PROPOSED

Species at Risk Act
Recovery Strategy Series

RECOVERY STRATEGY FOR THE ENGELMANN'S QUILLWORT (*ISOETES ENGELMANNII*) IN CANADA

Engelmann's Quillwort

August 2006

Parks Canada Parcs Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is *"to provide for the recovery of wildlife species that are Extirpated, Endangered or Threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an Endangered, Threatened or Extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/default_e.cfm) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/default_e.cfm).

Recovery Strategy for the Engelmann's Quillwort (*Isoetes engelmannii*) in Canada [Proposed]

August 2006

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PREFACE

The Species at Risk Act (SARA, Section 37) requires the competent Minister to prepare a recovery strategy for all listed Extirpated, Endangered or Threatened species. The Ontario Ministry of Natural Resources (on behalf of the Minister of Natural Resources) and the Parks Canada Agency (on behalf of the competent Minister) cooperatively led the development of this Recovery Strategy with the members of the Engelmann's Quillwort Recovery Team and in cooperation and consultation with the Canadian Wildlife Service - Ontario Region, stakeholders and private landowners.

The recovery strategy fulfills commitments of all jurisdictions for recovery planning under the Accord for the Protection of Species at Risk in Canada. All responsible jurisdictions reviewed the strategy for content and process requirements under their respective legislation and policy.

STRATEGIC ENVIRONMENTAL ASSESSMENT

A strategic environmental assessment (SEA) is conducted for all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support decision-making that is environmentally-sound.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on nontarget species or habitats. A summary of the SEA is presented below.

There are no anticipated adverse environmental impacts of the Recovery Strategy for Engelmann's quillwort (*Isoetes engelmannii)* in Canada. The assessment of environmental effect was conducted for each objective including population size and distribution, ecological requirements, identification and monitoring, identification and mitigation of negative impacts, policy and legislation, and education and communication. Implementation of the recommendations outlined in this strategy, in order to meet the above recovery goals, will result in positive or neutral environmental effects. In addition, it is anticipated that other species will benefit from the implementation of this recovery strategy, as it addresses waterway issues of importance beyond Engelmann's quillwort. No mitigation measures were described given that only positive or neutral impacts are expected.

EXECUTIVE SUMMARY

This national Recovery Strategy provides guidance for the recovery of Engelmann's quillwort *(Isoetes engelmannii)* in Canada. Engelmann's quillwort was listed as *Endangered* under the *Species at Risk Act* given that there are only two known populations in Canada, restricted to two rivers in Ontario. In addition, the Canadian populations are disjunct from the core range of the species in the northeastern United States.

Engelmann's quillwort is an aquatic member of a large group of fern allies, which are primitive plants with a long fossil history; they are thought to be remnants from the last glaciation. This species is unique and is considered an indicator of high species diversity and high quality aquatic habitats. Consequently, Engelmann's quillwort contributes to Canada's overall biodiversity.

There are a number of anthropogenic and natural threats to the Englemann's quillwort including mechanical damage, nutrient enrichment, unusual fluctuating water levels, herbicide application, invasive species, competition, predators, erosion and deliberate damage.

Recovery for this species is deemed feasible due to the presence of reproductive individuals and suitable habitat. Maintaining existing populations and their habitat should be a relatively small-scale undertaking.

The goal of this Recovery Strategy is: *To ensure the sustainability of Engelmann's quillwort populations on the Severn and Gull Rivers and any other populations that may be discovered.*

In order to achieve this goal, seven objectives have been identified and 24 actions have been ranked. The identified objectives include: determining the population sizes, distribution, viability, and genetic affinity to other populations; determining the ecological requirements of the species; identifying and monitoring the subpopulations; identifying and mitigating negative impacts; using government policy and regulation to conserve Engelmann's quillwort; establishing educational tools and programs for conservation and stewardship; and developing restoration techniques and protocol.

The critical habitat for Engelmann's quillwort has been proposed as a section on each of the Gull and Severn rivers in Ontario, coincident with all the known populations in Canada, as well as 300 m and 150 m downstream from the most distal population at the Severn and Gull Rivers, respectively (see figures 3 and 4). Upstream portions of critical habitat include 150 m for both locations. If other populations are discovered, it is recommended that the critical habitat provision will be applied similarly to these new areas.

Knowledge gaps fall within three broad categories: basic ecology, geographical and biological affinities of disjunct populations, genetic analysis to distinguish Engelmann's quillwort from its hybrid and threat analysis.

In order to evaluate the effectiveness of efforts to ensure the sustainability of Engelmann's quillwort, eight performance measures are presented. The performance measures are linked to each recovery objective in order to track progress more specifically.

To ensure the implementation of this recovery strategy, an action plan will be developed by 2009.

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SPECIES INFORMATION

Common Name: Engelmann's Quillwort, Appalachian Quillwort

Scientific Name: *Isoetes engelmannii* A. Braun

Current status: Endangered

Last Examination and Change: May 2001 (No Change)

Reason for designation: Few highly restricted populations in Ontario occurring in two rivers, disjunct from the core range of the species in the northeastern United States, and at risk from recreational boating activities, loss in water quality and possible impact of zebra mussels.

Canadian Occurrence: Ontario

Status history: Designated Endangered in April 1992. Status re-examined and confirmed in May 2001. Last assessment based on an update status report (Brunton, 2001)

1.0 BACKGROUND

Engelmann's quillwort is an aquatic member of a large group of fern allies of the family Isoetaceae (with 300 or more species worldwide); they are primitive plants with a long fossil history. Engelmann's quillwort is endemic to eastern North America. This plant is rarely common over a large area; however, they are often locally abundant in their scattered occurrences. Globally, Engelmann's quillwort is listed as G4 (globally widespread and apparently secure) (NatureServe, 2004). Nationally, it is listed as *Endangered* under the Species at Risk Act (SARA). Provincially, in Ontario, it is listed as S-1 (extremely rare). Progress is currently underway to have it provincially listed as *endangered* and regulated. This species is also listed as *endangered* in a number of American states; however, is not listed federally (Figure 1).

