COSEWIC
Assessment and Status Report

on the

Tubercled Spike-rush
Eleocharis tuberculosa

in Canada

SPECIAL CONCERN
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC. 2000. COSEWIC assessment and status on report the tubercled spike-rush, *Eleocharis tuberculosa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 17 pp.

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Tubercled Spike-rush — Photo taken at Barrington Lake, 2008 by Lilian Perry, used with permission.

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COSEWIC
Assessment Summary

Assessment Summary – April 2010

Common name
Tubercled Spike-rush

Scientific name
Eleocharis tuberculosa

Status
Special Concern

Reason for designation
In Canada, this sedge is known to exist only along peaty and sandy shorelines at six lakes in southwestern Nova Scotia. The use of all-terrain vehicles along the shores of the two larger lakes, where most of the Canadian population occurs, has degraded portions of the species' habitat. Cottage development and related impacts (water quality and habitat disturbances) are currently limited threats that have the potential to increase in the future. More intensive surveys of lakeshore habitats indicate that the species is somewhat more abundant than previously documented.

Occurrence
Nova Scotia

Status history
Designated Threatened in May 2000. Status re-examined and designated Special Concern in April 2010.

COSEWIC
Executive Summary

Tubercled Spike-rush
Eleocharis tuberculosa

Species information

Tubercled Spike-rush (*Eleocharis tuberculosa*) is a perennial species of sedge. It is named for the prominent tubercle that adorns its fruit, distinguishing it from other similar species. The species grows in dense tufts or clumps, with stalks up to 40 cm tall, each with a pair of blade-less basal leaves. The inflorescence is reduced to a single terminal spike of numerous, petal-less flowers containing both a pistil and stamens; each flower is concealed by a single scale. Many fertile stems can be produced from a single clump.

Distribution

Tubercled Spike-rush is endemic to the Atlantic coastal plain. It is most common in the southern portion of its range, along the coastal plain from Texas to New Jersey. It is rare in the northeast USA, and in Canada is only known from five populations on six lakes in southwestern Nova Scotia. Its range in Canada covers an area of only 873 km². The populations, however, only occupy an area of habitat covering less than 1 km^2.

Habitat

In the Canadian portion of its range, Tubercled Spike-rush is restricted to open, peaty or sandy substrates and floating peat mats along lakeshores. It occurs within the shoreline zone that is annually flooded in spring and is frequently flooded during wet years in late summer and autumn, making detection difficult in some years. It is a relatively weak competitor, and requires periodic disturbance from flooding and ice scour to prevent more competitive species from crowding it out of available lakeshore habitat.

Biology

The species is a perennial, potentially fairly long-lived, although there is no direct evidence on longevity. It produces abundant seed in Nova Scotia, but no tests of seed viability or field observations of reproduction by seed are known. It appears not to reproduce vegetatively beyond expanding the size of its tight clumps, meaning that the clumps function as individuals for the purposes of assessment. It has been observed spreading within a lake via fragmentation and drifting of the peat mats on which it occurs. Waterfowl could be important in longer-distance dispersal. Evidence from other spike-rush species of fluctuating wetlands and other Atlantic Coastal Plain shoreline species suggests longer-term seed banking may be significant to its persistence at a site, but the importance of seed banking vs. vegetative survival during extended periods of high water is not known.

Population sizes and trends

Total numbers are not well defined. The Barrington Lake population was estimated in 2008 at 150,000 to 200,000. Great Pubnico Lake has a large and widely distributed population of “many thousands” over its 10 km length. The three other populations are much smaller, with best estimates of between 50 and 2,000+ individuals. Localized monitoring at Barrington Lake suggested declines since 2004 because of ATV disturbance but it is not clear what proportion of the Canadian population the apparent declines might represent or even whether declines are occurring across the whole Barrington Lake population. Plants were not found at the Western Lake subpopulation (only 4 plants known previously) in 2008, where the shoreline was flooded because of beaver damming. The Little Ten Mile population discovered in 2009 was also inundated because of beavers. Beaver-induced flooding could have neutral or positive impacts on the longer term if the water level is later reduced, since the species is noted as requiring water level fluctuation and is likely well adapted to it, but the length of time mature plants or the seed bank can survive inundation is not known.

Limiting factors and threats

The peat substrate that *E. tuberculosa* depends upon is fragile and sensitive to human activity. ATV use appears to pose some threat to the largest population at Barrington Lake. Shoreline development is ongoing at Barrington Lake and to a lesser extent at Great Pubnico Lake. It likely contributes to increased ATV traffic within shoreline populations of Tubercled Spike-rush, but its direct impacts have been minor and localized to this point relative to the whole Canadian population. Shoreline development is anticipated to remain a relatively small threat through the next 10 years.

Special significance of the species

Eleocharis tuberculosa is biogeographically interesting, as one of a suite of Atlantic Coastal Plain endemics with disjunct populations in Nova Scotia. As a highly disjunct occurrence at the extreme northern limit of its range, the Nova Scotia populations may harbour significant genetic diversity for the species.

Existing protection

COSEWIC assessed *Eleocharis tuberculosa* as Threatened in May 2000; currently, it is listed as Threatened on Schedule 1 by the Canadian *Species at Risk Act* and as Threatened on the Nova Scotia *Endangered Species Act*. It is Endangered in Maine, Pennsylvania and New Hampshire (where it is only known from historic records) and is Threatened in New York. It is more common further south in its range. Its habitat in Nova Scotia is generally provincial Crown land shoreline, and slightly over half of the shoreline frontage in areas supporting the species is on provincial Crown land. Crown land status does not appear to limit ATV disruption of the species' habitat.

TECHNICAL SUMMARY

Eleocharis tuberculosa
Tubercled Spike-rush éléocharide tuberculée
Range of occurrence in Canada:Nova Scotia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2008) is being used)	Unknown but probably several years for this perennial
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? Data are equivocal on decline with considerable uncertainty across the entire population in Canada.	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	N/A
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	370 km²
Index of area of occupancy (IAO) Note: Great Pubnico Lake is incompletely surveyed. If each grid square were occupied by some plants then there could be a higher total for each grid index value.	28 km² [1x1 km grid] 68 km² [2x2 km grid]
Is the total population severely fragmented?	No
Number of “locations” (as per definition, in relation to threat)	Undefined
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Decline in quality
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations (as per definition, in terms of threat)? Uncertainty as to number of locations.	Unknown but likely not
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Barrington Lake	150,000-200,000
Great Pubnico Lake (incomplete survey data)	many thousands
Harpers Lake (incomplete survey)	2,000+
Gold - Western Lakes (values represent a minimum due to incomplete survey)	
Gold Lake subpopulation[1]	
Western Lake subpopulation	400 - 600
Little Ten Mile Lake	0 - 4+ [0 in 2008]
[1]includes 200 plants seen in 2008 plus 200-400 seen elsewhere in 1999 but unsurveyed in 2008	50
Total	Well over 150,000

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	None available

Threats (actual or imminent, to populations or habitats)

The main threat is ATV use that is eliminating some plants and damaging habitat in portions of the range but is seemingly not a serious yearly occurrence
Cottage development is a limited threat which may increase somewhat in future

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Endangered in the closest jurisdiction (Maine), secure in Massachusetts and most states southward along USA east coast	
Is immigration known or possible?	Unknown and unlikely over 430-500 km, most of which is ocean
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (April 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	None applicable

Reasons for designation:
In Canada, this sedge is known to exist only along peaty and sandy shorelines at six lakes in southwestern Nova Scotia. The use of all-terrain vehicles along the shores of the two larger lakes, where most of the Canadian population occurs, has degraded portions of the species' habitat. Cottage development and related impacts (water quality and habitat disturbances) are currently limited threats that have the potential to increase in the future. More intensive surveys of lakeshore habitats indicate that the species is somewhat more abundant than previously documented.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. The extent of a decline, if even occurring across the entire population, is unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although EO and IAO are below thresholds and habitat quality has declined in portions of the range, the number of locations is uncertain (could exceed 10) and the populations are not severely fragmented.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Decline of entire population is uncertain and number of mature individuals is >10,000.
Criterion D (Very Small Population or Restricted Distribution): Not applicable. Number of mature individuals is >>1000 and number of locations is uncertain but may exceed 10 with the IAO also exceeding maximum criterion limits.
Criterion E (Quantitative Analysis): None available.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Tubercled Spike-rush

Eleocharis tuberculosa

in Canada

2010

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SPECIES INFORMATION

Name and classification

Scientific name:	*Eleocharis tuberculosa* (Michaux) Roemer & Schultes, including the infraspecific taxa: *E. tuberculosa* var. *pubnicoensis* Fernald; *E. tuberculosa* forma *pubnicoensis* (Fernald) Svenson; *E. tuberculosa* forma *retrorsa* Svenson
Synonym:	*Scirpus tuberculosus* Michaux
Common name:	Tubercled Spike-rush, Long-tubercled Spike-rush, Cone-cup Spike-rush, Éléocharide
Family:	Cyperaceae (Sedges); *Eleocharis* subgenus *Eleocharis* sect. *Eleocharis* ser. *Tenuissimae*
Major plant group:	Monocot flowering plant

Some authors have split *Eleocharis tuberculosa* into three infraspecific taxa. Fernald (1950) recognized the smooth-bristled plants, endemic to Great Pubnico Lake, Nova Scotia, as variety *pubnicoensis,* and northern plants with retrorsely spinulose bristles as forma *retrorsa*. The typical plants (i.e., forma or variety *tuberculosa*) with divergently spinulose bristles are most common in the southern portion of the global range of *E. tuberculosa* in the U.S.A., but were also reported from Harpers Lake, Nova Scotia (Fernald 1922). Svenson (1937) treated both *pubnicoensis* and *retrorsa* as forms, while recent authors have synonymized all three taxa within *E. tuberculosa s. l*. (Gleason and Cronquist 1991, Bruhl and Smith 2002).

