New England Plant Conservation Program

Sabatia campanulata (L.) Torrey
Slender marsh-pink

Conservation and Research Plan for New England

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SUMMARY

Sabatia campanulata (L.) Torrey, slender marsh-pink, is a widespread perennial in the Gentianaceae (Gentian Family), distributed from Massachusetts to Indiana south to Florida and Texas. It is known from 19 states. It is rare in eight states and historical in two states. In New England, it is known only from Massachusetts, where it is listed as Endangered. It is listed in *Flora Conservanda* as a Division 2 species, globally secure, but regionally rare. It is currently extant at five sites (of which only three have been observed since the 1980's) and historical at seven sites, all in the southeastern part of the state, all within only three towns. One of the Massachusetts populations has been observed for over 175 years. The three recently observed sites are all owned by private conservation organizations. Population sizes are highly variable from only one plant to over 300 plants. None of the extant sites is occupied by evident plants every year.

Sabatia campanulata occurs in wet pine savannahs, along shores of ponds, in flatwoods in the Southeast, and in small remnant wetlands in the Southern Appalachian mountains. On Long Island, there are three documented populations; two occur at the upper edges of broad salt marshes; one occurs in an interdunal swale on a barrier beach. In New England, the three extant populations and all of the historical records with good locational information are on coastal plain pondshores that occur in glacial settings that have exposed margins during low-water periods. *Sabatia campanulata* is taxonomically distinct, but easily confused with *S. stellaris*. In New England, the two species do not co-occur, but in New York, both can be found along the upper borders of salt marshes.

Sabatia campanulata is insect-pollinated, produces large numbers of very small seeds, requires a cold treatment for germination, and may require light for germination. The species may be rare at the northern edge of its range because it does not overwinter during periods of severe cold. Other reasons for its rarity in New England include direct loss of habitat, succession, physical disturbance, and eutrophication. *Sabatia campanulata* is known to hybridize with *S. kennedyana*, but seeds of hybrid plants may not be viable.

The conservation objective for *Sabatia campanulata* in New England is to locate and protect six populations at six different ponds, with each population averaging at least 100 plants per year during years with low-water conditions. Two of the populations should be on Nantucket, two in Barnstable, and two at other sites in Massachusetts. If plants can be found in Rhode Island, where there is potential habitat, two populations should also be protected there. All populations should be monitored for numbers of plants, habitat extent, management effects, and associated species to develop a better model of habitat use to facilitate searches for new populations and to set effective management goals. Other research should be conducted on key factors that limit populations such as the capacity of the species to overwinter in New England, plant longevity, plant responses to fluctuating water levels, possible inbreeding depression, and competition with other species. Seeds should be collected from the range of sites and maintained in an *ex situ* seed bank. Reintroductions should be considered at one or more of the ponds in the Mary Dunn Pond Complex, if, after analysis, populations are extirpated and the habitat is appropriate.

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

Sabatia campanulata (L.) Torrey (slender marsh-pink) is an herbaceous perennial in the Gentian Family, one of three species of *Sabatia* known from New England. *Sabatia campanulata* is one of the rarest species in New England and is known currently from only three sites. Populations vary dramatically from year to year; some years there are no plants seen in all of New England. This conservation plan is written to highlight the rarity of this species and to review current information about taxonomy, biology, and ecology and the status of sites known in New England. There is a review of threats and an assessment of the need for conservation action. Recommendations are made concerning conservation goals and activities required to secure the species in New England.

Sabatia campanulata is known from 19 states along the Atlantic Coastal Plain and in the southern Appalachian Mountains. There was a disjunct population in Indiana. It is rare in seven states and known only from historical records in two states. It is listed as S3 in two states and listed as SR or SH in eight states. In New England, where it is at its northern limit, it has been collected only in Massachusetts, where there are eight historical sites as well as five sites with extant populations. Only three of these "extant" populations have been seen since the 1980's, however, despite repeated searches. It is listed in *Flora Conservanda* as a Division 2 species, globally secure, but regionally rare (Brumback and Mehrhoff et al. 1996). It is ranked G5, globally secure, by NatureServe.

In the Southeast, *Sabatia campanulata* occurs in long-leaf pine savannahs, on shores of ponds, and in flatwoods, and in small intermittent wetlands in the mountains. In the Mid-Atlantic States, it is a species of salt marsh borders and sandy wet meadows. In New York, *S. campanulata* is found along the upper borders of salt marshes and in interdunal swales. In New England, *S. campanulata* occurs along the upper margins of coastal plain ponds.

Sabatia campanulata is taxonomically distinct with no recognized varieties, but is easily confused with *S. stellaris* with which it co-occurs in New York, but not in New England. There have been numerous studies attempting to sort out the taxonomy of the taxon. It was not until broad-scale assessments of large numbers of collections and cytological studies were available that the relationships within the genus could be resolved. It is known to hybridize with *S. kennedyana* with which it co-occurs in New England, but seeds of these hybrids are not considered to be viable.