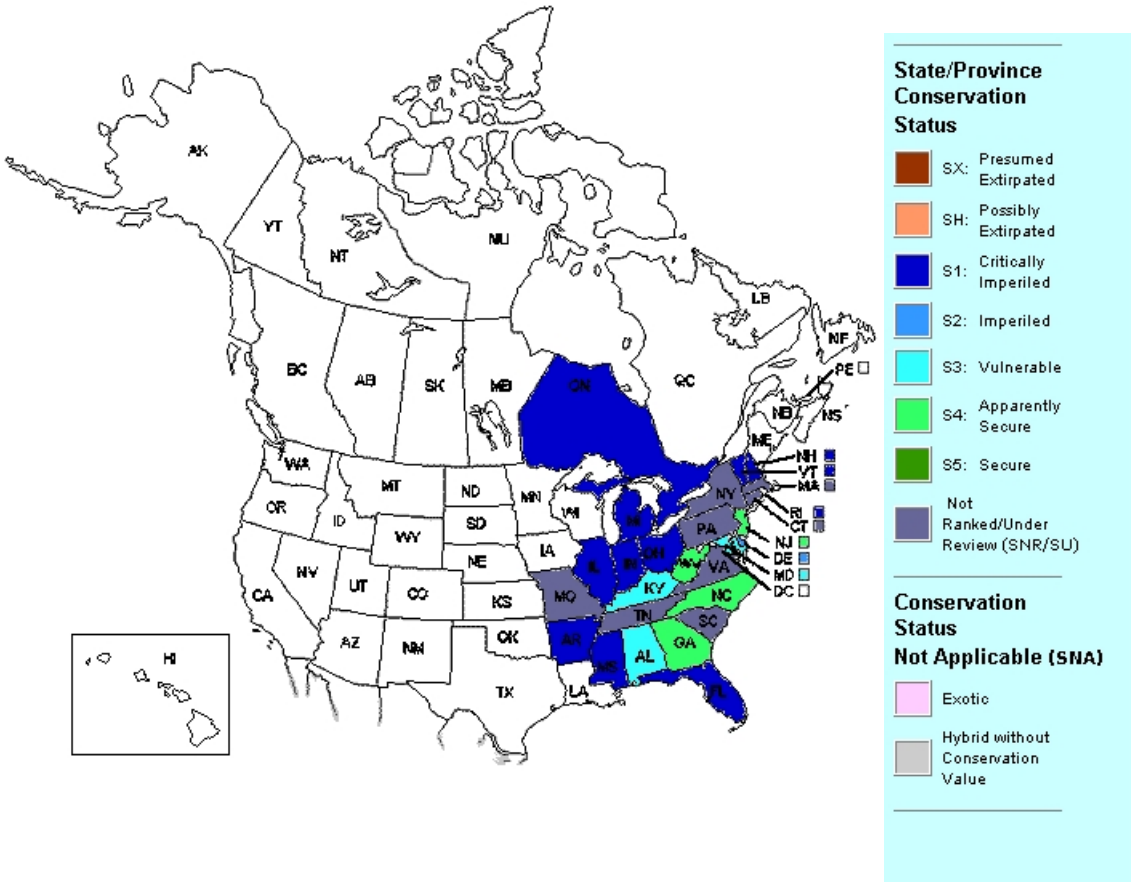

Figure 1. Engelmann's Quillwort status in North America (Copyright © 2005 NatureServe, 1101 Wilson Boulevard, 15th Floor, Arlington Virginia 22209, U.S.A. All Rights Reserved; NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.6. NatureServe, Arlington, Virginia)

1.1 Description

Engelmann's quillwort is a shallow water species generally growing in borders of ponds, lakes and reservoirs, as well as creeks and rivers. This species is frequently found growing as an emergent in the dry season in damp ground or in dry bogs and swamps, in mud, sand, and gravel, within the major part of its distributional range. It is an inconspicuous perennial plant with simple, grass-like leaves. The leaves are usually less than 20 cm long, are green to yellow-green in colour, erect and usually soft. Engelmann's quillwort is very similar in appearance to other species of quillwort with which it is often found.

1.2 Distribution

Engelmann's quillwort was first discovered in Ontario at the Gull River of Haliburton County in 1988 and the Severn River of the District Municipality of Muskoka (Britton et al. 1991). Its range is limited, confined to a 4.5 km section of the Severn River and about a 450 m section of the Gull River at West Guilford (Figure 2). Engelmann's quillwort plants have not been seen on the Simcoe County side of the Severn River; although, the presence of large sub-populations of Eaton's quillwort (*Isoetes x eatonii* Dodge), its sterile hybrid with the Spiny quillwort, indicates that it almost certainly persists there (Brunton 2003). Eaton's quillwort was first collected at Big Chute in 1980 (Kott and Bobbette 1980). The robust nature (large plant size and leaf number) of the hybrid makes this taxon the most conspicuous Isoetes at such Canadian Engelmann's quillwort sites.

The Canadian populations of Engelmann's quillwort are disjunct from the North American range of the species. It is believed that this distribution is related to dramatically different drainage patterns that existed in the Great Lakes Region of North America following the end of the Wisconsin glaciation (Chapman and Putnam 1984). This distribution is shared by a suite of shoreline and aquatic species, which are disjunct from their primarily Atlantic Coastal Plain range (Keddy and Sharpe 1989; Britton et al. 1991; Reznicek 1994).

Review of the possibility that Engelmann's quillwort was accidentally introduced by human activity (e.g. recreational boat traffic) was a major consideration of recent field investigations within the Canadian range (Brunton 2003) and is one of the subjects of on-going molecular studies (Wilson 2004). It is concluded from the field studies that the strongest evidence points to a native origin for both Canadian populations. Evidence includes the fact that the Canadian distribution of Engelmann's quillwort is consistent with that of a significant number of other native aquatic species typical of the Atlantic Coast plain that are rare in Ontario and/or Canada. Further, the abundance of Engelmann's quillwort along the Severn River fits well within the 'Mill Pond scenario', which was first described in new England, where large populations developed locally some decades after the creation of additional aquatic habitat from the flooding by mill pond construction over smaller, indigenous quillwort populations (Eaton 1900). Over time, such populations decline in number, remaining in scattered, smaller sub-populations at particularly suitable sites within the locally expanded range. Such Mill Pond scenarios are known to occur with Engelmann's quillwort populations in at least North Carolina, Pennsylvania, New Hampshire, and New York (Brunton, per. obs.). Finally, there is no known evidence or

documentation of Engelmann's quillwort (or any aquatic quillwort species) being inadvertently transported in the wild in North America, let alone over such great distances.

Although not confirmed, it is not expected that Engelmann's quillwort was ever substantially more common in Canada in historic times, as its national distribution is quite similar to that of other coastal disjunct vascular plants, which also maintain small, localized populations in the Great Lakes Region. Less than one percent of the global population of this species is found within Canada.

Outside of Canada, Engelmann's quillwort is most abundant in fresh water lakes and rivers along the Atlantic coastal plain in the eastern United States, and extending westward into the Mississippi River drainage. The previously known distribution of Engelmann's quillwort is described as New England south to southern Georgia and Alabama and west to Missouri (Kott and Bobbette 1980; Kott and Britton 1983). However, population levels in the United States have declined and the species is now extirpated from many historical sites, particularly in New England, Missouri, Georgia, and South Carolina. Presently, the central core of its range is in Virginia, southernPennsylvania and western North Carolina.

1.3 Population size and trends

In Canada, on-site surveys of about 120 potential sites along the Severn River and the Gull River from 2002-2005 identified seven populations of Engelmann's quillwort. On the Severn River, the overall population size for Engelmann's quillwort is currently estimated to be 1094 individuals (Heydon and Pidgen, 2005). In the Gull River the population estimate is 375 individuals (Heydon, 2006). During the same studies, 19 populations of the hybrid between Engelmann's quillwort and Spiny quillwort (Eaton's quillwort) were identified. The occurrence of Eaton's quillwort is taken as confirmation of the presence of Engelmann's quillwort (Figures 3 and 4) since the sterile hybrids have virtually always been found only in the presence of both parents (Brunton and Britton 1999, Brunton 2003). Therefore, the actual number of individuals of Engelmann's quillwort is most likely higher than that estimated above.