Morphological description

Except where noted, the following description follows Bruhl and Smith (2002). *Eleocharis tuberculosa* is an herbaceous perennial that forms dense clumps. Rhizomes, when present, are short and ascending, and are concealed by the crowded culms. The stiffly erect culms are elliptic or circular in cross-section, and are reported to be 0.3-1.5 mm wide and 15-75 cm tall. In Nova Scotia, *E. tuberculosa* is 40 cm tall or shorter (Smith pers. obs. 2008). The two basal leaves are bladeless, consisting of persistent sheaths. Flowering culms have a single, terminal, ovoid spikelet 5-15 mm long and 2.5-4 mm wide (Figure 1). The flower scales are spirally arranged, completely concealing the flowers. The achenes are brown, 0.9-1.7 mm long and 0.7-1.2 mm wide (Figure 2). The tubercle (persistent style base) is white to pale orange, and is as large as or larger than the achene. The 5-6 perianth bristles are somewhat surpassed by the tubercle. In forma *pubnicoensis* the bristles are nearly smooth, while in forma *retrorsa* they are retrorsely spinulose.

Figure 1. Close-up image of the terminal flower heads (spikelets) of a clump of *Eleocharis tuberculosa* plants (photo taken at Barrington Lake, 2008 by Lilian Perry, used with permission).

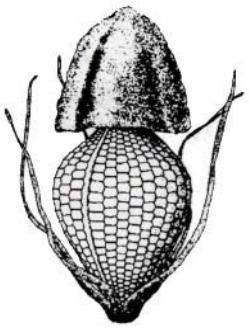

Figure 2. Illustration of an individual fruitlet (achene) of *Eleocharis tuberculosa* surrounded by several bristles and topped by a helmet-like tubercle (F.W. Scott, courtesy of the Nova Scotia Department of Natural Resources).

In Nova Scotia, *Eleocharis tuberculosa* is most easily confused with *Xyris* spp. (Yellow-eyed grass, primarily *Xyris difformis*). Both plants occur together, and after the petals of *Xyris* have fallen, the remaining bracts bear a superficial resemblance to the spikes of *E. tuberculosa*. However, they are easily distinguished with close inspection. Slender Spike-rush (*Eleocharis tenuis)* is an associate of *E. tuberculosa* at some Nova Scotia locations, but the generally larger size, thicker inflorescences and the large tubercles on the seeds clearly distinguish *E. tuberculosa* from *E. tenuis* and all other *Eleocharis* species in the Nova Scotia.

Spatial population structure and variability

Eleocharis tuberculosa has a chromosome number of 2n = 30 (Schuyler 1977). No other genetic data are available for this species.

Designatable units

Although some authors have split the Nova Scotia plants into two taxa, recent authors have not followed this practice (Gleason and Cronquist 1991, Bruhl and Smith 2002). Furthermore, all Nova Scotia plants occur within a single biogeographic region. Accordingly, multiple designatable units are not recognized here.

DISTRIBUTION

Global range

In the United States Tubercled Spike-rush is known from Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Louisiana, Maine, Massachusetts, Maryland, Mississippi, New Jersey, New York, North Carolina, Rhode Island, South Carolina, Tennessee, Texas and Virginia (Figure 3). It is considered extirpated in Pennsylvania and historic in New Hampshire (NatureServe 2009). Although Bruhl and Smith (2002) reported that they had not seen specimens from Connecticut, Delaware, Maine, Maryland, New Hampshire, New York, Rhode Island or Virginia, state records appear to be legitimate for all those jurisdictions based on S-ranks (NatureServe 2009, see Table 3) and USDA - NRCS (2009).

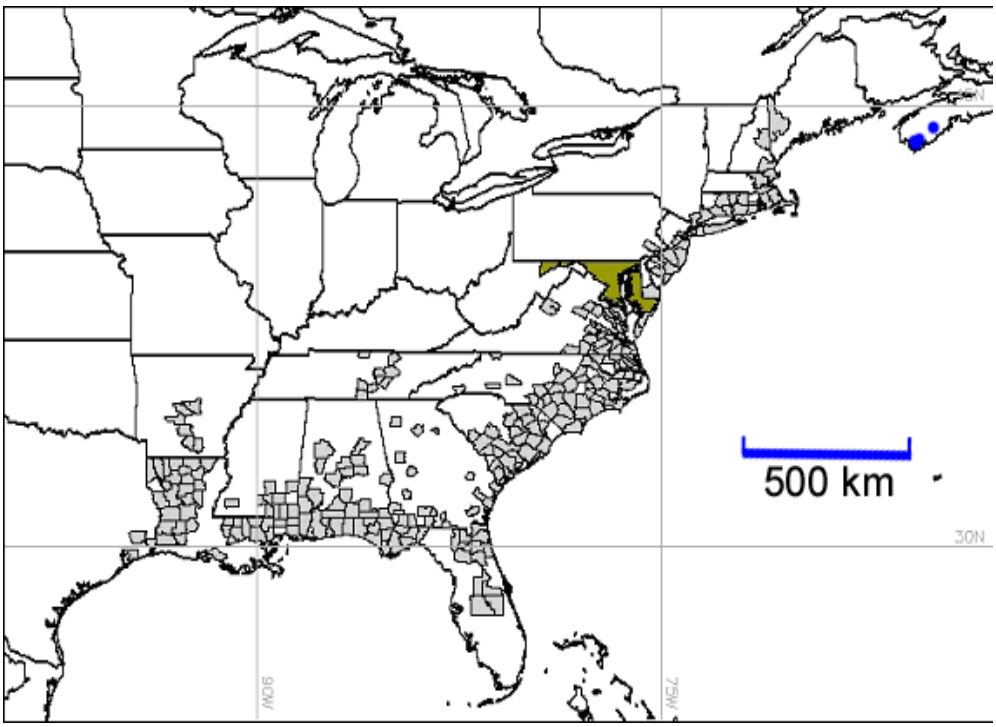

Figure 3. Global range of Tubercled Spike-rush, *Eleocharis tuberculosa*, after USDA (2009). County records were not available for Maryland.

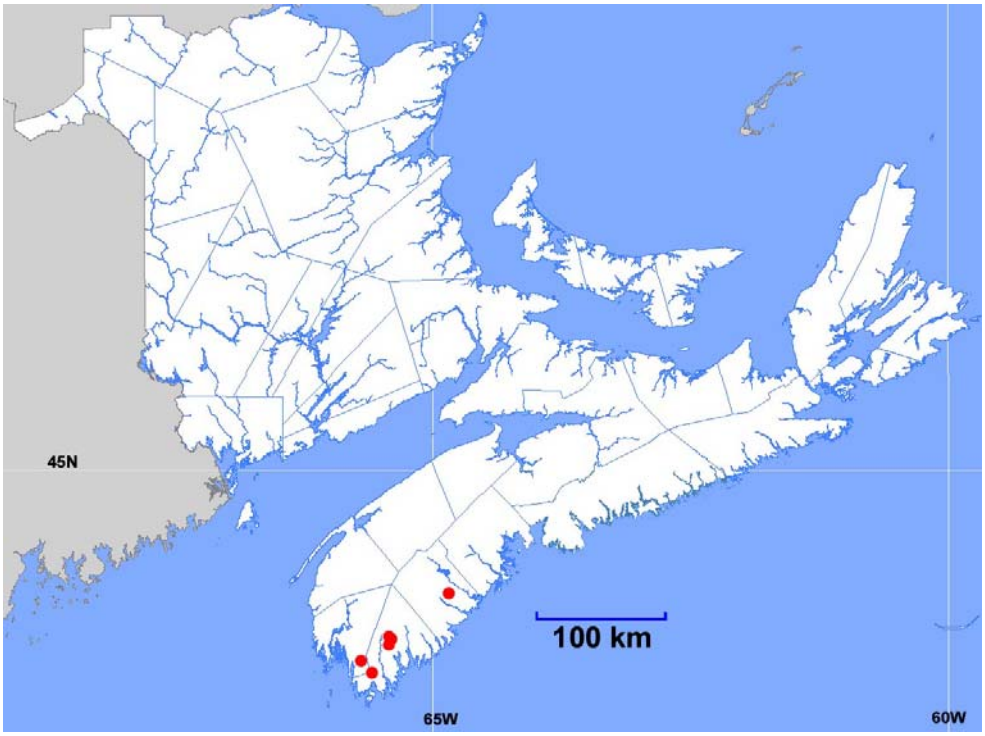

Figure 4. The Canadian range of Tubercled Spike-rush, *Eleocharis tuberculosa*, indicated by dots.