Sabatia campanulata is insect-pollinated, self-compatible, and produces hundreds of small seeds per capsule. Details concerning most life history events, including germination, early growth, and longevity are poorly understood. Threats to the survival of the species in New England include: off-road vehicle and bicycle impacts, trampling, herbicide use, water level regulation, succession, invasive species, and herbivory.

The conservation objective for *Sabatia campanulata* in New England includes the protection and management of six populations in New England, all in Massachusetts. If populations can be found in Rhode Island, two of these populations should also be protected. Each population should support at least 100 plants during years with low-water conditions. All populations should be monitored annually. A monitoring protocol is presented. Additional information should be collected about life history events, herbivory impacts, and how to increase population size with management. Seeds should be collected for an *ex situ* seed bank. Reintroductions are discussed, but not recommended until adequate surveys have been conducted to understand the full extent of the species in New England.

DESCRIPTION

Because there has been considerable confusion about the identity of *Sabatia campanulata*, there are numerous detailed descriptions of the species that have been constructed to try to bring order to the taxon (Bicknell 1915, Wilbur 1955, Perry 1971). Much of the following description is adapted from Wilbur (1955) and Perry (1971), who are the most recent monographers with the broadest geographic knowledge of the genus *Sabatia.*

Sabatia campanulata is a perennial, growing from an erect, much-branched underground caudex that is 1 to 4 cm long and unique to the genus. Plants form a winter rosette with short ovate leaves that do not persist into the growing season. Stems are 20 to 70 cm tall, two to many, erect or spreading, and alternately branched, giving plants an asymmetrical appearance. There are no basal leaves present during the growing season. Leaves are opposite, linear to elliptic, broader toward the base and narrower toward the summit. Lowest leaves are 1 to 4 cm long and 1 to 12 mm wide. Upper leaves are very narrow, almost needlelike. Internodes are 1 to 2 times the length of the leaves, giving the plant a very sparse appearance.

The inflorescence is a highly-branched cyme with terminal, solitary flowers. The peduncles are bracteate. Flowers are most often rose to pink. Occasionally, plants have white flowers. These have been segregated into *S. campanulata* forma *albina* (Fernald 1932). The base of each corolla lobe has a 2 to 3 mm yellow area bordered by a dull red line. The corolla tube is cylindrical and 2 to 3 times the length of the calyx tube, exceeding it by 2 to 3 mm. Corolla lobes are spreading, oblanceolate 0.6 to 2.4 cm long, and 3 to 9 mm wide. The calyx tube is turbinate or campanulate, 1 to 3 mm long, and nearly as long as broad. The calyx lobes are setaceous, generally equaling the length of the corolla lobes. The anthers are bright yellow. The ovary at maturity is slightly exerted from the calyx tube, cylindric, and 5 to 7 mm long and 2.5 to 4 mm wide. Seeds are extremely small.

Most of the focus on the description and identification of *Sabatia campanulata* has concerned distinguishing it from *S. stellaris*, with which it has often been confused. Bicknell (1915) noted that the bases of the leaves of *S. campanulata* broaden and are

rounded, while *S. stellaris* narrows to the base. Bicknell also mentions that the calyx lobes nearly equal the length of the corolla lobes in *S. campanulata*, while they are noticeably shorter in *S. stellaris,* and that *S. campanulata* dries black upon collection, while *S. stellaris* remains green or tan. Wilbur (1955) and Perry (1971), using a broader collection of material than was available to Bicknell, note that the leaf and calyx characters are highly variable over the range of the species. They note that *S. campanulata* is a perennial growing from a short rhizome, while *S. stellaris* is an annual with a taproot and that *S. campanulata* has a bracteate peduncle, while there are no bracts on the peduncles of *S. stellaris*. The base chromosome number of *S. campanulata* is 17, while the base chromosome number for *S. stellaris* is 18.

There has also been confusion about habitat for both *Sabatia campanulata* and *S. stellaris* in the identification of these taxa. New England and Northeastern general keys make the distinction that *S. campanulata* occurs on pondshores, while *S. stellaris* occurs in salt marshes (Peterson and McKenna 1968, Newcomb 1977). In New York, extant populations of *S. stellaris* are limited to salt marshes, but *S. campanulata* also occurs in brackish tidal settings and does not occur on pondshores (personal observation). One extant population of *S. campanulata* in New York occurs in a salt marsh near a site where there is freshwater seepage from gravelly uplands. Within 0.5 km, there are a series of coastal plain ponds with seemingly appropriate habitat for *S. campanulata* based on New England habitat descriptions. *Sabatia campanulata* does not occur at these ponds. Habitat cannot be used effectively to distinguish these two taxa.

In Massachusetts, *Sabatia campanulata* can co-occur with *S. kennedyana*. Both species are perennial and have pink flowers. *Sabatia kennedyana* has flowers with eight to twelve petals. Mature plants have a basal rosette and plants typically occur in shallow water. *Sabatia campanulata* has flowers with five petals, has no basal rosette at maturity, and occupies the uppermost damp border of coastal plain ponds.