Population trends are not known for Canadian Engelmann's quillwort, though at least one formerly large population in the Severn River has been reduced since the early 1990s, apparently as a result of physical site impact such as mechanical damage, wave action, and/or abnormally high rates of sedimentation (Brunton, pers. obs.). Engelmann's quillwort populations have

declined throughout the northern portion and western portions of its North American range over the last century (Taylor *et. al.* 1993).

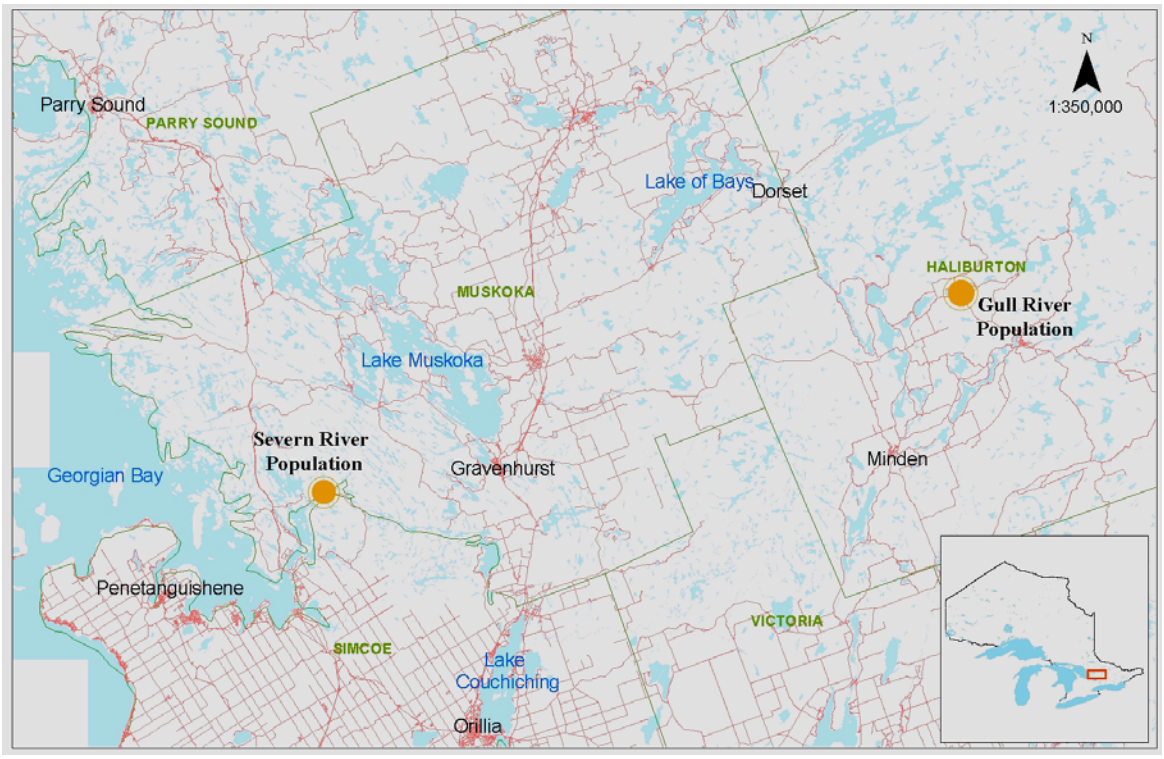

Figure 2. The known Canadian locations of Engelmann's quillwort (*Isoetes engelmannii*).

1.4 Biology and Ecology

Engelmann's quillwort is a sexual diploid, which produces viable spores, as indicated by the abundance of its hybrid with Spiny quillwort. Vegetative reproduction has not been reported for any of the *Isoetes* species of North America. Canadian plants of Engelmann's and Eaton's quillwort have mature megaspores by early August. Plants of shallower water likely mature at an earlier date than those in deeper water. Dispersal of spores begins when the sporangium is ruptured, either by physical impact or by decay at the end of the growing season. The frequency of dense stands suggests that spores are often dispersed only a short distance, or may be carried

downstream on buoyant detached leaves. Spores probably concentrate downstream in back-eddies and other slow-water areas. Sporophytes develop in such habitats following the contact of microspores with megaspores and can do so even in dynamic habitats (e.g. developing on sand spits in flowing river waters). This development presumably occurs during the late summer and fall period. Spore germination and vernalization requirements in reference to survival and distribution of Isoetes species have been discussed in Ontario, including Engelmann's quillwort (Kott and Bobbette 1980; Kott and Britton, 1982).

There appear to be few natural predators of Engelmann's quillwort perhaps in part, because they typically grow in rather sterile environments (i.e. not nutrient rich). Waterfowl and muskrats feed upon and dislodge fully developed plants; however, it is not clear if such events are common or have a direct effect on species distribution.

1.5 Habitat

All Canadian populations of Engelmann's quillwort are found in similar aquatic habitats characterized by fresh, flowing, circumneutral to calcareous water and substrate (pH 6.0 - 8.1). Sites are typically protected from heavy river currents and wave action by an intervening headland, island, etc. While typically submerged, Engelmann's quillwort can also be found as a late summer emergent of wet, silty beaches amongst boulders, occasionally in association with other *Isoetes* species. Backshore vegetation consists of mixed and deciduous forest cover. The Haliburton County population is partially shaded whereas the Severn River population in the District Municipality of Muskoka and the Simcoe County populations of *I. ×eatonii* grow in full sunlight.

Plants are found in a sand or silty-sand layer over clay or clayey-sand substrate. These are often within a dense granitic cobble bed but occur on open, relatively rock-free river sediment as well. Common associated species include Eel-grass (*Vallisneria americana*), Spiny quillwort (*Isoetes echinospora*), Najad *(Najas flexilis*), waterweed (*Elodea canadensis*), pondweeds *(Potamogeton illinoensis, P. pectinatus, P. natans*), grassleaf arrowhead (*Sagittaria graminea),* and crested arrowhead (*Sagittaria cristata*). The latter, a Provincially Rare Great Lakes endemic, appears to be as common as grassleaf arrowhead in the habitats of the Severn River Engelmann's quillwort sites.

The ecological flexibility of the Engelmann's quillwort might be limited. While Engelmann's quillwort can be maintained in cultivation for years in a standing pot of water, it is almost never found in nature in still, warm water. The fact that this species is found upstream of the Big Chute dam does indicate, however, that it can adapt to water level fluctuations. Water levels increased approximately 3.0 m with the construction of the dam in 1917, and it is interesting to note that Engelmann's quillwort is found in a number of sites upstream (but not downstream) of the dam.

The Haliburton County population is situated along an essentially natural section of the Gull River, where the water level is regulated, although not significantly. The habitat of this population looks very similar to that of a number of small-stream Engelmann's quillwort populations in Virginia and New Hampshire (Brunton pers. obs.). Water flows are controlled by a dam at the outlet of Eagle Lake, upstream of the Gull River population. Water levels fluctuate approximately 1 m annually at the outlet of Maple Lake, which is downstream of the population. This section of the river is also not suitable for navigation by large pleasure boats, which could have cruised continuously from areas of Engelmann's quillwort occurrences, thus reducing the opportunity for the transport of live plant material.