Canadian range

In Canada, *E. tuberculosa* is known only from southwestern Nova Scotia, where it occurs in five populations on six lakes (Figure 4). Five of the occupied lakes (Great Pubnico, Barrington, Harpers, Western and Gold Lakes) are within the southernmost 30 km of mainland Nova Scotia in Shelburne and Yarmouth Counties. The other site, at Little Ten Mile Lake, is 90 km from the southern tip of Nova Scotia in Queens County.

The Great Pubnico Lake and Harpers Lake populations were first documented by Fernald (1921, 1922). The Barrington Lake population was discovered in 1998 (Newell and Zinck 2000), the Gold - Western Lakes population in 1999 (Boates and Bishop 1999), and the Little Ten Mile Lake population in 2009 (Blaney and Mazerolle pers. obs. 2009). There is no evidence that the Canadian distribution of this species has changed since the 1920s and the recent discoveries were most likely overlooked by earlier workers.

The extent of occurrence of *E. tuberculosa* is about 873 km^2. The actual area of occupancy is < 1 km^2 as detailed in Table 1. Two indices of area of occupancy (IAO) were calculated based on the number of 1 km² and 4 km² UTM grid squares with at least one record for *E. tuberculosa*. The IAO for the 1 km² grid is 28 km², and for the 4 km² is 68 km². Distribution on Great Pubnico Lake is probably incompletely known. If all grid squares on that lake were occupied, the totals above would rise to 43 km² for the 1 km² grid and 88 km² for the 4 km² grid.

Table 1. 2008-2009 counts of reproductive clumps of Tubercled Spike-rush and total population estimates for all sites.

Population	# Clumps seen in 2008	# Likely present in 2008-2009	Comments
Barrington Lake	150,000-200,000	150,000-200,000	Estimate obtained by extrapolating density of densest patches across area of those patches.
Great Pubnico Lake	minimum 2,500	Many thousands	Only a small portion of known sites were visited in 2008.
Harpers Lake	2,000+	2,000+	Several previously recorded (1999) small populations not visited in 2008. 2,000 total likely represents a strong majority of this lake's plants.
Western-Gold Lakes Gold Lake subpopulation	200	200-600	200 clumps recorded in 2008 from area not previously noted. 200-400 clumps previously recorded (1999) from area unsurveyed in 2008. These may still be present.
Western-Gold Lakes Western Lake subpopulation	0	0	No more than 4 clumps recorded previously (1999), though with note that more may have been present. Plants and/or seeds may well survive beaver-induced flooding observed in 2008.
Little Ten Mile Lake	50	50	First discovered in 2009.
Total	**150,000-200,000**	**Well above 150,000**	

A large proportion of the shoreline and habitat of Tubercled Spike-rush at the largest population on Barrington Lake is on Crown lands and actual cottage development does not seem to have had much direct impact on the species' habitat. Consequently, there likely has been little or no decline in the IAO, number of locations or population numbers over the past decade (see habitat trends).

HABITAT

Habitat requirements

Eleocharis tuberculosa is reported from a variety of habitats, including wet soil, freshwater ponds, lakeshores, streams, meadows, pine woods, grasslands, disturbed areas and bogs (Bruhl and Smith 2002). Fernald (1950) indicates it grows on sandy and peaty shores, while Gleason and Cronquist (1991) associate it with sandy shores. In Florida, it is associated with stream banks, seepage areas, and shallow emergent communities, where it often forms dense turfs (Ward and Leigh 1975), and it is regularly reported from Longleaf Pine wetlands (e.g., Smith 1996).

In Nova Scotia, it is confined to lakeshores and floating peat mats (Smith pers. obs. 2008, Figure 5). It occurs on pure sand or gravel beaches but appears to reach its highest densities on shallow peat over sand, or on floating peat mats. This suggests a successional ecology, with *E. tuberculosa* colonizing and even dominating newly formed peat mats, gradually being replaced by more aggressive sedges and rushes when the peat persists. Such communities are typically replaced over time by ericaceous shrubs. *Eleocharis tuberculosa* was not observed growing with woody species at any of the Nova Scotia locations, suggesting that it is incapable of persisting once shrubs have established. On the other hand, if the peat is removed or decomposes, *E. tuberculosa* populations apparently decline, with only a few survivors persisting on open sand or gravel.

Figure 5. Lakeshore habitat of *Eleocharis tuberculosa* at monitoring site 3, Barrington Lake (photo by Lilian Perry, used with permission).

Figure 6. ATV habitat damage to vegetation immediately adjacent to *Eleocharis tuberculosa* monitoring site 2, top of Barrington Lake (Photo by Lillian Perry, 2008, used with permission).

Work by Keddy *et al*. (Keddy and Wisheu 1989, Hill and Keddy 1992, Wisheu and Keddy 1994, Wisheu *et al*. 1994) indicates that the coastal plain flora of Nova Scotia require periodic disturbance to prevent more competitive species from excluding them. This is consistent with the observed distribution of *E. tuberculosa.* However, if *E. tuberculosa* does indeed require peat substrate to establish new populations, ice scour may have a net negative influence on population levels.

The following plants were found associated (within 2 m) with *E. tuberculosa* during surveys in 1994-1999 (Newell and Zinck, 2000) and 2008: Rough Bentgrass (*Agrostis scabra*), Bog Aster (*Oclemena nemoralis*, =*Aster nemoralis*), Branched Bartonia (*Bartonia paniculata*), Bluejoint Reed Grass (*Calamagrostis canadensis*), Pickering's Reed Grass (*C. pickeringii*), Few-seeded Sedge (*Carex oligosperma*), Smooth Twigrush (*Cladium mariscoides*),Toothed Flatsedge (*Cyperus dentatus*), Spoon-leaved Sundew (*Drosera intermedia*), Three-way Sedge (*Dulichium arundinaceum*), Slender Spike-rush (*Eleocharis tenuis*), Rough Cottongrass (*Eriophorum tenellum*), Narrow-leaved Fragrant Goldenrod *(Euthamia galetorum*), Golden Hedge Hyssop (*Gratiola aurea*), Brown-fruited Rush (*Juncus pelocarpus*), Thread Rush (*J. filiformis*), Jointed Rush (*J. articulatus*), Canada Rush (*J. canadensis*), Water Lobelia (*Lobelia dortmanna*), Southern Bog Clubmoss (*Lycopodiella appressa*), Swamp Yellow Loosestrife (*Lysimachia terrestris*), Bog Muhly (*Muhlenbergia uniflora*), Sand Panic Grass (*Dichanthelium acuminatum* ssp. *spretum*, =*Panicum spretum*), Virginia Meadow Beauty (*Rhexia virginica*), Brown Beakrush (*Rhynchospora fusca*), White Beakrush (*R. alba*), Water Parsnip (*Sium suave*), Prairie Cord Grass (*Spartina pectinata*), Virginia Marsh St. John's-wort (*Triadenum virginicum*), Lance-leaved Violet (*Viola lanceolata*), Bog Yellow-eyed-grass (*Xyris difformis*) and Northern Yellow-eyed-grass (*X. montana*).