Common names for *Sabatia campanulata* include bog marsh-pink, marsh pink, and slender marsh-pink. Slender marsh-pink is the most frequently found name and emphasizes the narrow leaves and does not add to the confusion about habitat. "*Campanulata*" refers to the bell-like shape of the flowers.

TAXONOMIC RELATIONSHIPS, HISTORY, AND SYNONYMY

Worldwide, there are about 70 genera and nearly 1000 species in the Gentianaceae (Gleason and Cronquist 1991). Most species are tropical or subtropical. In the United States and Canada, there are 17 genera and about 100 species. There are 17 species in the genus *Sabatia,* which is indigenous to the United States, Canada, and the West Indies. Three species of *Sabatia* are extant and native in New England: *S. campanulata, S. kennedyana,* and *S. stellaris. Sabatia dodecandra* is known historically from New England.

Sabatia campanulata is in the Subsection Campanulatae, which is made up of four species, including *S. stellaris, S. grandiflora, and S. brevifolia* (Perry 1971). *Sabatia grandiflora* occurs in Florida and Cuba; *S. brevifolia* occurs in South Carolina, Alabama, and Florida. Perry was able to cross *S. campanulata* with *S. stellaris*, producing F1 offspring with pollen grains with low stainability, a measure of viability. *Sabatia campanulata* could also be crossed with *S. kennedyana*, but seeds of offspring of these crosses are not considered to be viable.

Early descriptions of *Sabatia campanulata* are reviewed by Blake (1915). *Sabatia campanulata* was first described as *Chironia campanulata* by Linnaeus in 1753 from material labeled "Canada" in the Linnaean Herbarium (Blake 1915). A presumed cotype collected by Kalm in the Leche Herbarium is labeled "America." In 1806, the name was changed to *Sabbatia gracilis* by Salisbury who recognized narrow-leaved *S. campanulata* as a distinct species. Torrey revised the description in 1839, returning to *Sabbatia campanulata.* Gray did not accept the original description based on a Canadian specimen, because *S. campanulata* does not occur in Canada. He instead returned to the name *Sabatis gracilis*, dropping the second "b," but doubted that the material in Massachusetts was anything more than a variant of *S. stellaris*. He did, however, maintain *S campanulata* under the name *S. gracilis* in his flora, noting that it had an ambiguous form, and included New England in its range.

Some further confusion was added in 1903 with the publication of the *Flora of the Southeast* by Small (1903). Small accurately recounted the details of calyx features for *Sabatia campanulata* and *S. stellaris* in his keys, but reversed their details in the species descriptions. Most botanists in New England, however, followed Gray and called the pondshore *Sabatia, S. gracilis.*

Merritt Fernald and Eugene Bicknell were both fascinated by the Massachusetts populations of *Sabatia*. Bicknell (1915), working on Nantucket specimens and not referring to material from Barnstable, noted distinctive differences between plants he collected at several Nantucket stations and both the *S. stellaris* he knew from Long Island and *S. campanulata* at locations farther south. He urged the identification of a new taxon, based on his Nantucket observations. Fernald (1916), working with Barnstable and Pembroke material, also noted differences between Massachusetts material and descriptions for *S. campanulata* from more southern stations. Both Fernald and Bicknell worked to identify characters that distinguish Massachusetts *S. campanulata* from *S. stellaris*. Bicknell focused on leaf and calyx measurements, while Fernald cited habitat distinctions. Fernald published his findings as *S. gracilis* (Fernald 1932), but soon revised them to distinguish two varieties of *S. campanulata* with New England material assigned to *S. campanulata var. gracilis*. He considered these two entities to be geographic variants (Fernald 1937). As late as 1952, Gleason (1952) questioned the separation of *S. campanulata* from *S. stellaris,* suggesting that there was either only one entity or as many as four.

It was not until 1955 that Wilbur used new taxonomic approaches to sort out the confusion in the genus. He reviewed *Sabatia* from throughout the range and recognized

that there was significant variation in leaf form and that the main features differentiating *S. campanulata* from *S. stellaris* were that *S. campanulata* is a perennial growing from a rhizome with long calyx lobes and that *S. stellaris* is an annual with a small taproot and has shorter calyx lobes (Wilbur 1955).

Perry (1971) extended the assessment initiated by Wilbur, adding cytological evidence and information on crossings and breeding systems. *Sabatia campanulata* has a base chromosome number of 17, while *S. stellaris* has a base chromosome number of 18. *Sabatia kennedyana,* which co-occurs with *S. campanulata* at one extant site and at five historical sites, has a base chromosome number of 20.