2.0 THREATS

Understanding threats to Engelmann's quillwort is challenging given the inconspicuous nature of the species and the difficulty in studying them. However, excellent research has been conducted to date and with our current understanding of Engelmann's quillwort, ten broad categories of threats to this species are described. Table 1 illustrates whether the threat is actual or potential, human-induced or natural, and high, medium or low priority. Descriptions of each threat follow the table.

Table 1. Qualification of threats to Engelmann's quillwort given current understanding.

Threat	Actual/ Potential	Human/ Natural	Level of Importance
1. Mechanical Damage	Actual	Human/Natural	H
2. Nutrient Enrichment	Potential	Human	H
3. Herbicide Application a) Aquatic Herbicide Application b) Terrestrial Herbicide Application	 Actual Potential	 Human	 H

4. Competition	Potential	Natural/ Human	H
5. Erosion	Potential	Human	M
6. Invasive Species	Potential	Human/ Natural	M
7. Long-term Changes Water Levels	Potential	Human	L
8. Other Water Contaminants	Potential	Human	L
9. Predators	Potential	Natural	L
10. Deliberate Removal	Potential	Human	H

2.1. Description of Threats

Mechanical damage (e.g. boat traffic, wave action, ice movement, dredging, raking, foot traffic, boat house and dock construction, and sand covering from beach creation) can cause damage to the site and individuals. Loss of habitat can occur if a dock covers a plant, which can destroy individuals and/or lower reproductive success. Such damage has been observed at locations in the Severn River, where boat traffic is significantly higher in comparison to the Gull River site (Heydon & Pidgen 2005).

Nutrient enrichment due to runoff and other sources can cause increased competition from other more aggressive species, which can result in local declines and extinctions. Increased levels of phosphorus at some locations may contribute to nutrient enrichment and the apparent proliferation of aquatic competitors and algae, which reduces the light available to submerged aquatic plants. Similar results were concluded in demographic field studies done on *Isoetes lacustris* in Western Europe (Voge, 1997).

Herbicide application, either for control of aquatic vegetation or from land runoff (i.e. terrestrial application), can potentially remove individuals or entire sub-populations (Heydon & Pidgen 2005).

Competition from other aquatic plants (native such as Eaton's quillwort and exotics) can cause declines in Engelmann's quillwort by out-competing them for essential components such as light

and nutrients(Brunton 2001). Aquatic plants may be proliferating due to improved water quality from zebra mussel infestations and input of nutrients from surrounding land development.

Erosion from land sources such as shoreline development (i.e. construction of docks, construction of boathouses, building cottages, shorewall construction and removal of natural shoreline vegetation) and boat wake can result in site disturbance, reduction of sunlight, which then might result in decreased performance and recruitment (Heydon and Pidgen, 2005).

Invasive species such as Zebra mussels, which in recent years have become abundant in the Severn River site (Brunton 2001), can have negative impacts on quillworts. For example, encouragement of other competing macrophytes such as milfoil would be a negative impact. In addition, multiple attachments of mussels on the plants themselves may pose a physical threat to their leaves.

Long-term changes in water levels due to dam and hydroplant operation or changes in climate could potentially cause a loss of individuals and habitat. At the Severn River, the population is located directly upstream of a Trent-Severn Waterway lock where there is potential for excessive changes in water level in order to move boat traffic through. In addition, ice scouring is a potential effect of excessive water level fluctuations (Brunton 2001).

Other water contaminants (e.g. petroleum products, heavy metals, salt from roads) have caused the eradication of Engelmann's quillwort in major industrial areas in the eastern United States (Brunton 2003) and could potentially impact the survivorship of Canadian populations. Both the Gull River and Big Chute sites are located close to facilities (where accidental toxic spills could occur) potentially causing detrimental effects to the populations (Heydon & Pidgen 2005).

Predators, such as waterfowl and muskrats can physically damage sites and cause death to individuals through foraging activities.

Deliberate removal of individuals could seriously impair the viability of these populations. Removal might be an explanation for the surprisingly rapid decline in quillwort species that was observed at the Gull River site (Brunton, 2001).

3.0 KNOWLEDGE GAPS

The recovery objectives emphasize the need to undertake some basic ecological investigations of this species. The ecology of the genus *Isoetes* has long been neglected in North America due to our inability, until the last decade, to confidently identify individual plants. The subtlety and variability of aquatic habitats complicates this further. Why, for example, are Engelmann's and Eaton's quillwort found at some sites along the Severn and Gull Rivers but not at other seemingly identical sites along those waterways? Further determination of the basic ecological requirements of Canadian Engelmann's quillwort is required for this species in order to decipher specific habitat characteristics.

Similarly, the geographic and biological affinities of widely disjunct populations are not known. It will be necessary to genetically determine such connections to assess appropriate recruitment and restocking options, if necessary, as well as to provide insight into the origin of this species and perhaps other rare disjuncts in Canada.

A mechanism for distinguishing the depauperate Canadian Engelmann's quillwort plants from associated aquatic quillworts without resorting to the removal of leaves and the examination of megaspores is currently being assessed. Only generalized and inaccurate population detection and population census, which are estimated only from sampled populations, can occur. A practical, non-destructive, and more accurate technique for identification would dramatically improve our monitoring and investigative productivity. Further work on this is required.

More research is required to fully understand the actual threats to Engelmann's quillwort in Canada and their relative priority. Further and refined knowledge on actual threats is essential to ensure that effective mitigation measures are put into place and that threats to habitat are minimized/alleviated.

4.0 CRITICAL HABITAT (Proposed)

Critical habitat for Engelmann's quillwort is proposed at both the Severn and Gull Rivers as the locations of sub-populations and the area in-between these sub-populations. The boundaries of the critical habitat are:

1. **the high water mark along the shoreline;**

2. **150 m from most distal sub-population on the upstream side at both river locations;**
3. **the Big Chute Dam and 150 m beyond the most distal sub-population on the downstream side at the Severn River and Gull Rivers, respectively (Figures 3 and 4).**

Upland extensions of critical habitat are considered essential for the survival and recovery of Engelmann's quillwort; however, further scientific investigation is required to determine the extent of these extensions. Therefore, the proposed identification of critical habitat is a partial one.

Because the ecological requirements necessary for persistence of the species remain uncertain at present (Heydon and Pidgen 2005), **an occupancy-based approach to the identification of critical habitat has been employed.** Populations of these species are comprised of geographically separated sub-populations, and the critical habitat proposed here takes in all such sub-populations.

Critical habitat includes populations of Engelmann's quillwort and its hybrid, Eaton's quillwort, as it represents the largest proportion of the genetic heritage of *I. Engelmannii* in Canada and is currently felt that Engelmann's quillwort is most likely to be present near Eaton's quillwort (Brunton 2003).

