extant occurrence.		Alabama (SR): 4+ counties	Massachusetts (SX): 3 historic occurrences.
Illinois (S1/Endangered): 3 counties		Arkansas (SR): 1 county	New Jersey (SH): 1 historic occurrence
Michigan (S1/endangered)		Delaware (SR): 1 county	New York (SX): 4 historic occurrences
South Carolina (S2/ special concern): 3 counties		Florida (SR): 7+ counties	
Virginia (S1)		Georgia (SR): 5+ counties	
		Indiana (SR)	
		Kansas (SR): 1 county	
		Kentucky (SR): 1 county	
		Louisiana (SR)	
		Mississippi (SR): 2 counties	
		Missouri (SR): 2 counties	
		North Carolina (SR)	
		Oklahoma (SR)	
		Texas (SR): 4 counties	

Status of All New England Occurrences — Current and Historical

Only four occurrences of this taxon have been reported in New England, with three of these (all in Massachusetts) believed to be extirpated. The taxon currently exists at a single site in Connecticut. Figures 2 and 3 (below) show the extant and historical occurrences of the taxon in New England, respectively.

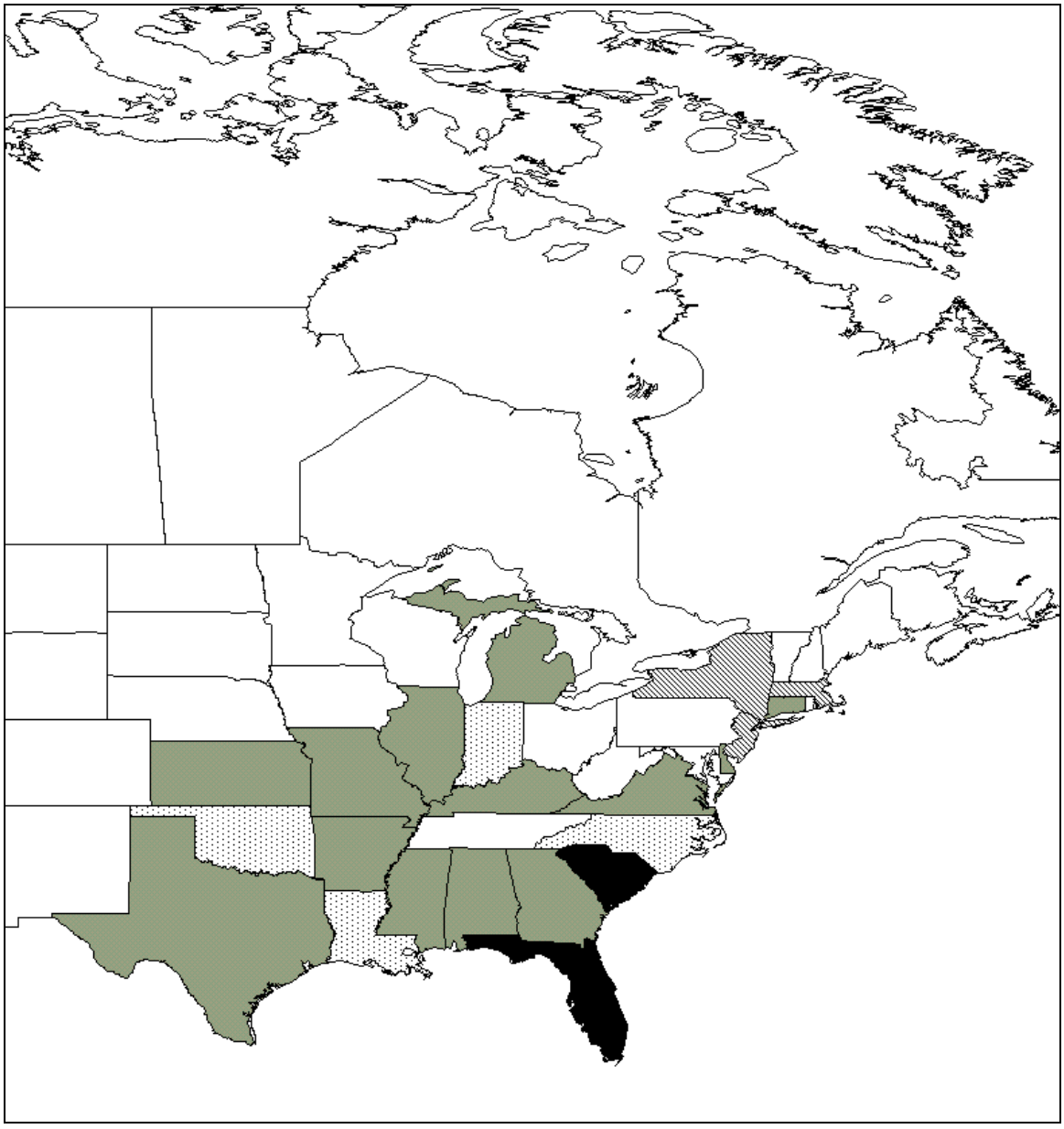

Figure 1. Occurrences of *Echinodorus tenellus* in North America. States shaded in gray have one to five (or an unspecified number of) current occurrences of the taxon. States shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" for which no further information is available). See Appendix for explanation of state ranks.