Synonyms for *Sabatia campanulata* (L.) Torr. include: *Chironia campanulata* L., *C. gracilis* Michx., *S. campanulata* var. *gracilis* (Michx.) Fern., *S. gracilis* (Michx.) Salisb., *S. campanulata* (L.) Torrey forma *albina* Fernald, *S. campanulata* (L.) Torrey var. *amoena* (G. Dom.), and *S. campanulata* (L.) Torrey var. *grandiflora* (A. Gray) S. F. Blake (Kartesz and Kartesz 1994). Currently, *S. campanulata* is accepted as a legitimate species with no varieties, but exhibits significant variation in leaf form and calyx length throughout its range.

SPECIES BIOLOGY

There are few studies specifically focused on *Sabatia campanulata*. Most reports use field observations and morphological traits to differentiate *S. campanulata* from other taxa. Most of the information on life history has been obtained from Perry (1971), from personal observations, from Heritage field forms, and from personal communications.

Sabatia campanulata produces capsules with many tiny seeds. In one greenhouse study of *S. campanulata* associated with interspecific crosses, capsules that were produced from artificial pollination methods had approximately 700 seeds (Perry 1971). Even if only low number of flowers are produced every few years, these would likely result in a large seed bank.

Seeds can germinate in both spring and fall (R. Lombardi, Consulting Botanist, personal communication). Seeds need a cold treatment, but not a damp cold treatment to germinate (W. Brumback, New England Wild Flower Society, personal communication). As with other gentians, *S. campanulata* may need light for seeds to germinate. It is possible that seeds germinate in the fall when other vegetation dies back and that plants overwinter the first year as a rosette. Another possibility is that seeds germinate in the early spring and persist as a rosette until the following spring. High-water levels in ponds or dense grasses, that are often found associated with *S. campanulata,* may limit recruitment. The pondshore environment is highly variable and there are usually periods of dieback of plants associated with high water conditions followed by drought that exposes the pondshore. Germination of *S. campanulata* may occur during these fluctuations and be episodic. It is likely that seeds do not germinate under water and that small plants do not survive if they are flooded for long periods when they are very small.

Recruitment of new individuals by seed probably requires extended periods when water levels are low in the ponds. Plants may not flower the first year after a water level draw-down, but may flourish in year two and subsequent years, if water levels remain low.

All flowers in the genus *Sabatia* are insect-pollinated (Perry 1971). A wide range of insects visit *Sabatia* flowers. Most common are bumblebees (*Bombus* spp.) and bees in the family Halicitidae. Perry (1971) lists a range of species generally for *Sabatia*, but only *Halictus* sp. specifically for *S. campanulata.* All of these pollinators are generalists, visiting a wide range of flowers besides *Sabatia*. There is no reason to think that pollination is limiting for populations of *S. campanulata* in New England, because fruit production is good at Massachusetts sites.

All species of *Sabatia* are self-compatible, although floral anatomy and phenology favor outcrossing (Perry 1971). Flowers last for several days. On day three, anthers dehisce and pollen is shed on days four and five. The stigma is not receptive until day six. Anthers are also arranged in a form that arches away from the stigma. Populations of *S. angularis*, an annual species, are known to decline in vigor as a result of inbreeding depression (Dudash 1991).

Many species in the Gentianaceae are known to have mycorrhizal associates (Harley and Smith 1983). It is unknown if *Sabatia campanulata* has mycorrhizal associates or if any root associates play a significant role in the ecology of the species in New England.

The number of plants at each site varies dramatically over time. One site on Nantucket supported a large population over 100 years ago. In 1921, Alice Albertson (1921: 300) described *Sabatia* as "deserv[ing its] reputation, of being one of Nantucket's most popular wildflowers. Their very pinkness as the flowers shine among the taller grasses, near a pond's border, gives an alluring touch of colour." The same site has supported plants that have been noted during surveys only twice in the past 11 years, with 18 plants in 1982 and only four plants in 2002. The site was visited many times in the intervening 19 years, but no individuals of *S. campanulata* were seen. It is uncertain if plants were either overlooked or were present only in the seed bank during years when plants were absent.

Sabatia campanulata may be a "weak perennial" that does not live very long. Some Gentians family species are short-lived (W. Brumback, personal communication). In cultivation, plants of *S. kennedyana* often die after flowering or they barely persist, producing a small shoot at the base of the plant, which usually does not survive winter. It is not certain if plants in the wild follow this same pattern (W. Brumback, personal communication.) *Sabatia campanulata* may follow the same pattern as *S. kennedyana.*

It is unclear what happens to *Sabatia campanulata* when it is under water – whether it persists as a belowground rhizome or dies. The few remnant populations in Massachusetts are all located at the extreme upper edges of ponds, where they are likely to be flooded rarely and only for short periods of time.

HABITAT/ECOLOGY

In the Southeast, annotations on herbarium specimens indicate that *Sabatia campanulata* occurs along the coastal plain in wet pine savannahs, along shores of ponds, and in flatwoods (R. Lombardi, personal communication). In some areas, the species is common. In the Carolinas, *Sabatia campanulata* occurs in long-leaf pine savannahs and bogs (Radford et al. 1968).