Habitat trends

Shoreline development is limited on five of six lakes supporting Tubercled Spike-rush. Only Barrington Lake with roughly 40 cottages (Perry pers. comm. 2009) has a significant portion of its shoreline subdivided into cottage lots. Perry (pers. comm. 2009), who has a cottage on Barrington Lake and has monitored Tubercled Spike-rush there since 2000, does not believe that cottages have had significant impacts on the lake's population to this point because between 40 and 70% of the lake's spike-rush population is on undeveloped Crown land and the remaining populations are either away from cottages or are at cottage sites owned by cottagers who do not alter the shoreline zone. Little Ten Mile Lake, Harpers Lake, Gold Lake, and Western Lake are accessible only by ATV tracks, and have limited shoreline development. Great Pubnico Lake has multiple ATV access points, road access at several points and some cottage and Crown lease cabin development, including a small marina adjacent to a dense spike-rush population. However, developed shoreline still amounts to a small fraction of total shoreline there. Subdivided but undeveloped potential cottage lots represented less than 10% of shoreline on Great Pubnico Lake in 2009 (SNSMR 2008). The limited scale of development on most lakes and the wet, often peaty, nature of Tubercled Spike-rush habitat mean that shoreline development seems to have had limited direct effects on the species to this point. The species is also somewhat protected from

development because of the large portion of its population that is backed by provincial Crown land (see *Habitat Protection/ownership*, below). Development thus does not seem likely to reduce populations substantially in the near future, although some expansion of cottage development is likely, especially at Barrington Lake (Perry pers. comm. 2009).

Development of cottages likely does correlate with an increase in ATV traffic along shorelines, which is the most significant anthropogenic factor influencing Tubercled Spike-rush habitat at present. Heavily rutted ATV trails have been made in some years within areas occupied by Tubercled Spike-rush on Barrington Lake (i.e. 2005, but not as much in recent years, Perry pers. comm. 2009) and in 2002 (with no monitoring since) on Great Pubnico Lake (MacKinnon pers. comm. 2009). In addition to killing some plants when travelling through Tubercled Spike-rush habitat, ATVs sometimes break apart the thin peat mats that are ideal habitat for the species. This appears to interact with winter ice scouring to produce local change from peaty to sandy or gravelly substrates that are much less suitable for spike-rush (Perry pers. comm. 2009). Lillian Perry (pers. comm. 2009) has documented local loss over a recent winter of 0.5 – 1.0 m of peaty sedge mat from the lakeshore margins within the densest Tubercled Spike-rush populations on Barrington Lake. It is unclear whether these local declines in habitat availability on Barrington Lake, noted by Perry as ongoing since approximately 2005 (pers. comm. 2009), represent a fluctuation in habitat that may reverse itself in future. It is also unclear how much of this loss is directly associated with ATV impacts. ATV impacts have not been noted on any of Western, Gold, Harpers or Little Ten Mile Lakes (Smith pers. obs. 2008, Boates pers. comm. 2008, Blaney and Mazerolle pers. obs. 2009).

High water levels caused by beaver dams meant that in 2008 all available habitat was submerged and no plants were found at Western Lake, where four plants were previously documented. Beaver-induced flooding also inundated plants on Little Ten Mile Lake in 2009. Beaver-induced water level fluctuations are a natural occurrence within the Nova Scotia range of Tubercled Spike-rush and could contribute to the maintenance of an open shoreline zone if they occur with a suitable persistence and frequency. The duration of flooding that would eliminate adult plants or seeds from the seed bank (and therefore be relevant as an impact on habitat) is unknown, though studies on other *Eleocharis* species suggest potential for very long-lived seed banks. There is some evidence that beaver numbers have increased in recent years in southwest Nova Scotia, but trapping records do not suggest this to be outside normal population fluctuation and it is not believed that present beaver numbers are beyond levels occurring prior to European settlement (O'Brien pers. comm. 2009). These facts suggest that water level fluctuations associated with beaver activity are not a significant threat to Tubercled Spike-rush habitat. The limited understanding of the species' ecology and the small (and therefore potentially more easily extirpated) areas occupied by the plant at the beaver-impacted lakes limits the certainty that we can attach to that conclusion.

Habitat protection/ownership

As a species occurring largely within the zone of annual water level fluctuation, much of the area occupied by Tubercled Spike-rush is technically on provincial Crown land. The ownership of the terrestrial lake frontage at Tubercled Spike-rush lakes is also largely provincial Crown land. The overall Crown proportion of the species' documented area of occupancy, with area of occupancy including areas of potential occurrence identified because of the locational uncertainty of particular records), is 63% (AC CDC 2009). Similar calculations for individual lakes show that area of occupancy is 21% Crown frontage at Barrington Lake, 62% Crown frontage at Gold Lake, 57% frontage at Great Pubnico Lake, 100% Crown frontage at Western Lake and 12% Crown frontage at Harpers Lake. The actual proportions of plants at sites backed by Crown land is significantly higher than 21% at Barrington Lake (Perry pers. comm. 2009) and lower than 12% at Harpers Lake because of especially large numbers within or outside Crown parcels. The Little Ten Mile Lake site is on the shore of land owned by a forestry company. One of the cottage owners on Barrington Lake has been actively monitoring the *E. tuberculosa* population on that lake, and is interested in conserving the habitat at that location.

The species is protected under the Nova Scotia *Endangered Species Act*, which prohibits killing or disturbing individuals of listed species, or damaging or destroying their core habitat. Neither this protection nor the species' occurrence on Crown land appears to have thus far limited habitat disruption by ATVs. None of the areas of occurrence are on federal land, so immediate prohibitions under the federal *Species at Risk Act* (SARA) do not apply.

BIOLOGY

Little is known about the biology of *E. tuberculosa*. Other than the papers cited below, the only published research related to this species consists of taxonomic revisions and floristic checklists.

Life cycle and reproduction

Eleocharis tuberculosa is a perennial. Fertile stems are unbranched with numerous bisexual flowers in a single, dense, oval terminal spike. Like the majority of species in the family Cyperaceae and the genus *Eleocharis*, flowers are small and inconspicuous and are likely wind-pollinated (Magalhães *et al*. 2005 and references therein), although self-pollination (numerous references in Snyder and Richards 2005) and (in species with showy inflorescences) insect-pollination (Magalhães *et al*. 2005 and references therein) are also reported in other members of the family Cyperaceae.

The tufted growth form suggests it may reach sexual maturity within one or two years (Bernard 1990), but this remains unconfirmed, as does the species' average or maximum life span. Cyperaceae taxonomist Tony Reznicek (pers. comm. 2009) stated

"The plant forms pretty robust clumps, so I'm guessing it is relatively long-lived, but I have no idea how long, whether basically indefinite or merely 10-20 years or so. But so far as I can tell, it is not short-lived, like some clump forming perennials – that's just a guess, however."

The species is non-stoloniferous and rhizomes are short and ascending (Bruhl and Smith 2002), suggesting that vegetative reproduction may be limited to expansion of the tight clumps, meaning that clumps rather than stems are properly considered one individual under the COSEWIC definition. Tony Reznicek (pers. comm. 2009) notes "I don't believe it reproduces vegetatively to any extent. It is a densely cespitose clump former, and places where it occurs in colonies I suspect are from coalescing of dense patches of clumps". Seed production is extensive in Nova Scotia, as noted by many observers, but nothing is known about seed viability or recruitment rates. As a potentially quick-maturing species of habitats subject to substantial water level fluctuation, seed banking may be an important feature of Tubercled Spike-rush life history, as is true of many coastal plain shoreline species (Keddy and Reznicek 1986) and some other *Eleocharis* species (Wilson *et al*. 2006, Baldwin *et al*. 2001, Bell and Clarke 2004, cited in Leck and Schutz 2005). However, there seems to be no reference to it having been germinated in seed bank assays of coastal plain wetland habitats within its range (Gerritson and Greening 1989, Kirkman and Sharitz 1994, Schneider 1994, Cohen *et al*. 2004, Neill *et al*. 2009). If seed banks occur, they could be long-lived as seeds of four Australian *Eleocharis* species of temporary wetlands were estimated to persist 50 to 100 years (Bell and Clarke 2004) and soils from other fluctuating wetlands contained *Eleocharis* seeds that germinated following annual rewetting of soil samples for 12 years (Leck and Brock 2000, Baskin *et al*. 2002, both cited in Leck and Schutz 2005).

Dispersal

During fieldwork in 2008 by Tyler Smith, several isolated clumps of peat were observed washed up on otherwise sandy beaches, supporting apparently healthy plants of *E. tuberculosa.* This suggests that fragmentation of peat mats may provide a mechanism for dispersal within a watershed.