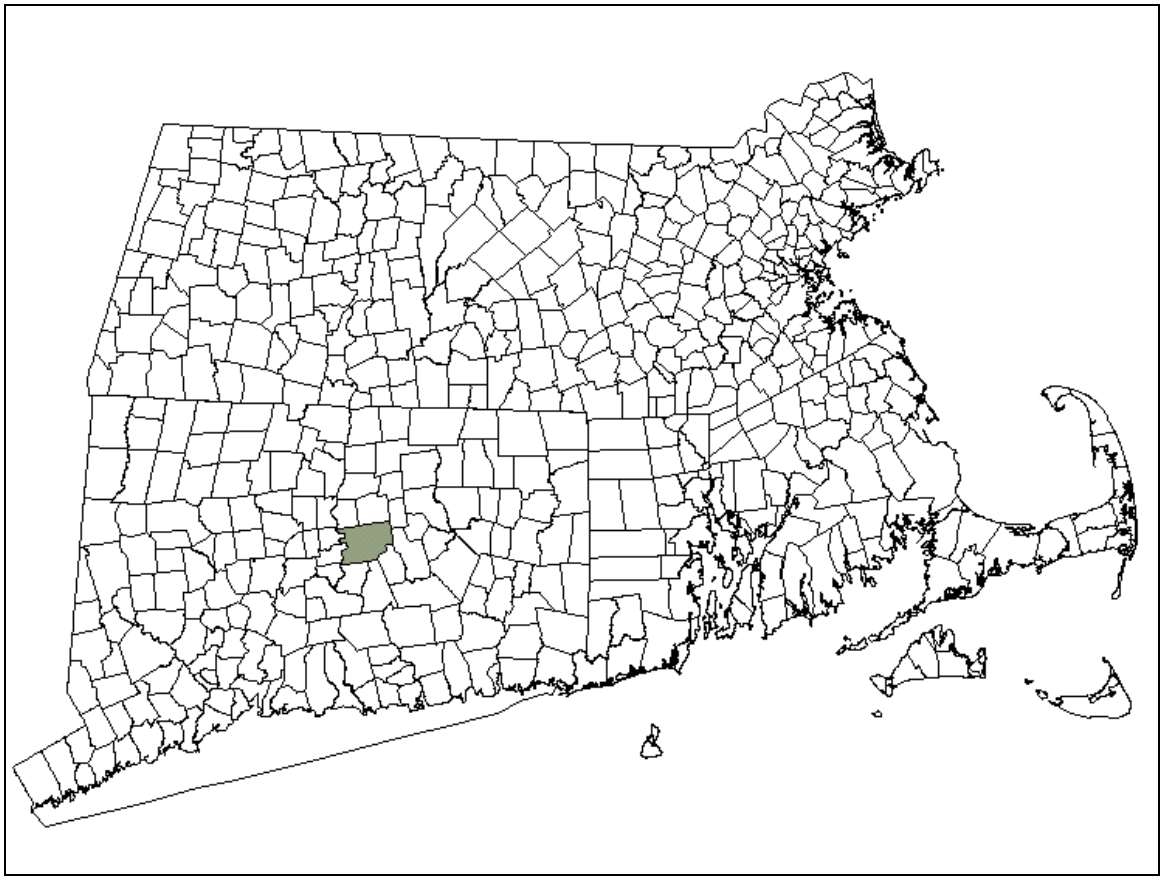

Figure 2. Extant occurrences of *Echinodorus tenellus* in New England. Town boundaries for southern New England states are shown. The town shaded in gray has one occurrence of the taxon.