Distances between sub-populations range from 16 to 1456 m (average distance 272.6 on the Severn River; 142.3 on the Gull River) indicating that there is the possibility of dispersal and colonization over considerable distances in suitable aquatic habitat. Therefore, critical habitat includes the area between known sub-populations. In addition, given the ranges above, on average it is anticipated that dispersal could take place 300 m beyond the most distal population downstream at the Severn River site and 150 m beyond the most distal population downstream at the Gull River site (assuming no upstream dispersal). Since 300 m downstream at the Severn River runs into the Big Chute Dam, this structure is used as a boundary. **Therefore, the downstream boundaries of critical habitat include the Big Chute Dam at the Severn River and 150 m beyond the most distal population at the Gull River.**

From 2004-2005, one new subpopulation was discovered 150 m upstream from the old most distal sub-population within the Severn River. It is expected then that upstream dispersal is possible; however, it is unknown as to how it is occurring (e.g. waterfowl). Therefore, in the

absence of more specific information, **the upstream boundaries of critical habitat have been identified as 150 m beyond the most distal plant at both the Severn and Gull River sites.**

In order to mitigate threats that might occur upland (i.e. pesticide and fertilizer use), it was felt that an upland extension to the critical habitat is required. However, currently, there is insufficient evidence to determine the type and extent of the upland area required to mitigate the specific threats. Therefore, **the shoreline boundary of critical habitat is defined by the Ordinary High Water Mark (OHWM),** which is the usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. Further scientific research will be undertaken in 2006 and 2007 in order to confidently determine what upland extension to critical habitat is required for the survival and recovery of this species.

Figure 3. The locations of Engelmann's quillwort *(Isoetes engelmannii)* on the Gull River, and the critical habitat. (In this iteration, critical habitat is only identified on provincial crown lands and federal lands; no private lands are involved.)

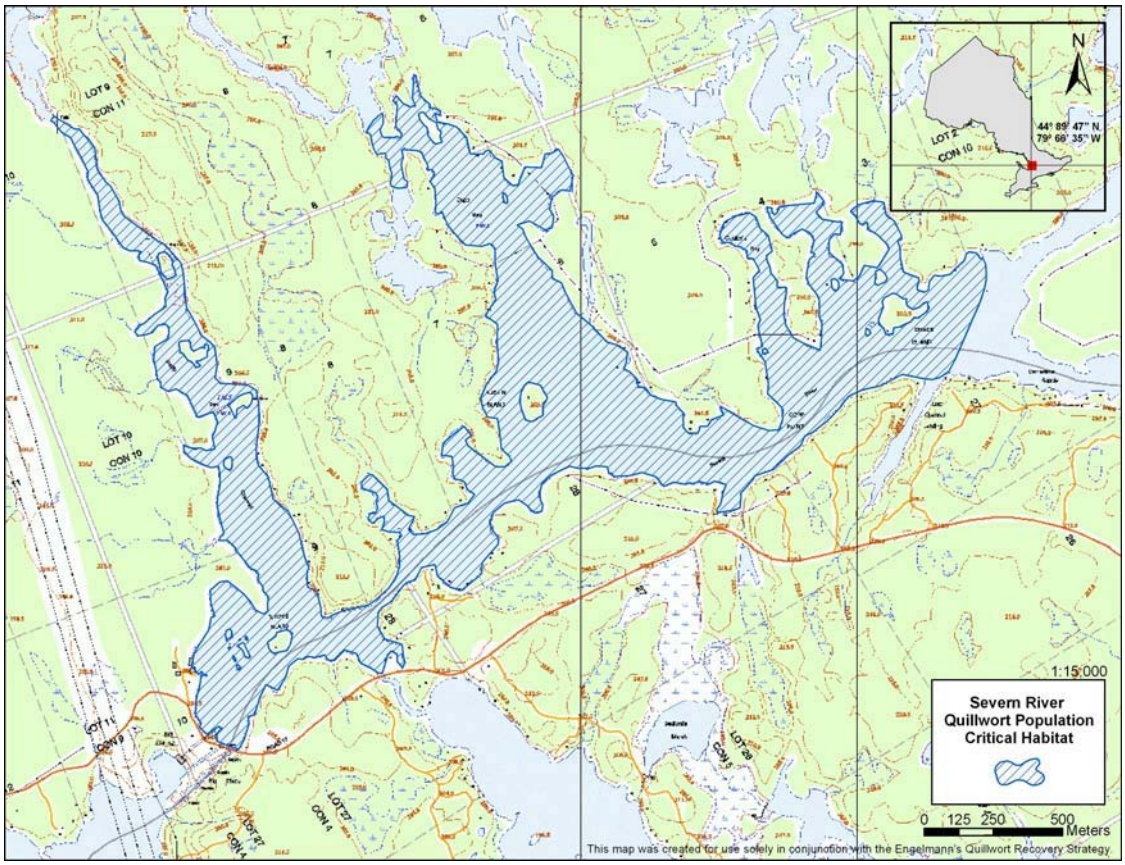

Figure 4. The critical habitat of Engelmann's Quillwort (*Isoetes engelmannii*) on the Severn River. (In this iteration, critical habitat is only identified on provincial crown lands and federal lands; no private lands are involved.).

4.1 Examples of activities likely to result in the destruction of critical habitat

The critical habitat of this species is potentially threatened by a number of activities. The construction of docks and boathouses could alter the habitat through disturbance and result in excessive sedimentation, as well as significantly reduce light levels. In addition, there are various forms of mechanical damage, which could negatively impact the critical habitat for this species including dredging, sand placement, raking of aquatic plants and shoreline alteration. Thirdly, aquatic herbicide use could remove individuals or even sub-populations. Lastly, eutrophication of the water and sediment resulting from adjacent land use, such as fertilization and insufficient

septic systems, could negatively affect this species and its habitat through increased herbaceous competition.

4.2 Existing Habitat Protection

All of the populations in the Gull River (and thus critical habitat) are on provincial crown lands (Figure 5)[1]. The populations in the Severn River exist on Federal lands (i.e. the Trent-Severn Waterway National Historic Site of Canada) except for one sub-population of the hybrid, which is located on provincial crown land and part of the Severn River Conservation Reserve (Figure 6). The Federal sites are subject to protective legislation and regulation under the Species at Risk Act. The sites on Federal lands are subject to the Historic Canal Regulations of the Department of Transport Act. The Provincial sites are currently offered some protection through provincial legislation such as the Public Lands Act, which regulates land use activities on crown lands, as well as the Provincial Policy Statement, which can provide municipal protection from development activities on private lands. Progress is underway to have this species regulated by the Ontario Ministry of Natural Resources under the Endangered Species Act. The federal and provincial governments will cooperate in providing adequate protection measures to these sites.