There are also occurrences in the mountains of Tennessee, Kentucky, and Virginia. At one Virginia site in the Blue Ridge Mountains, *S. campanulata* occurs in a wetland described as a *Rhynchospora alba/Vaccinium macrocarpon* association (Rawinski 1991). The community is found in a site with low calcium levels and high levels of magnesium. The pH ranges from 5.7 to 6.3. Species associates include: *Acer rubrum, Alnus serrulata, Sanguisorba canadensis, Spiraea tomentosa, Solidago uliginosa, Rubus hispidus,* and *Juncus subcaudatus.*

In Indiana, *Sabatia campanulata* habitat is described as "freshwater swamps" (Deam 1984). The only site in Indiana has been extirpated.

In New Jersey, *Sabatia campanulata* occurs in brackish and freshwater marshes along the coast (Stone 1973). It also occurs in the New Jersey Pinelands. In New York, *S. campanulata* occurs exclusively in wet meadows bordering salt marshes, growing with *Myrica pensylvanica, Vaccinium macrocarpon, Polygala cruciata, Helianthus angustifolius, Linum striatum,* and *Schoenoplectus pungens* (personal observation). In Maryland, *S. campanulata* is also described as occurring in salt and brackish marshes (Brown and Brown 1984).

In New England, *Sabatia campanulata* occurs only along the borders of coastal plain ponds. All three populations that have supported plants in the past twenty years occur at the extreme upper edge of pondshores in areas that are seldom flooded. Common associates documented in Natural Heritage Program occurrence files include: *Pinus rigida, Euthamia tenuifolia, Dichanthelium* sp., *Calamagrostis canadensis, Vicia* sp., *Lycopus amplectans, Schizachyrium scoparium, Ilex glabra, Solidago rugosa, Rubus hispidus, Quercus* sp., *Smilax glauca, Lysimachia quadrifolia, Lotus corniculatus, Rhexia virginica, Coreopsis rosea, Hieracium* sp., S*abatia kennedyana, Drosera filiformis, Drosera intermedia, Panicum virgatum, Xyris* sp., *Viola lanceolata, Hypericum canadense, Polygala cruciata, Potentilla canadensis, Agrostis* sp., *Rhynchospora capitellata,* and *Vaccinium macrocarpon.* The substrate is sand or peat mixed with sand. Plants are found often among tall grasses. At the site of the largest extant population in Massachusetts, some individuals of *Sabatia campanulata* are found at lower elevations within the pond during low-water periods, but the majority of plants are found at higher-elevation sites that are less frequently flooded. There is no clear relationship between water level and population number. In nearly all of the years that this site has been monitored, the site of the majority of the plants was not flooded.

The largest population in New England has been monitored eleven times over the past twenty five years. During that period, the population has varied from no plants (1997 and 2003) to highs of 500 (1988) or several hundred plants (1985). Both 1997 and 2003 were years with high rainfall. Both 1985 and 1988 were years during which there were long periods of drought.

Sabatia campanulata co-occurs with many other rare species, and the community in which it is typically found is also a target of conservation interest. There may also be rare animals, particularly odonates, at sites that support *S. campanulata*. In Massachusetts, *S. campanulata* is known to occur with *Sabatia kennedyana, Scleria reticularis, Hypericum adpressum,* and *Lachnanthes caroliniana*. In New York, *S. campanulata* co-occurs with *Helianthus angustifolius, Iris prisimatica,* and *Hedyotis uniflora.* Any management activity to conserve *S. campanulata* should consider the ecological needs of other conservation interests at the site.

THREATS TO TAXON

Disturbance

The most significant threat to *Sabatia campanulata* in New England is physical disturbance to occupied sites. The largest site in Massachusetts (MA .001 [Barnstable]) is under a power line among pitch pines that are cut back to maintain clearance under the transmission lines. Vehicle use, chemical defoliants, and trampling could impact existing plants. In cultivation, plants of *S. kennedyana* and some other Gentian family species are often damaged if their root systems are disturbed (W. Brumback, personal communication). Small seedlings can be repotted, but as the root systems develop, successful transplanting of these plants becomes more difficult. These plants tend to have long taproots, and plants with taproots, in general, do not tolerate disturbance as well as plants with fibrous root systems. Physical damage to root systems in the wild could also limit growth and even plant survival. Clearing under the power line has undoubtedly maintained habitat for *S. campanulata* over time, but could eliminate plants as well. The site is also subject to illegal dumping and pedestrian trails. Pedestrian trails have also been mentioned as a threat to one of the Nantucket populations (MA .005). Physical disturbance may have contributed to the loss of some of the populations that are now extirpated.