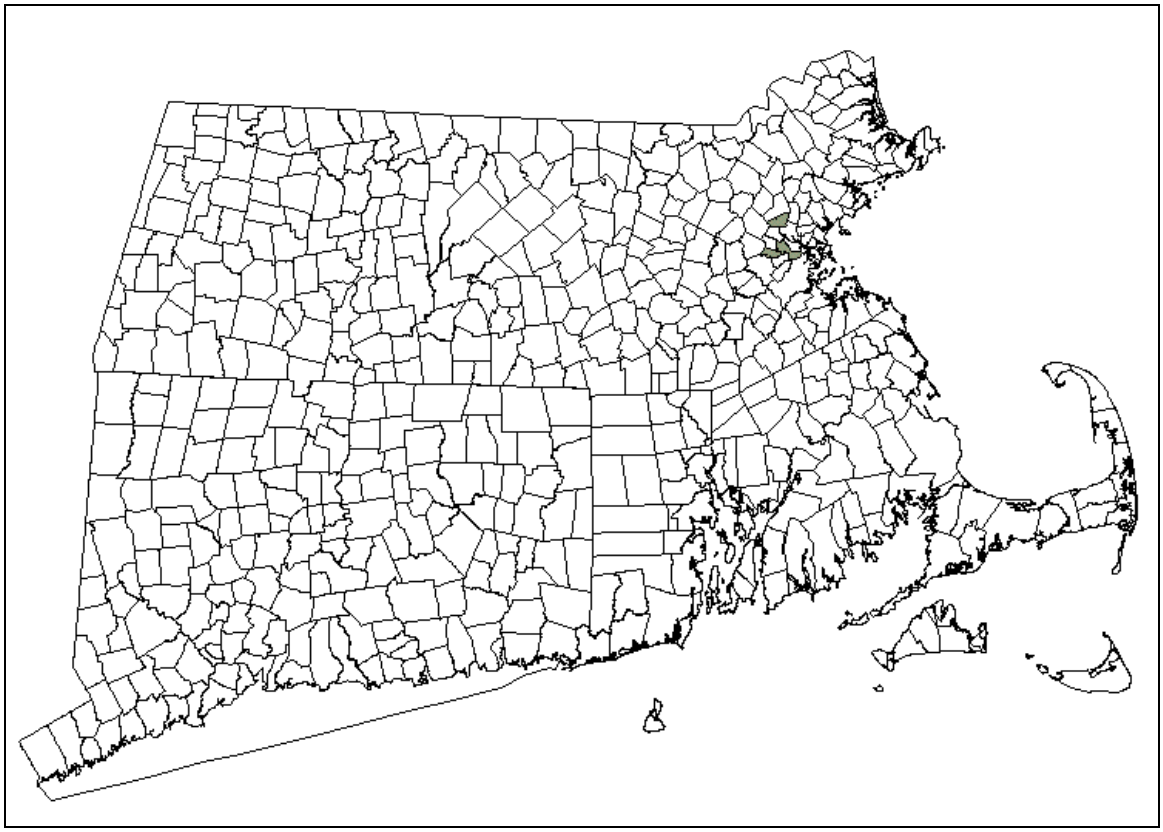

Figure 3. Historical occurrences of *Echinodorus tenellus* in New England. Towns shaded in gray have one historical record of the taxon.