Seed dispersal in the digestive tract of waterfowl is plausible. Feeding experiments on domestic ducks showed that retention of up to 72 h improved germinability of *Eleocharis* species (Bell 2000, cited in Leck and Schutz 2005). Mueller and van der Valk (2002, cited in Leck and Schutz 2005) found that small numbers of viable seeds of the bulrushes *Scirpus acutus* and *S. validus* (widespread North American species also within the family Cyperaceae) were retained within Mallards, *Anas platyrhynchos*, up to 29-30 h. Viable seeds of *Scirpus* spp. (2-26% intact seeds) and of *Carex* spp. (8-13%) were also found in fecal samples from free-ranging Mallards and Northern Pintails (*Anas acuta*). Water flow or movement of seeds within mud attached to waterfowl or mammals would provide other potential mechanisms for seed dispersal. The majority of seeds of four *Eleocharis* species floated for at least two days (Bell 2000, cited in Leck and Shutz 2005).

Wind is likely the predominant pollen vector as with other *Eleocharis* species (Goetghebeur 1998, Magalhães et al. 2005). Wind pollination would provide a means of genetic dispersal within populations and potentially between adjacent populations, although pollen dispersal distances are unknown.

Interspecific interactions

Wooten and Elakovich (1991) found that aqueous extracts of *E. tuberculosa* inhibited the growth of Lesser Duckweed (*Lemna minor*) and Lettuce (*Lactuca sativa*). This suggests that *E. tuberculosa* may allelopathically inhibit the growth of competitors. However, the strength of the interaction was weak relative to that found in assays of other aquatic plants. Whether or not *E. tuberculosa* actively inhibits competitors in the field is unknown.

POPULATION SIZES AND TRENDS

Search effort

All lakes except for the Little Ten Mile Lake site discovered in 2009 were visited by Tyler Smith during four days in September 2008. No additional potential lakes were surveyed in 2008.

Newell and Zinck (2000), in combination with Atlantic Canada Conservation Data Centre data (AC CDC 2009), show that botanists spent 16+ days on Great Pubnico Lake searching for the species between 1994 and 2002, 3 days on Harpers Lake between 1995 and 1999, and two days on Barrington Lake in 1998 (plus extensive time by Lillian Perry, pers. comm. 2008) and two days each on Western and Gold Lakes in 1999. Additional undocumented visits have also occurred in and around the Western - Gold - Harpers Lakes area (Boates pers. comm. 2008). The shores of Little Ten Mile Lake and the adjacent Ten Mile Lake were comprehensively surveyed in 2009 over one day by Blaney and Mazerolle (pers. obs. 2009). Tubercled Spike-rush is thus quite well documented on all lakes on which it is known to occur. Small populations within those lakes likely establish and become extirpated over time meaning that some older location information may be out of date, but the distribution of the species on all the above lakes except Great Pubnico is likely nearly completely documented. The poor road access, extensive shoreline, and shallow, rocky bays (which make boating difficult during the best periods for detection of spike-rush) of Great Pubnico Lake mean that it is very likely that further sites exist beyond the many already documented there.

Tubercled Spike-rush is an inconspicuous species to anyone unfamiliar with the genus *Eleocharis*, and is frequently completely flooded (and thus even more inconspicuous) during high water periods (Newell and Zinck 2000, Tyler Smith pers. obs. 2008, Blaney and Mazerolle pers. obs. 2009). It is, however, relatively obvious and distinctive during low water periods for botanists familiar with it. Given the extensive work on the floristics of southern Nova Scotia's Atlantic Coastal Plain flora zone

(summarized in Blaney and Smith 2009) it is clear that Tubercled Spike-rush is a rare species in southern Nova Scotia and that it is largely or entirely absent from the more heavily surveyed areas of that zone, which are: 1) the lower Tusket River watershed (25-40 km northwest of most known Tubercled Spike-rush records) and, 2) the Kejimkujik - Ponhook - Molega Lakes area (75-100 km northeast of most known Tubercled Spike-rush records, but only about 15 km north of the recently discovered Little Ten Mile Lake population).

The 2009 discovery of the species at Little Ten Mile Lake, 60 km northeast of the previous northernmost record, came during extensive botanical surveys of previously unsurveyed lakes in the Ponhook - Molega Lakes region, during which the Atlantic Canada Conservation Data Centre surveyed the shores of 26 lakes (Blaney and Mazerolle 2009, Blaney and Mazerolle pers. obs. 2009). The single record during these extensive surveys demonstrates the rarity of Tubercled Spike-rush in the Ponhook - Molega Lakes area. There remain, however, 100+ almost completely unsurveyed lakes between the Tubercled Spike-rush sites in the Great Pubnico - Barrington Lakes area and the Ponhook - Molega Lakes area, as well as many other lower potential lakes north of these areas but within the zone supporting a diversity of Atlantic Coastal Plain flora. The species' observed infrequency in southern Nova Scotia strongly suggests that large numbers of new populations are unlikely to be found, but there is a reasonable likelihood that some additional undiscovered populations exist.

Abundance

All population estimates are for reproductive clumps, which are *mature individuals* for the purposes of COSEWIC assessment. Vegetative individuals are difficult to identify in dense mats. It is unclear what proportion of the total population does not flower each year, but it is apparently low (Smith pers. obs. 2008). For each patch where *E. tuberculosa* was recorded in 2008, its abundance was estimated by visually estimating density within a representative area, followed by a visual estimation of the extent of the patch. Due to time constraints, the entire shoreline of the lakes could not be surveyed. Highest priority was placed on the areas noted as having the highest populations in previous surveys (Table 1). The survey of Barrington Lake was supplemented with data collected by Lillian Perry as part of her ongoing independent monitoring program, which she began in 2000.

Barrington Lake supports one of two large populations of *E. tuberculosa* in Nova Scotia. At Barrington Lake most plants are found in three areas: midway up the west shore, and the northeast and northwest bays. The densest patches have more than 100 plants per m^2, and cover a total area of 1500 - 2000 m^2, giving a total population between 150,000 and 200,000. Scattered individuals occur outside the main areas in the southern end of the lake.

Great Pubnico Lake supports the other large Tubercled Spike-rush population. The lake is 10 km long by 1 to 4 km wide and 149 sites have been documented through surveys between 1994 and 2002 (AC CDC 2009). Records are densely congregated

around Little Bay in the lake's northwest corner and sparsely distributed throughout the northern two thirds of the lake. It is likely that other undocumented sites also occur on the lake (Elderkin pers. comm. 2009). Lawrence Benjamin (pers. comm. 2009) and Mark Elderkin surveyed Great Pubnico Lake for the species in 1998 and noted "we could spot the habitat after awhile, and could find it on any sandy shore on the lakeshore or islands". Tubercled Spike-rush, however, only occupies a small proportion of the shoreline, and large, dense patches are only known from a handful of sites, with many of the documented sites consisting of small numbers of plants. The size of the lake precluded an exhaustive survey in 2008, and despite the minimum 16 field days spent on the lake by all recent botanists (see *Search Effort*), no good population estimates for the whole lake are available. Tyler Smith recorded at least 2,000 individuals from near the marina and 2,500 overall in the Little Bay area in 2008, and the marina site represents only a small proportion of the total number on the lake (MacKinnon pers. comm. 2009, Elderkin pers. comm. 2009). The total number on Great Pubnico Lake is thus best described as "many thousands".

Because of issues related to high water levels and difficulty of access, neither the Harpers Lake nor the Western - Gold Lakes populations were comprehensively surveyed in 2008, so the numbers reported below should be considered minimum estimates.

The floating peat mat at Harpers Lake was thoroughly surveyed in 2008 but the shoreline was largely unsearched. Previous surveys suggested all but a few clumps of *E. tuberculosa* plants at Harpers Lake occur on the floating peat mat, so the 2008 survey is likely to have captured the majority of plants at this location. The peat mat covered an area of several 100 m^2. *Eleocharis tuberculosa* was abundant primarily in areas with little other vegetation at the west side of the mat. In this area, there were an estimated 2,000 individuals densely packed over 10 m^2.

Western and Gold Lakes are connected by a 600 m long stream, with plants separated by no more than 980 m, therefore they are considered subpopulations within a single population. The 2008 survey of Western Lake was conducted on foot, and was limited to the northern shore between the inflow and outflow, where the plant was previously recorded. This section of the shoreline was entirely submerged under at least 15 cm of water, apparently due to beaver dams encountered on the outflow creek. This left no appropriate habitat, and no floating peat mats were visible from the shore. Only four clumps had ever been observed on Western Lake, but numbers might be somewhat larger with an intensive survey (Newell and Zinck 2000). In 2008, about 10% of the Gold Lake shoreline between the outflow creek and the road access was surveyed on foot. Plants were not previously documented from this area and approximately 200 individuals, occupying approximately 10 m^2, were recorded. Newell and Zinck (2000) reported 200 to 400 plants from different areas of Gold Lake. Assuming that these latter plants could still be present, minimum numbers on Gold Lake are between 200 and 600 plants.