Loss of Processes Maintaining Habitat

The main natural process that has maintained habitat for *Sabatia campanulata* at New England sites is the fluctuation of water levels in ponds. *Sabatia campanulata* is found exclusively on exposed margins of ponds in New England. During periods of extreme high water, *S. campanulata* is probably dormant as a seed in the soil seed bank. During high-water periods, the upland species that grow with *S. campanulata* and might outcompete it over time are killed back. When the water level drops, the pond border is

only sparsely vegetated and is ideal habitat for *S. campanulata*, except during severe, extended droughts when even *S. campanulata* may not survive. Within the complex of ponds that has supported *S. campanulata*, there are well sites that supply water for the town of Barnstable. Water levels are locally reduced and the impacts on pondshore vegetation is significant, such that upland species are able to invade sites previously maintained within the tension zone of alternating periods of high and low water. The natural rhythm of high and low water periods over many years are essential to maintain habitat for some species, possibly including *S. campanulata.*

Collection

Maria Owen (1888: 47) lamented the wanton picking of *Sabatia* on Nantucket in the 1880's. She described these harvesters as "idle pleasure seekers with ruthless greed picking the Sabbatias, with a determination worthy of a better cause, not to leave one..." *Sabatia campanulata* is an attractive plant that resembles other plants in the horticultural trade. Collection, while now somewhat less acceptable publicly, could be a problem.

Hybridization

Sabatia campanulata is known to hybridize with *S. kennedyana* at one of the extant populations in New England. Hybrids are not likely to be fertile and are probably not numerous. It seems unlikely that seed would be viable, since *S. campanulata* has a base chromosome number of 17, while *S. kennedyana* has a base chromosome number of 20. It would be worth noting the number of hybrids and determining whether there is any viable seed.

Isolation, Inbreeding Depression

Plants in one of the Nantucket populations (MA .005) have been described as depauperate. All Massachusetts populations are very isolated. The next nearest populations are on eastern Long Island. It is possible that plants in New England are subject to inbreeding depression.

Grazing

Deer grazing has been noted at one site (MA .001 [Barnstable]) and has been suggested as a cause for the low population at one of the Nantucket sites (MA 005; P. Somers, Massachusetts Natural Heritage and Endangered Species Program, personal communication). Rabbit droppings have also been noted near plants. Herbivory by deer, rabbits, or other animals could heavily impact limited populations, particularly if annual browse reduces seed production. It has also been noted that some plants are eaten by insects (P. Polloni, Consulting Botanist, personal communication).

Direct Loss of Habitat

The loss of ponds by filling or other disturbances or the eutrophication of ponds may have led to the loss of some historical populations. None of the currently occupied sites is likely to be lost to development, although adverse activities could be conducted in nearby areas and impact habitat for *Sabatia campanulata*.

Invasive Species

At one site, *Phragmites australis* is present and has been listed as a threat (R. Lombardi, personal communication). The expansion of *Phragmites* or the introduction of other invasive species could alter available habitat for *Sabatia campanulata*. There is a negative correlation between the density of *S. kennedyana* and *P. australis* in dune swales (Coleman 2003).

DISTRIBUTION AND STATUS

General Status

Sabatia campanulata is known primarily along the coastal plain from Massachusetts south to Florida and Texas (NatureServe 2003). It is also known from the Appalachian Mountains in western North Carolina and Virginia and in Tennessee and Kentucky. There was a disjunct population in Indiana that is now extirpated. Within the range, *S. campanulata* is not known from Rhode Island and Connecticut. It is also considered to be extirpated from Pennsylvania. *Sabatia campanulata* is listed as an S1 or S2 species in eight states and is listed as S3 in New Jersey and North Carolina. It is apparently secure in the Southeast, particularly South Carolina, Georgia, Florida, Mississippi, Alabama, Louisiana, and Texas. *Sabatia campanulata* is listed globally as G5 and nationally as N? Table 1 and Figure 1 summarize the status of *S. campanulata* in North America. Data are collected from NatureServe (2003).

Status of All New England Occurrences — Current and Historical

Sabatia campanulata is currently known from three recently observed sites in Massachusetts (two other technically extant occurrences have not been seen since the 1980's, despite repeated searches). Herbarium specimens were reviewed by Roberta Lombardi at Duke University, the University of Massachusetts at Amherst, and at the Maria Mitchell Association on Nantucket. Specimens at the Gray Herbarium and in the New England Botanical Club collection were also reviewed. More than 57 specimens have been collected in Massachusetts in four towns in four counties at a total of 13 identifiably distinct sites. However, a Concord collection is unlikely to be indigenous to the site and is not considered here. Six of these occurrences are clustered together in a

complex of ponds in one town; of these six, only one is considered to be currently occupied. There are two other current sites, both in one town.

The distributions of extant and historic populations of *Sabatia campanulata* in New England are shown in Figures 2 and 3, respectively.