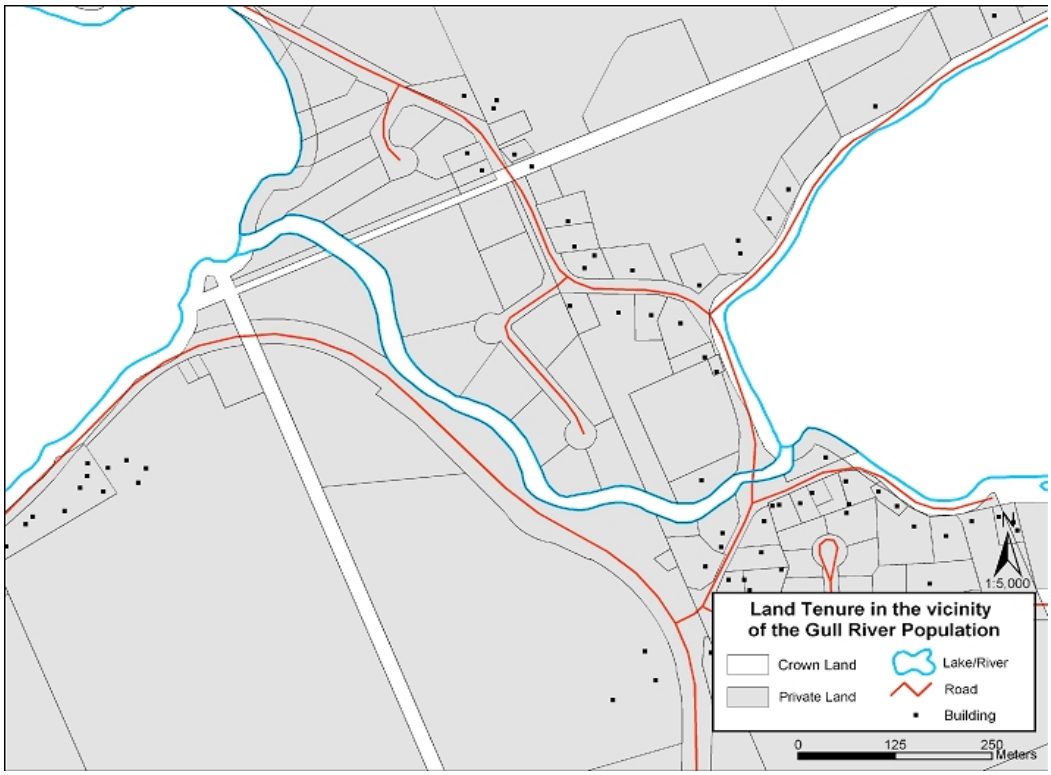

Figure 5. Current land tenure and existing habitat protection at the Gull River site.

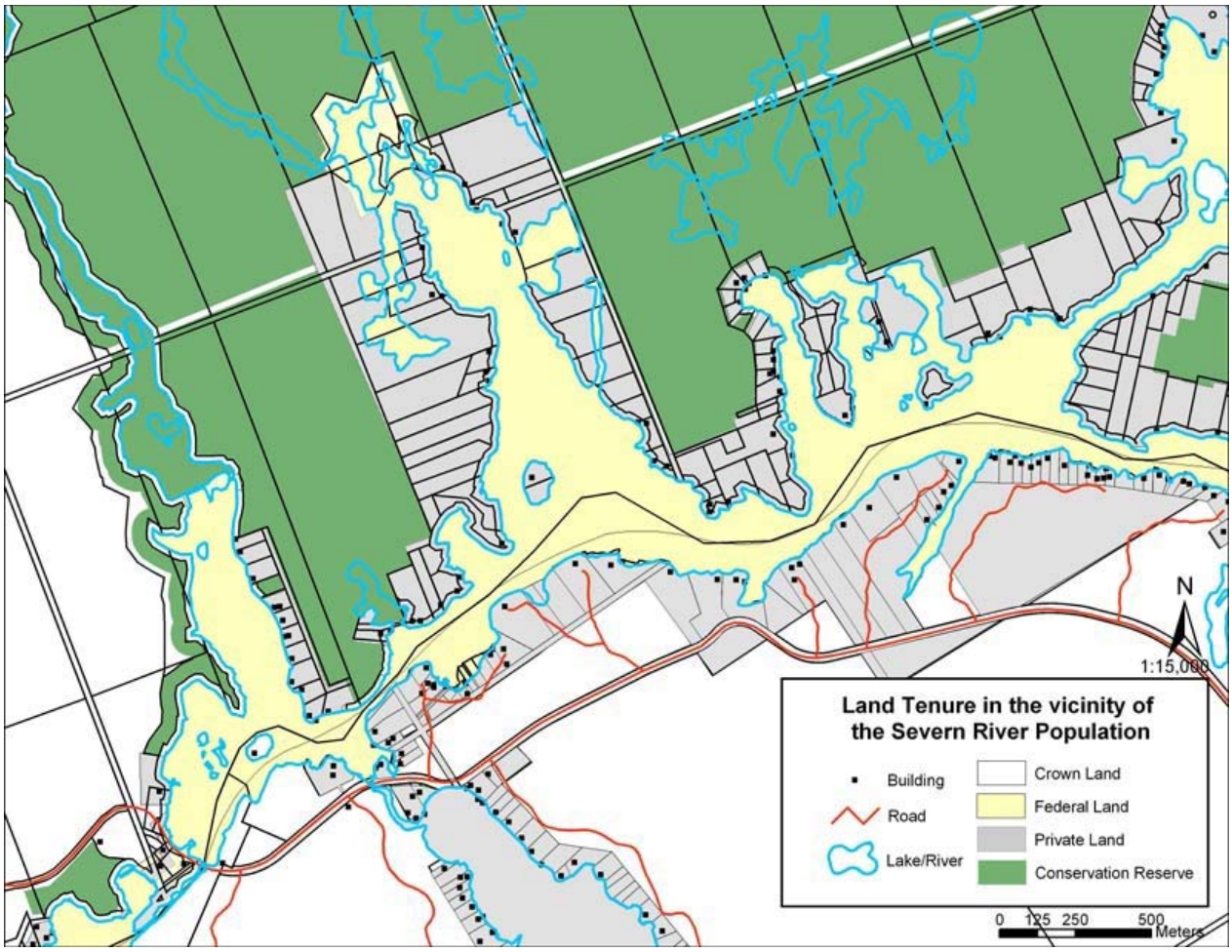

Figure 6. Current land tenure and existing habitat protection at the Severn River site.

4.3. Schedule of Studies to Provide Complete Identification of Critical Habitat

a) Confirm the type and extent of threats to Engelmann's quillwort on upland and aquatic areas at both the Severn and Gull River sites. Suggested completion date: 2008.

b) Determine land and water use patterns at both the Severn and Gull River sites (e.g. fertilizer, pesticide and herbicide use, septic use, cottage or business uses). Suggested completion date: 2008

c) Determine the type (e.g. vegetative or general) and extent (i.e. width) of the critical habitat extension that is required to effectively mitigate threats to Engelmann's quillwort at both the Severn and Gull River sites. Suggested completion date: 2008.