In 2009, David Mazerolle and Sean Blaney recorded about 50 plants over about 25 m of shoreline at a single site on Little Ten Mile Lake. The species was not seen elsewhere during comprehensive surveys of the shorelines of Ten Mile and Little Ten Mile Lakes and suitable habitat was limited on both lakes, although high water levels could have hindered detection to some extent (Blaney and Mazerolle pers. obs. 2009).

Fluctuations and trends

Available data do not allow for assessment of trends across the whole Canadian population of Tubercled Spike-rush.

Current population estimates have increased greatly from those in Newell and Zinck (2000) at Great Pubnico Lake (from 300 clumps to “many thousands” of clumps), Barrington Lake (from 2,000 to 3,000 clumps to 150,000 to 200,000 clumps) and at Harpers Lake (from 200 clumps to 2,000 clumps). The 2000 and 2008 population values are not comparable within the Gold Lake subpopulation of the Gold - Western Lakes population, because 200 new clumps were found in 2008 but the area supporting the previously reported 200 to 400 clumps was not searched. The Western Lake subpopulation of this same population was not found in 2008 because of beaver-induced flooding and thus declined from 4 clumps to 0 although it may still be surviving as dormant rhizomes or in the seed bank. No earlier data are available for the new population of about 50 plants found on Little Ten Mile Lake in 2009.

It is not certain, however, that the apparent increases above are real. Differences in survey intensity, survey timing and water level conditions could account for most or all the large population increases reported in this report relative to the previous status report (Newell and Zinck 2000). Lillian Perry (pers. comm. 2009), reports that mid-August is the best time for detecting plants, but previous surveys on Barrington Lake were as late as October after many plants may have shed their fruit and become much less obvious. Perry (pers. comm. 2009), who was present during the 1999 fieldwork, also reported that the densest populations on the western side of the lake were probably not included in the Newell and Zinck (2000) population estimate. Differences in detectability (and perhaps in actual numbers, though this is not clear) because of water level fluctuation can be substantial (Newell and Zinck 2000), and it is possible (though not specifically noted) that some previous surveys were conducted during high water periods when many plants would not have been evident. It is not clear how much the substantial (but less than one degree of magnitude) year to year fluctuations (Table 2, Newell and Zinck 2000, Perry pers. comm. 2009) are driven by loss of mature plants during high water levels and recruitment during low water levels as opposed to differences in detectability between high and low water conditions.

Table 2. Population sizes for four 1.8 x 1.8 m plots monitored on Barrington Lake by Lilian Perry.

Patch No.	Year				
	2004	**2005**	**2006**	**2007**	**2008**
1	60	50	20	30	32
2	150	55	30	90	70
3	130	120	120	200	95
4	100	120	80	few	16
Total plants	**440**	**345**	**250**	**~320+**	**213**

Lillian Perry has monitored Tubercled Spike-rush populations in four 1.8 x 1.8 m shoreline plots on the west side of Barrington Lake since 2004 (Table 2). Four non-randomly selected plots do not necessarily represent the situation over the whole lake, but between 2004 and 2008 numbers declined in all four plots, with the total declining from 440 to 213. The decline was not uniform, with a substantial increase noted in 2007 over 2006, and this variation makes the significance of the observed decline even less clear.

High water levels caused by beaver dams meant that in 2008 no plants were found at Western Lake, where four plants were previously documented. It is not known what lengths of submergence would eliminate adult plants or seeds in the seed bank, but evidence from other *Eleocharis* species of fluctuating wetlands (Bell and Clarke 2004, cited in Leck and Schutz 2005) and from other Atlantic Coastal Plain shoreline species (Keddy and Reznicek 1993) suggests that seed banking is likely to provide a means for Tubercled Spike-rush to survive extended periods of high water levels of at least 10+ years, which would be roughly the same time scale at which beavers might maintain high water levels. The apparent reduction in numbers at the small Western Lake site and potential future reductions in numbers at Little Ten Mile Lake, where beavers had also raised water levels, thus most likely represent fluctuations rather than an ongoing trend toward reduced numbers of locations. The two spike-rush lakes known to have been affected by beavers together represent less than 1% of the total Canadian population of Tubercled Spike-rush, so even if beaver flooding were a threat, it has not affected the Canadian population significantly.

Rescue effect

The nearest Tubercled Spike-rush location to Nova Scotia is the single Maine record from Oxford County in southwestern Maine (Maine Natural Areas Program 2009, Cameron pers. comm. 2009), 430 km west of Great Pubnico Lake. The nearest jurisdiction where the species is apparently stable and locally common is Massachusetts. While it is possible that waterfowl may act as a natural vector enabling *E. tuberculosa* to recolonize Nova Scotia from the United States (see discussion under *Dispersal*), the frequency of such dispersal events is likely too low to be of any conservation importance.

LIMITING FACTORS AND THREATS

Anthropogenic threats

The most serious anthropogenic threat to Tubercled Spike-rush in Nova Scotia is habitat damage caused by ATV use on sensitive shoreline peat. At Barrington Lake, limited data suggest that population declines where ATV tracks were made in the summer may be linked to increased ice-scour erosion and loss of Tubercled Spike-rush habitat (Perry pers. comm. 2009). The magnitude and permanence of any population and habitat loss caused by ATVs at Barrington Lake is not clear, and Lillian Perry (pers. comm.) states that heavy ATV damage has not been an annual occurrence in recent years. Deeply rutted ATV tracks were also clearly impacting certain large populations at Oak Point on Little Bay of Great Pubnico Lake in 2002 (MacKinnon pers. comm. 2002), but the level of threat posed over the whole lake by ATVs was unclear in 2002, as it is at present. The shoreline habitat at the other lakes is narrower and less conducive to ATV use and no significant ATV impacts have been observed elsewhere.

Shoreline development is limited on five of six lakes supporting Tubercled Spike-rush. Only Barrington Lake with roughly 40 cottages (Perry pers. comm. 2009) has a significant portion of its shoreline subdivided into cottage lots. Perry (pers. comm. 2009) has monitored Tubercled Spike-rush there since 2000, and does not believe that cottages have had significant impacts on the lake's population to this point because between 40 and 70% of the lake's spike-rush population is on undeveloped Crown land and the remaining populations are either away from cottages or are at cottage sites owned by cottagers who do not alter the shoreline zone. Little Ten Mile Lake, Harpers Lake, Gold Lake, and Western Lake are accessible only by ATV tracks, and have very limited shoreline development. Great Pubnico Lake also has road access and some development, including cottages, Crown lease cabins and a small marina adjacent to a dense Tubercled Spike-rush population, but developed shoreline still amounts to a very small fraction of total shoreline there. Subdivided but undeveloped potential cottage lots represented less than 10% of shoreline on Great Pubnico Lake in 2009 (SNSMR 2008). Development thus does not appear to have significantly reduced populations to this point nor does it seem likely to significantly reduce populations in the near future, although some expansion of cottage development is likely, especially at Barrington Lake (Perry pers. comm. 2009). Over the longer term as undeveloped lakeshore properties become increasingly scarce and valuable, development is likely to become a more significant issue because all spike-rush lakes are between 3 km and 11 km from the major highway in the region. However, the high proportion (63%, see *Habitat protection/ownership*) of occupied habitat on Crown land should continue to buffer against development impacts in the future.

Any permanent increase in water levels through human-created dams could pose a grave threat; however, there is presently no indication that any of the spike-rush lakes will be subjected to artificial regulation of water levels. There is also no evidence that exotic invasive species or pollution-related changes in water chemistry, both identified as potential threats to Atlantic Coastal Plain shoreline flora in Eaton and Boates (2003), are a threat to *E. tuberculosa* at present.

Natural impacts

Flooding by beavers has at least temporarily reduced numbers at the Western Lake subpopulation and may do the same at the Little Ten Mile Lake site. However Tubercled Spike-rush depends on habitat maintained, at least in part, by periodic fluctuations in water level (Zaremba and Lamont 1993). Evidence from other *Eleocharis* species of fluctuating wetlands (Bell and Clarke 2004) and from other Atlantic Coastal Plain shoreline species (Keddy and Reznicek 1993) suggests that seed banking is likely to provide a means for Tubercled Spike-rush to survive extended periods of high water levels of at least a few years to 10+ years, roughly the same time scale at which beavers might maintain high water levels. Beaver populations in southwest Nova Scotia are not considered to be above pre-settlement levels (O'Brien pers. comm. 2009). It is thus likely that current high water levels at Western and Little Ten Mile Lakes do not present a major threat to persistence at those sites, but the lack of species-specific understanding of the flood tolerance of the mature plants and seeds of Tubercled Spike-rush means this conclusion should be made with some caution. The small size in both area and numbers of plants at the beaver-affected lakes limits the impact of any potential threat posed by beavers relative to the whole of the Canadian population, but the small populations may also face an increased risk of extirpation by water level fluctuations simply because of their size.