Table 2. New England Occurrence Records for *Echinodorus tenellus*. Extant occurrences are shown in bold.			
State	**EO Number**	**County**	**Town**
MA	.001	Middlesex	Cambridge
MA	.002	Middlesex	Watertown
MA	.003	Middlesex	Winchester
CT	**.001**	**Hartford**	**Glastonbury**

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

Although widespread in the New World, *Echinodorus tenellus* is rare in New England (Brumback and Mehrhoff et al. 1996), a region where it appears to reach its northern limit. The primary conservation objective for *Echinodorus tenellus* in New England is to maintain the single occurrence in Connecticut at present or higher population levels. Since population levels change from year to year, a median target level should be about 500 individuals each year, 25% of which are flowering. Because of the high incidence of clonal growth in this taxon, these individuals should be distributed among several areas (or subpopulations) along the pond margin to increase the potential for population differentiation. Secondary conservation objectives are to search for other occurrences in the region and to conduct species biology research on the species to determine habitat requirements, precise levels of reproduction, genetic variability, and seed viability and longevity in New England.

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IV. APPENDICES

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1. Some Herbarium Specimen Documentation of *Echinodorus tenellus* in the United States.

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

1. Some Herbarium Specimen Documentation of *Echinodorus tenellus* in the United States.

ALABAMA
Covington Co., Open Pond, Haynes 7578 (UNA)
Houston Co., SE Cottonwood, 1 Aug 1971, Kral 43407 (VDB)
Geneva Co., NE Geneva , 25 Jun 1974, Kral 53499 (VDB)
Barbour Co., 7 Jul 1998, McDonald 11611 (VDB)

ARKANSAS
Baxter Co., W of Mt. Home, 26 Oct 1974, Lipscomb 992 (SMU).

CONNECTICUT
Hartford Co., Glastonbury, 29 Sep 1989, Mehrhoff 13091 (CONN)
Hartford Co., Glastonbury, 18 Aug 1989, Metzler 89001 (CONN)

DELAWARE
Canterbury, Aug 1874, Canby s.n. (GH, US, F)

FLORIDA
Fort Meade, 20 Mar 1880, Smith s.n. (US)
Hillsborough Co., Tampa, Curtiss 2739 (GH, MO, NY, US, M, K, VT, PH, MIN, LE)
Hillsborough Co., 15 Mar 1958, Cooley et Monachino 5623 (GH)
Hillsborough Co., Tampa, East Nursery pond, 4 Dec 1960, Lakela 23649, (FLAS, GH, K)
Wakulla, Shaderville, 20 Sept 1959, Godfrey 58895 (GH)
Marion Co., Dunellon, 11 June 1900, Curtiss 6658 (GH, MO, NY, US, UC, VT, LE, MIN)
Alachua Co., E. of Gainesville, 9 Aug 1942, Laessle s.n. (FLAS)
Hernando Co., Weeki Wachee Springs, 26 April 1961, Cooley et Wood 8058 (GH, LL, MIN)
Hernando Co., Brooksville, 8 Jun 1958, Kral 6734 (GH, US)
Hernando Co., Brooksville, 14 Jul 1958, Godfrey 57247 (UC)
Jackson Co., Lake Seminola, 28 Oct 1958, Godfrey 57876 (GH, UC)
Leon Co., Tallahassee, 31 May 1925, Harper s.n. (NY, US)
Leon Co., Tallahassee, 29 Nov 1958, Godfrey 57984 (GH, UC)

GEORGIA
Open Pond, Decatur Pond, 12 Aug 1901, Harper 1202 (GH, MO, NY, US)
Mason Co., W of Saidora, 18 Sep 1960, Rexroat 7190a (ILLS)
Mitchell Co., SW of Camilla, 27 Jul 1946, Duncan 6685 (GA)
Lowndes Co., S. Valdosta, 10 Jun 1967, Norris 859 (VSC)
Decatur Co., E side of Bainbridge, 13 Oct 1991, Kral 80041 (VDB)
Grady Co., SW of Beachton, 17 Aug 1993, Anderson 14532 (FSU)