5.0 RECOVERY

5.1 Recovery Feasibility

The recovery of Engelmann's Quillwort is considered feasible based on four criteria as outlined in Environment Canada's National Policy on Recovery Feasibility:

a) There are individuals present that are capable of reproduction in order to maintain the current populations. It is felt that recovery efforts will not result in Engelmann's quillwort becoming a common species in central Ontario waterways. It seems most likely to have been a naturally rare disjunct species that has never been in large numbers in this region. Its status may represent a position near to or at the species' historic peak of abundance.

b) Sufficient suitable habitat is available for the species as long as it is maintained through threat mitigation. In addition, more habitat could be made available through restoration and management efforts. Habitat-related environmental enhancement would likely involve a diversity of community and agency partners and stakeholders to maintain and sustain Engelmann's quillwort in Canada. It is anticipated that such coordinated enhancement programs would include shoreline naturalization, reduction in bank erosion, reduction in the volume and toxicity of polluted stormwater (run-off), and removal/ prevention of on-going and/ or anticipated mechanical impacts.

c) Significant threats to the species can be mitigated through a variety of techniques outlined within this strategy.

d) A variety of recovery techniques are available, many of which have proven to be successful with other aquatic plants.

Accordingly, maintaining existing populations and their habitat in sustainable conditions constitutes a relatively small-scale undertaking.

5.2 Recovery Goal, Objectives, and Activities

5.2.1 Recovery Goal

To ensure the sustainability of Engelmann's quillwort populations on the Severn and Gull Rivers and any other populations that may be discovered. Habitat sustainability implies persistence within the species' known Canadian range with ecological integrity levels sufficiently high to support viable Engelmann's quillwort populations.

5.2.2 Recovery Objectives

Objectives intended to deliver the goal of the Engelmann's quillwort Recovery Strategy are listed below (Table 2) and are based on a five year timeline for completion (i.e. 2011). Actions, which address these objectives, are outlined in the following section (Table 3).

Table 2. Engelmann's quillwort recovery objectives

Number	Objective
1	Population size and distribution, population viability, and genetic affinity to other populations are more fully understood.
2	Ecological requirements sufficiently understood such that the identification of critical habitat could be refined.
3	All known subpopulations are monitored at varying levels of effort every three years.
4	Extent of each threat to Engelmann's quillwort is more fully understood and threat-specific mitigation techniques established.
5	Threats to Engelmann's quillwort and its habitat are minimized through Federal, Provincial, and municipal legislation, policy and regulation with a focus on critical habitat in 2006/2007.
6	Educational tools and programs for stewardship and conservation developed with landowners, land managers and stakeholders such that threats to Engelmann's quillwort and its habitat are minimized with a focus on critical habitat in 2006/2007
7	Restoration techniques and a protocol for implementation are developed and suitable, unoccupied habitats are identified for reintroduction should this measure be required.

5.2.3 Actions to be taken to address threats

Delivery of the Goals and Objectives of the Engelmann's quillwort Recovery Strategy require specific actions to be implemented directly or with partners (Table 3). These are summarized below. Given the uncertainty around some of the threats to this species and other knowledge gaps, many of the actions are based on gaining knowledge rather than specifically addressing threats. Wherever possible and appropriate, specific threats to Engelmann's quillwort have been addressed by these actions.

Table 3. Recovery actions to achieve Recovery Objectives

Objective Statement	Priority	Actions	Effects	Threats addressed
Population size and distribution, population viability, and genetic affinity to other populations are more fully understood.	L	Survey of potential habitats	Determination of population size to increase knowledge of distribution and abundance	Indirect. Threats better understood.
	L	Assessment of existing location records in North America	Understanding of continental population and relationship of Ontario's population to it	As above.
	H	Identify important populations	Provides priority sites for protection and monitoring	As above.
	H	Determine genetic markers and develop fingerprinting technique	Leads to development of fingerprinting methods; identifies appropriate origins for potential transplanting material; species identification	As above.
	H	Determine genetic affinity of Ontario's population to others	Provide evidence for native origin of Ontario's population	As above.
Ecological requirements sufficiently understood such that the identification of critical habitat could be refined.	H	Ecological study of habitat of Ontario populations	Identify habitat requirements; typical habitat can be used to identify other potential sites	Indirect. Threats better understood.
All known subpopulations are monitored at varying levels of effort every three years.	M	Develop monitoring plan	Efficiently direct monitoring efforts	Indirect. Threats better understood.

Objective Statement	Priority	Actions	Effects	Threats addressed
	H	Establish permanent monitoring transects for selected populations	Provides data to determine trends. Feeds into monitoring plan	As above.
	M	Conduct photographic surveys of selected populations	Mechanism for periodic review of large populations Feeds into monitoring plan.	As above.
	H	Prepare an annual report of all activities for the year and provide monitoring data to NHIC	Summarizes and tracks actions taken; provides background and direction for future work	As above.
Extent of each threat to Engelmann's quillwort is more fully understood and threat-specific mitigation techniques established.	H	Identify factors negatively impacting populations and implement mitigation measures where necessary.	Reduce negative impacts on populations	Mechanical damage, nutrient enrichment, herbicide application, water contaminants, erosion or sedimentation from land sources, collection.
	M	Research and investigate effective mitigation	Determine useful mitigation measures	As above.
Threats to Engelmann's quillwort and its habitat are minimized through Federal, Provincial, and municipal legislation, policy and regulation with a focus on critical habitat in 2006/2007.	H	Initiate process for listing under provincial Endangered Species Act	Provides protection for species on crown and private lands	Mechanical damage, nutrient enrichment, excessive water level fluctuations, herbicide application, water contaminants, erosion or sedimentation, plant collection
	H	Develop and apply provincial habitat mapping guidelines for Engelmann's quillwort to facilitate application of the Provincial Policy Statement in municipal land use planning processes	Protects populations from impacts of development on adjacent lands.	As above.
	M	Develop management guidelines for species where it exists on Trent Severn Waterway.	Provides protection for species on federal lands	As above.
	H	Use federal, provincial and municipal policy and legislation to provide protection through normal plan	Provides protection on federal, crown and private lands	As above.

Objective Statement	Priority	Actions	Effects	Threats addressed
		input and review on federal, crown, and private lands		
	H	Raise awareness of Parks Canada Trent Severn Waterway staff, MNR district and area staff and municipal planning staff involved in land use planning and management	Assure consideration of protection of Engelmann's quillwort during planning and management activities	Mechanical damage, nutrient enrichment, herbicide application, erosion or sedimentation.
Educational tools and programs for stewardship and conservation developed with landowners, land managers and stakeholders such that threats to Engelmann's quillwort and its habitat are minimizedwith a focus on critical habitat in 2006/2007.	H	Develop communication strategy	Establishes communication priorities and products for public, municipalities, resource management agencies	Mechanical damage, nutrient enrichment, herbicide application, water contaminants, introduced invasive species, erosion or sedimentation, plant collection
	H	Initiate adjacent landowner contact program	Promotes good stewardship practices by adjacent property owners; Prelude to listing under Endangered Species Act	As above.
Restoration techniques and a protocol for implementation are developed and suitable, unoccupied habitats are identified for reintroduction should this measure be required.	L	Determine if artificial propagation is possible	Necessary for future possible restoration efforts if this becomes necessary to sustain species in Canada.	Mitigation for loss due to threats.
	L	Identify sites suitable for restoration	Establishes restoration priorities	Erosion or sedimentation.
	L	Determine restoration techniques for Engelmann's quillwort habitat	Necessary for possible future restoration efforts	Mitigation for loss due to threats.