Defining locations based on threat

At the Harpers Lake, Gold - Western Lakes and Little Ten Mile Lake populations, anthropogenic threats are minimal at present. The main observed or conceivable threat at those sites would be prolonged flooding by beavers that reduced numbers of mature plants and potentially numbers in the seed bank. This threat would apply to an entire lake and thus each lake could represent one location, with the Gold - Western Lakes population including two locations because beavers could influence the two lakes independently.

At Barrington and Great Pubnico Lakes, loss of plants and habitat damage from ATV use is the primary threat. ATV travel along lakeshores occurs at a scale from tens of metres to greater than 1 km. At Barrington Lake, ATV activity has been noted from much of the shoreline (although with differing severity) and treating that population as a single location is thus appropriate. At the Great Pubnico Lake population, the great majority (131 of 149) of documented sites are on the 1.5 to 2.6 km wide Little Bay in the lake's northwest corner. This is also the area where ATV damage has been noted on shoreline communities (MacKinnon pers. comm. 2009). Of the 18 other sites on Great

Pubnico Lake, 12 are on islands which are unlikely to be affected by ATVs and 6 are on shores of unknown susceptibility to ATV traffic. In the absence of detailed information on ATV use on the lake, and in the absence of a complete survey of this large lake, the Great Pubnico Lake population could be divided into locations in a number of ways. For example, two locations with Little Bay as one location and all other sites on the main Great Pubnico Lake as a second location; Little Bay as one location and the many islands with documented sites but no threats from ATV activity as another and the remainder of the shoreline with or without documented occurrences of the species or ATV activity as an additional one or more locations. Incomplete survey of Great Pubnico Lake means that the maximum number of locations possible under this latter scenario is unclear.

The five populations of Tubercled Spike-rush in Canada could be divided into a minimum of seven locations for the purposes of COSEWIC assessment (1. Little Bay of Great Pubnico Lake; 2. all other parts of Great Pubnico Lake; 3. Barrington Lake; 4. Harpers Lake; 5. Gold Lake; 6. Western Lake; and 7. Little Ten Mile Lake) or a number in excess of 10 locations. The number of locations has not been defined for this species because of the uncertainty in number of applicable locations based on the relatively low level of anthropogenic impacts on the species' habitat over large stretches of its shoreline habitat, the incomplete surveys of known lakes of occurrence, and the potential for new discoveries in adjacent unsurveyed lakes. There are likely more than 10 locations present if data were available for the unsurveyed portions of the six lakes or other unsurveyed lakes in the region. As well, locations may not be appropriate to apply for assessment purposes because of the concern that stretches of shoreline habitat without any significant threat might exceed half of the taxon’s range.

SPECIAL SIGNIFICANCE OF THE SPECIES

Eleocharis tuberculosa is of biogeographic interest, as the Nova Scotia populations represent significant range disjunctions, a pattern notable in a suite of Atlantic Coastal Plain species (Sorrie and Weakley 2001). As a highly disjunct occurrence at the extreme northern limit of its range, the Nova Scotia populations may harbour significant genetic diversity for the species. No Aboriginal Traditional Knowledge is known for this species in North America and only minor medicinal or cultural uses have been reported for some other species of this genus (Moerman 2010).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Table 3 indicates provincial or state level status ranks and designations for Tubercled Spike-rush. It is reported but not ranked (likely indicating non-rare status in most or all cases) across the Gulf states as far west as Texas, and north along the Atlantic coastal plain as far as New Jersey. Tubercled Spike-rush is Endangered in Maine, New Hampshire (where it is known only from historic records) and Pennsylvania and Threatened in New York. COSEWIC assessed *Eleocharis tuberculosa* as Threatened in May 2000; currently, it is listed as Threatened on Schedule 1 by the Canadian *Species at Risk Act* and as Threatened on the Nova Scotia *Endangered Species Act*.

Table 3. *Eleocharis tuberculosa* state and provincial S-ranks (NatureServe 2009) with state and provincial status designations (from jurisdictional heritage program websites, October 2008).

State / Province	S-rank	State / Province Status
Nova Scotia	S1	Threatened
Alabama	Not Ranked	
Arkansas	Not Ranked	
Connecticut	Not Ranked	
Washington D.C.	Not Ranked	
Delaware	S4	
Florida	Not Ranked	
Georgia	S4	
Louisiana	Not Ranked	
Massachusetts	Not Ranked	
Maryland	Not Ranked	
Maine	S1	Endangered
Mississippi	S5	
North Carolina	S5	
New Hampshire	SH	Endangered
New Jersey	S4	
New York	S2	Threatened
Pennsylvania	S1	Endangered
Rhode Island	Not Ranked	
South Carolina	Not Ranked	
Tennessee	Not Ranked	
-Texas	Not Ranked	
Virginia	S5	

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Authorities consulted

Atlantic Canada Conservation Data Centre Database, Sackville, NB

Lawrence Benjamin, Wildlife Technician, Nova Scotia Department of Natural Resources, Kentville, NS

Dr. Sherman Boates, Manager, Wildlife Resources – Biodiversity, Nova Scotia Department of Natural Resources, Kentville, NS (regarding previous surveys)

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INFORMATION SOURCES

Atlantic Canada Conservation Data Centre. 2009. Nova Scotia Rare Species Database (digital database, accessed September 20, 2009).

Baskin, C.C., J.M. Baskin and E.W. Chester. 2002. Seed germination ecology of summer annual species of dewatered reservoir shorelines (mudflats), a temporally unpredictable habitat. Pp. 353-368 *In:* Chester, E.W. and J.S. Fralish (eds.), *Land Between the Lakes, Kentucky and Tennessee: Four Decades of Tennessee Valley Authority Stewardship*. The Centre for Field Biology. Austin Peay State University, Clarksville, TN.

Baldwin, A.H., M.S. Egnotovich and E. Clarke. 2001. Hydrologic change and vegetation of tidal freshwater marshes: Field, greenhouse and seed-bank experiments. *Wetlands* 21: 519-531.

Bell, D.M. 2000. The ecology of coexisting *Eleocharis* species. Ph.D. Thesis, University of New England, NSW, Australia.

Bell, D.M. and P.J. Clarke. 2004. Seed-bank dynamics of *Eleocharis*: can spatial and temporal variability explain habitat segregation? *Aust. J. Bot*. 52: 119-131.

Benjamin, L. 2009. Email correspondence to S. Blaney. September 2009. Wildlife Technician, Nova Scotia Department of Natural Resources, Kentville, NS.

Bernard, J.M. 1990. Life history and vegetative reproduction in *Carex*. *Canadian Journal of Botany* 68: 1441-1448.

Blaney, C.S. and D.M. Mazerolle. 2009. Personal observations from fieldwork on lakes in Queens and Lunenburg Counties, NS. Botanists, Atlantic Canada Conservation Data Centre, Sackville, NB.

Blaney, C.S. and T. Smith. 2009. Update COSEWIC status report on Redroot (*Lachnanthes caroliniana*). 6 Month Interim Report, April 2009. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 32 pp.

Boates. S. pers. comm. 2008. Department of Natural Resources, Kentville, NS.

Boates, S. and Bishop, C. 1999. Unpublished field notes on survey of the coastal plain species on Harpers, Gold and Western Lakes.

Bruhl, J.J. and S.G. Smith. 2002. *Eleocharis* R. Brown (subg. *Eleocharis* sect. *Eleocharis*) ser. *Tenuissimae* Svenson. pp. 90-99 *in* Flora of North America Volume 23, edited by Flora of North America editorial committee. Oxford University Press, New York.

Cameron, D. 2009. Email correspondence to S. Blaney. September 2009. Botanist, Maine Natural Areas Program, Augusta, ME.

Cohen, S., R. Braham and F. Sanchez. 2004. Seed Bank Viability in Disturbed Longleaf Pine Sites. *Restoration Ecology* 12: 503-515.

Davis, D.S. and S. Brown. 1997. The natural history of Nova Scotia, vol. II: theme regions. Nova Scotia Museum and Nimbus Publishing. 304 pp.

Eaton, S.T. and J.S. Boates. 2003. Securing the science foundation for responsible stewardship and recovery of ACPF species at risk. NS Department of Natural Resources, Kentville, NS.