ILLINOIS
St. Clair Co., 11 Aug 1892, Eggert s.n. (MO, LE)
East St. Louis, 4 Aug 1892, Eggert s.n. (NY)

KANSAS
Harvey Co., N of Burrton, 24 Jul 1973, Platt s.n. (KANU)

KENTUCKY
Christian Co., 18 Aug 1983, Chester 83-287 (VDB)

MASSACHUSETTS
Middlesex Co., Winchester, 7 Aug 1876, Morong s.n. (F)
Middlesex Co., Winchester, 8 Aug 1876, Morong s.n. (MO)
Middlesex Co., Winchester, 17 Aug 1876, Morong s.n. (NY, US)
Middlesex Co., Winchester, 28 Aug 1878, Faxon s.n. (GH, MO, NY, US)
Middlesex Co., Winchester, Sep 1878, Morong s.n. (F)
Middlesex Co., Winchester, 10 Oct 1901, Rand s.n.. (GH)
Middlesex Co., Winchester, 13 Oct 1901, Williams s.n. (CONN, VT, GH, MASS, NEBC)
Middlesex Co., Winchester, 10 Sep 1902, Churchill s.n. (MO)
Middlesex Co., Winchester, 27 Sep 1916, Ware s.n. (US)
Middlesex Co., Cambridge, Aug 1868, James s.n. (GH)
Middlesex Co., Cambridge, Aug 1869, James s.n. (MO, NY, US)
Middlesex Co., Cambridge, Sep 1869, James s.n. (MO)
Middlesex Co., Cambridge, 1873, James s.n. (NEBC)

MICHIGAN
Saint Joseph Co., White Pidgeon, 11 Aug 1837, Sager s.n. (GH)

MISSOURI
St. Louis, Aug 1845, Engelmann s.n. (MO, S, K, BR, TEX, GOET)
St. Louis, Aug 1848, Engelmann s.n. (NY)
2 Aug 1892, Eggert s.n. (S, BR, MIN)
Howell Co., West Plains, 4 Sept 1949, Steyermark 69124a (F, US, WIS)

MISSISSIPPI
Osyka, Jul 1899, Cocks s.n. (Tulane)
Lamar Co., W of Purvis, 29 Aug 1973, Rogers 9223 (NLU)

NEW YORK
Queens Co., Maple Grove, Long Island, 4 Aug 1904, Bicknell s.n (NY)
Queens Co., Long Island 16 Sept 1921, Ferguson 934 (NY, NYS)
Queens Co., Long Island 25 Oct 1928, Ferguson 7378 (NY, US)

NEW JERSEY
Burlington Co., Delanco, 17 Aug 1906, Van Pelt s.n. (GH)
Burlington Co., Delanco, 11 Aug 1908, Van Pelt s.n. (NY)
Burlington Co., Delanco, 19 Sep 1918, Pennell 9917(NY)

SOUTH CAROLINA
Santee Canal, July, Ravanel s.n. (GH)
Bamberg Co., SE of Denmark, 12 Jul 1984, Nelson et Bennett 3563 (USCH)
Aiken Co., White Pond, 23 Aug 1971, Leonard et al. 4995 (TENN, NLU)

TEXAS
Jackson Co., Horseshoe Lake, 9 Sept 1920, Drushell 4143 (VT, MO, US)
Garden City, 10 Jul 1942, Cory 40587 (TEX)
Kenedy, King Ranch, 24 Sept 1954, Lundell et Cornell 15163 (LL)
Kenedy, 21 Apr 1959, Correll et Rollins 21002 (LL)
Brooks Co., S of Encino, 6 Oct 1993, Carr 13190 (TEX)

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

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

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

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

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

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

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

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