Table 1. Occurrence and status of *Sabatia campanulata* 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)	North Carolina (S3); occurs in 18 counties	South Carolina (SR): occurs in 14 counties	Pennsylvania (SX)
New York (S1, E, six counties)	New Jersey (S3)	Georgia (SR): occurs in 24 counties	Indiana (SX)
Maryland (S1)		Florida (SR): occurs in 22 counties	
Delaware (S1)		Mississippi (SR)	
Virginia (S2)		Alabama (SR)	
Kentucky (S1, E)		Texas (SH): occurs in 19 counties.	
Arkansas (S1): occurs in 3 counties		Louisiana (SR)	
		District of Columbia (SR)	
		Tennessee (SR)	

Figure 1. Occurrences of *Sabatia campanulata* in North America. States shaded in gray have one to five current occurrences of the taxon. Areas shaded in black have more than five confirmed occurrences. States with diagonal hatching are designated "historic" or "presumed extirpated," where the taxon no longer occurs. States with stippling are ranked "SR" (status "reported" but not necessarily verified or without further information). See Appendix for explanation of state ranks.

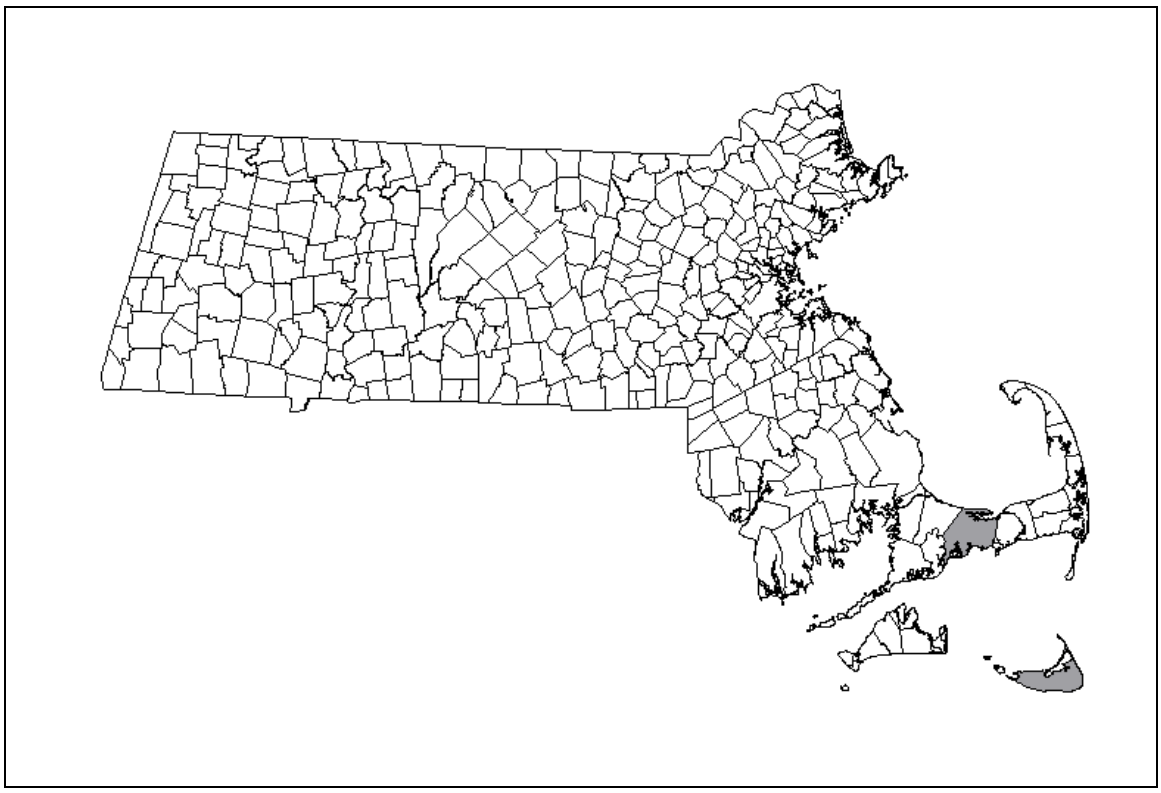

Figure 2. Extant occurrences of *Sabatia campanulata* in New England. Town boundaries for Massachusetts are shown. Towns shaded in gray have one to five confirmed, extant occurrences of the taxon.