Environment Canada. 2005. Narrative Descriptions of Terrestrial Ecozones and Ecoregions of Canada. http://www.ec.gc.ca/soer-ree/English/Framework/Nardesc/atlmar_e.cfm

Fernald, M.L. 1921. The Gray herbarium expedition to Nova Scotia. *Rhodora* 23: 89-111, 130-152, 153-171, 184-195, 223-245, 257-278, 284-300.

Fernald, M.L. 1922. Notes on the flora of western Nova Scotia. *Rhodora* 23: 157-164, 165-180, 201-208.

Fernald, M.L. 1950. Gray's Manual of Botany. Eighth edition. Dioscorides Press. Portland, Oregon. 1632 pp.

Gerritsen, J. and H.S. Greening. 1989. Marsh Seed Banks of the Okefenokee Swamp: Effects of Hydrologic Regime and Nutrients. *Ecology* 70:750-763.

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. 2nd Edition. The New York Botanical Garden, Bronx, NY. 910 pp.

Goetghebeur, P. 1998. Cyperaceae. Pp. 141-190 *in* K. Kubitzki (ed.). *Flowering plants. Monocotyledons: Alismatanae and Commelinanae (except Graminae)*. Springer-Verlag, Berlin ; New York.

Hill, N.M. and P.A. Keddy. 1992. Prediction of rarities from habitat variables: coastal plain plants on Nova Scotian lakeshores. *Ecology* 73:1852–1859.

Keddy, PA. and I.C. Wisheu. 1989. Ecology, biogeography, and conservation of Coastal Plain plants: some general principles from the study of Nova Scotian wetlands. *Rhodora* 91:72–94.

Keddy, P.A. and A.A. Reznicek. 1982. The role of seed banks in the persistence of Ontario's coastal plain flora. *Am. J. Bot.* 69: 13–22.

Kirkman, L.K. and R.R. Sharitz. 1994. Vegetation Disturbance and Maintenance of Diversity in Intermittently Flooded Carolina Bays in South Carolina. *Ecological Applications* 4: 177-188.

Leck, M.A. and M.A. Brock. 2000. Ecological and evolutionary trends in wetlands evidence from seeds and seed banks. *Plant Species Biol*. 15: 97–112 (Corrigendum 16, 183–184).

Leck, M.A. and W. Schutz. 2005. Regeneration of Cyperaceae, with particular reference to seed ecology and seed banks. *Perspectives in Plant Ecology, Evolution and Systematics* 7: 95–133.

Magalhães, A.F., A.L.T.G. Ruiz, A. Flach, A.D. Faria, E.G. Magalhães and M.C.E. Amaral. 2005. Floral scent of *Eleocharis elegans* (Kunth) Roem. & Schult. (Cyperaceae). *Biochemical Systematics and Ecology* 33: 675-679.

Maine Natural Areas Program. 2009. Long-tubercled Spike-rush Fact Sheet. Web site: http://www.maine.gov/doc/nrimc/mnap/features/eletub.htm [accessed September 2009].

Moerman, D. 2010. Native American Ethnobotany. A database of foods, drugs and fibres of Native American Peoples, derived from plants. http://herb.umd.umich.edu/. Site accessed by E. Haber, May 2010.

Mueller, M.H. and A.G. van der Valk. 2002. The potential role of ducks in wetland seed dispersal. *Wetlands* 22, 170–178.

Natureserve. 2009. Natureserve Explorer database. Web site: http://www.natureserve.org/explorer [accessed September 2009].

Newell, R.E. and M. Zinck. 2000. COSEWIC status report on the tubercled spike-rush, *Eleocharis tuberculosa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 17 pp.

Neill, C., M.O. Bezerra, R. McHorney and C.B. O'Dea. 2009. Distribution, species composition and management implications of seed banks in southern New England coastal plain ponds. *Biological Conservation* 142: 1350-1361.

Perry, L. 2008. Email correspondence to T. Smith. July-November 2008. Amateur Botanist and expert on *Eleocharis tuberculosa* on Barrington Lake. Barrington, NS.

Perry, L. 2009. Email correspondence to S. Blaney. September 2009. Amateur Botanist and expert on *Eleocharis tuberculosa* on Barrington Lake. Barrington, NS.

Reznicek, A.A. 2009. Email correspondence to S. Blaney. September 2009. Cyperaceae Taxonomist, University of Michigan, Ann Arbor, MI.

Schuyler, A.E. 1977. Chromosome observations on some eastern North American *Eleocharis* (Cyperaceae). *Brittonia* 28: 129-133.

Schneider, R.L. 1994. The role of hydrologic regime in maintaining rare plant communities of New York's coastal plain pond-shores. *Biological Conservation* 68: 253–260.

Service Nova Scotia and Municipal Relations (SNSMR). 2008. Digital Property Series. Digital Geographic Information System Database.

Smith, L. 1996. The rare and sensitive wetland plant communities of interior Louisiana. Louisiana Natural Heritage Program, Louisana Department of Wildlife and Fisheries. Baton Rouge, LA. 40 pp.

Smith, T. 2008. Personal observations from fieldwork on known *Eleocharis tuberculosa* lakes. Contract Botanist, Halifax, NS.

Snyder, J.M. and J.H. Richards. 2005. Floral phenology and compatibility of sawgrass, *Cladium jamaicense* (Cyperaceae). *American Journal of Botany* 92:736-743.

Sorrie, B.A. and A.S. Weakley. 2001. Coastal plain vascular plant endemics: phytogeographic patterns. *Castanea* 66:50-82.

Svenson, H.K. 1937. Monographic studies in the genus *Eleocharis* IV. Rhodora 39: 248-250

USDA, NRCS. 2009. The PLANTS Database (http://plants.usda.gov, 7 April 2009). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

van der Valk, A.G. and C.B. Davis. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. *Ecology* 59:322-335.

Ward, D.B. and Leigh, E.M. 1975. Contributions to the flora of Florida: 8, *Eleocharis* (Cyperaceae) 40:16-36.

Wilson, S.D., D.R.J. Moore and P.A. Keddy. 2006. Relationships of marsh seed banks to vegetation patterns along environmental gradients. *Freshwater Biology* 29: 361-370.

Wisheu, I.C. and P.A. Keddy. 1994. The low competitive ability of Canada's Atlantic Coastal Plain shoreline flora: implications for conservation. *Biological Conservation* 68: 247–252.

Wisheu, I.C., C.J. Keddy, P.A. Keddy and N.M. Hill. 1994. Disjunct Atlantic coastal plain species in Nova Scotia: distribution, habitat and conservation priorities. *Biological Conservation* 68: 217–224.

Wooten, J.W. and Elakovich, S.D. 1991. Comparisons of potential allelopathy of seven freshwater species of spike-rushes (*Eleocharis*). *Journal of Aquatic Plant Management* 29: 12-15.

Zaremba, R.E. and E.E. Lamont. 1993. The status of the coastal plain pond-shore community in New York. *Bulletin of the Torrey Botanical Club* 120: 180–187.

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Tyler Smith was a post-doctoral fellow at Saint Mary's University at the time of report preparation. He received a B.Sc. in Ecology (Botany Minor) from the University of Guelph and a Ph.D. in Plant Science from McGill University. His dissertation research was an investigation of the systematics and niche evolution of a group of *Carex* species, and included extensive fieldwork across eastern North America, traditional and molecular taxonomic research, and niche analysis based on fieldwork and herbarium collections. Tyler was the field botanist for Royal Botanical Gardens in Hamilton, Ontario, from 1998 to 2002. While there he managed the herbarium collection, directed the vegetation component of the Cootes Paradise wetland restoration, and conducted an extensive program of floristic and conservation research. He was a member of the *Morus rubra* recovery team, and chaired the recovery team for *Trichophorum planifolium*. He has co-authored several COSEWIC reports, as well as the recovery strategy for *Trichophorum planifolium.*

Sean Blaney is the Botanist and Assistant Director of the Atlantic Canada Conservation Data Centre (AC CDC), where he is responsible for maintaining status ranks and a rare plant occurrence database for plants in each of the three Maritime provinces. Since beginning with the AC CDC in 1999, he has discovered dozens of new provincial records for vascular plants and documented thousands of rare plant locations during extensive fieldwork across the Maritimes region. Sean is a member of the COSEWIC Vascular Plant Species Specialist Subcommittee, the Nova Scotia Atlantic Coastal Plain Flora Recovery Team, and has co-authored several COSEWIC and provincial status reports. Prior to employment with AC CDC, Sean received a B.Sc. in Biology (Botany Minor) from the University of Guelph and an M.Sc. in Plant Ecology from the University of Toronto, and worked on a number of biological inventory projects in Ontario as well as spending eight summers as a naturalist in Algonquin Park, where he co-authored the second edition of the park's plant checklist.