5.2.4 Actions Already Completed or Underway

a) Distribution and population surveys of both the Severn and Gull River populations were completed in 2000 and 2002 (Figure 4; Brunton 2001; Brunton 2003).

b) After designation of the Gull River site as a candidate Area of Natural and Scientific Interest (ANSI) in the Site District 5E-9 report (Brunton 1991), the highway adjacent to the main Gull River site was re-routed (in 1992) to avoid destruction of that population.

c) Process to regulate Engelmann's quillwort under Ontario's Endangered Species Act was initiated in 2004.

d) A trial underwater video monitoring project was completed at Big Chute in 2003 (Stevens 2003) and again in 2004.

e) The development of genetic markers was completed in 2004 (Coleman and Wilson pers. comm. 2004).

f) The development of genetic fingerprinting is underway at Trent University with final results expected in 2006.

g) The determination of genetic affinities with other North American populations was initiated at Trent University in 2004.

h) Ecological research and baseline integrity monitoring of Engelmann's quillwort sites with the Severn River population were initiated in 2004 (Heydon and Pidgen 2005). Ecological studies are continuing during 2005/2006 and 2006/2007.

i) Monitoring Plan for Engelmann's Quillwort (*Isoetes engelmannii*) in the Severn River Big Chute completed in early 2005 (Heydon, 2005).

j) Habitat review and collection of molecular research material from Engelmann's quillwort sites in the northeastern United States was undertaken in 2004.

5.3 Evaluation

The effectiveness of efforts to ensure the sustainability of Engelmann's quillwort populations and habitats on the Severn and Gull Rivers and any other populations that may be discovered can be measured (Table 4). These measures will differ in scope depending on the objective, as some objectives are more focused on information needs while others are more focused on threat mitigation. Performance measurements for each of the suggested Recovery Strategy objectives are listed below.

Table 4. Performance Measures

Objective Statement	Performance Measures
Population size and distribution, population viability, and genetic affinity to other populations are more fully understood.	• Accurate estimates of population size made • Accurate mapping of distribution made • Studies on genetic affinity to other populations conducted • Population and distribution trends created
Ecological requirements sufficiently understood such that the identification of critical habitat could be refined.	• Complete annual reports summarizing results of studies • Publish studies • Identification of critical habitat refined
All known subpopulations are monitored at varying levels of effort every three years.	• Monitoring reports produced every three years • Population and distribution trends created
Extent of each threat to Engelmann's quillwort is more fully understood and threat-specific mitigation techniques established.	• Ranked list of threats developed • Threat-specific mitigation techniques developed
Threats to Engelmann's quillwort and its habitat are minimized through Federal, Provincial, and municipal legislation, policy and regulation with a focus on critical habitat in 2006/2007.	• Engelmann's quillwort regulated under the provincial Endangered Species Act • Mitigation measures incorporated into Trent/Severn Waterway management plan, the TSW shoreline application and review process and any other guidance material • Appropriate policies and zoning provisions identified in Official plans and zoning by-laws; may depend on timing of updates/revisions • Threats to critical habitat minimized • Number and extent of populations remains stable
Educational tools and programs for stewardship and conservation developed with landowners, land managers and stakeholders such that threats to Engelmann's quillwort and its habitat are minimized with a focus on critical habitat in 2006/2007	• Communications plan completed • Stewardship programs in place with landowners, land managers and stakeholders • Number of populations remains stable • Threats to critical habitat minimized
Restoration techniques and a protocol for implementation are developed and suitable,	• Effectiveness of restoration determined • Feasibility of propagation determined

Objective Statement	Performance Measures
unoccupied habitats are identified for reintroduction should this measure be required.	• Restoration undertaken if required • Suitable, unoccupied habitats mapped

5.4 Effects on Other Species

The recovery actions outlined in this strategy will likely benefit other plant species found within these two rivers. Reducing mechanical damage in general will serve to reduce impacts on other plant species such as Eaton's quillwort. In addition, managing nutrient enrichment will allow the systems to remain representative of an oligotrophic environment that supports native vegetation. It is not anticipated that these recovery actions will have any negative impacts on other taxa.

6.0 ACTION PLANS RELATED TO THE RECOVERY STRATEGY

A Recovery Action Plan for Engelmann's quillwort will be produced by 2009.

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APPENDIX A: Members of the Engelmann's Quillwort Recovery Team and External Advisors

Recovery Team Members	External Advisors
Gary Allen (former member) Ministry of Natural Resources, Midhurst District	**W. Carl Taylor,** Milwaukee Public Museum
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Joan Chamberlain Trent-Severn Waterway, Parks Canada	**Paul Wilson,** Biology Department, Trent University
Angie Horner (former co-chair) Ministry of Natural Resources, Bancroft District	**Martha Coleman,** Biology Department, Trent University
Brian Hutchinson (former co - chair) Ontario Service Centre, Parks Canada	**Neil Emery** Biology Department, Trent University,
Paula Julio Ministry of Natural Resources, Bancroft District	**Keri Pidgen,** Biology Department, Trent University
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Marguerite A. Xenopoulos Biology Department, Trent University,	

APPENDIX B: Glossary

Corm – a bulb like enlargement of an underground stem.

Diploid – a plant cell with two sets of chromosomes.

Endemic – native to a particular area.

Megaspore – the larger kind of spore produced in plants that produce two different kinds of spores; it germinates into an egg-producing gametophyte.

Microspore – the smaller kind of spore produced in plants that produce two different sizes of spores; it germinates into a sperm-producing gametophyte.

Papilla – minute blunt or rounded projections on a surface.

Sporangium -- the chamber in which spores are produced.

Spore – the reproductive body in plants lacking true flowers and seeds.

Sporophyte – the stage in which spores are produced in plants that reproduce by alternation of generations.

Velum – a thin membranous covering or partition.

Vernalization – accelerating the growth of a plant by subjecting the seeds to low temperatures.

APPENDIX C: Jurisdiction responses

Acknowledgement of Receipt of the Proposed Recovery Strategy for Engelmann's Quillwort (June 2006) by the Ontario Ministry of Natural Resources on behalf of the Province of Ontario

This proposed Recovery Strategy for the Engelmann's Quillwort has been prepared in cooperation with the members of the Engelmann's Quillwort Recovery Team, co-lead by the Ontario Ministry of Natural Resources (OMNR) and Parks Canada Agency and with participation by Canadian Wildlife Service. It represents advice to the OMNR on the recovery goals, approaches and objectives that are recommended to protect and recover the species. It does not necessarily represent the views of all individual members of the recovery team, or the official positions of the organizations with which the individual committee members are associated. The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives. Implementation of the plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations

Received by:
Cameron Mack
Director, Fish and Wildlife Branch
Natural Resource Management Division
Ontario Ministry of Natural Resources

On behalf of the Province of Ontario

Date: August 10, 2006

Species at risk – act today so they have tomorrow