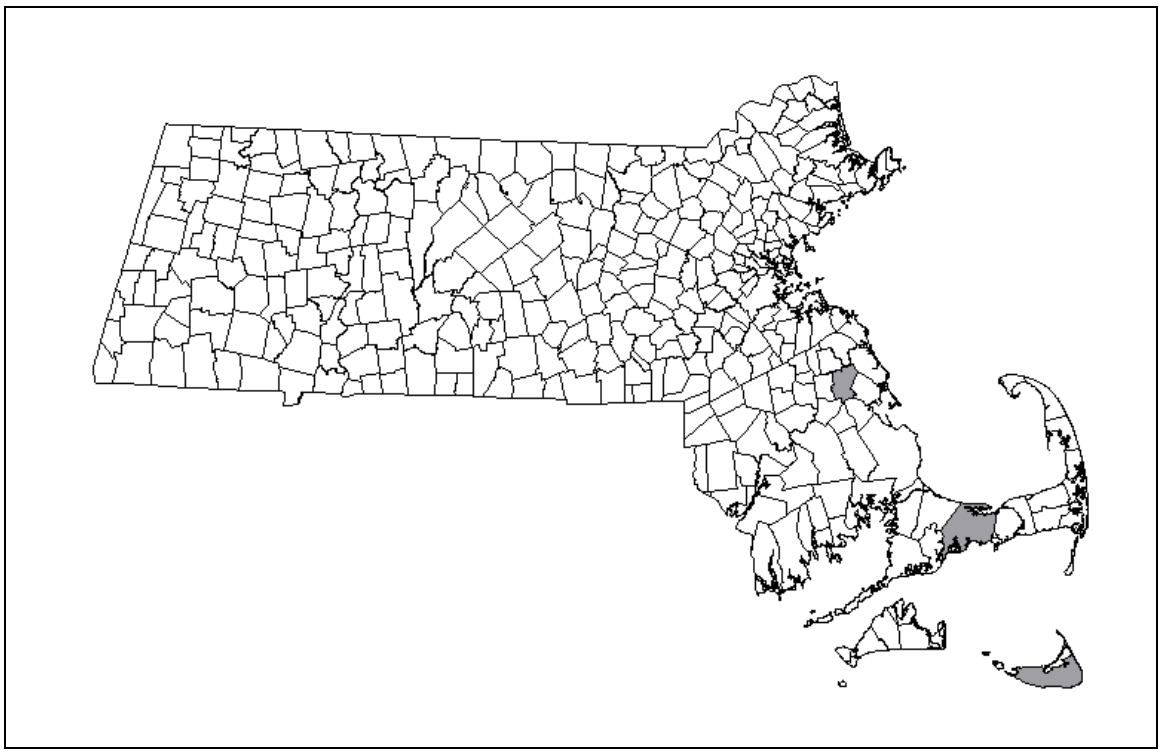

Figure 3. Historic occurrences of *Sabatia campanulata* in New England. Towns shaded in gray have one to five historic records of the taxon. Note that the putative Concord population is not shown.

Table 2. New England Occurrence Records for *Sabatia campanulata.* Shaded occurrences are considered extant.			
State	**EO #**	**County**	**Town**
MA	**.001**	**Barnstable**	**Barnstable**
MA	.002	Plymouth	Pembroke
MA	**.003**	**Barnstable**	**Barnstable**
MA	**.004**	**Barnstable**	**Barnstable**
MA	**.005**	**Nantucket**	**Nantucket**
MA	.007	Barnstable	Barnstable
MA	.008	Barnstable	Barnstable
MA	.009	Barnstable	Barnstable
MA	.010	Nantucket	Nantucket
MA	**.011**	**Nantucket**	**Nantucket**
MA	No#1	Nantucket	Nantucket
MA	No#2	Barnstable	Barnstable
MA	No#3	Middlesex	Concord

II. CONSERVATION

CONSERVATION OBJECTIVES FOR THE TAXON IN NEW ENGLAND

The primary conservation objective for *Sabatia campanulata* in New England is to protect six populations: two on Nantucket, two in Barnstable, and two at other ponds in Southeastern Massachusetts. If populations of *Sabatia campanulata* can be found in Rhode Island, two populations should be protected there as well.

Each population should consist of at least 100 plants per year during years when the water level in ponds is low, exposing a sandy margin. The minimum viable population size for *Sabatia campanulata* is not known anywhere within its range. One Massachusetts population has supported over 300 plants for two of the years it was monitored. Two of the New York populations have hundreds of plants annually. *Sabatia campanulata* is present or at least flowers well only during low-water years in Massachusetts, remaining either sterile during high-water years or present only in the seed bank. To maintain a vigorous population over time, it will be necessary for populations to remain moderately robust during optimal periods to produce adequate seed to persist through periods when growing conditions are poor. Until better data are available to refine minimal viable population levels for *S. campanulata*, an average of 100 plants per year is suggested as a conservative guideline.

A second objective is to understand the rarity and conservation needs of *Sabatia campanulata* in New England, by conducting site and population monitoring and population biology studies. Issues worth exploring with research include: under what conditions and at what time of year do seeds germinate, when do plants flower, are they monocarpic, what pollinates *S. campanulata* and are viable seeds produced, do they overwinter during severe cold periods, what do plants do when the water level is very high, is inbreeding depression a concern, is herbivory a major concern for populations, are invasive species displacing plants, and is hybridization with *Sabatia kennedyana* an issue?

A third objective is to establish an *ex situ* seed bank to preserve the genome of *Sabatia campanulata* in New England. If all natural populations are lost, seeds will be needed to supply material for future studies and reintroduction efforts, if called for in future iterations of this plan. Seeds from New England populations have been collected, but not held in a long-term conservation seed bank. Seeds have not been tested to determine if they are long lived in storage. With only three populations remaining in Massachusetts, it is desirable to collect material from general locations where plants are present. Seed should be kept separately for each collection to distinguish genetic differences among regional populations.

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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.