

Management Plan for the Prototype Quillwort (*Isoetes prototypus*) in Canada

Prototype Quillwort



2012

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PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed Special Concern species and are required to report on progress within five years.

The Minister of the Environment is the competent minister for the management of the Prototype Quillwort and has prepared this management plan, as per section 65 of SARA. It has been prepared in cooperation or consultation with the Governments of New Brunswick and Nova Scotia.

Success in the management of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment Canada or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this management plan for the benefit of the Prototype Quillwort and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

ACKNOWLEDGMENTS

The authors of this management plan are David Mazerolle, Sean Blaney (both from the Atlantic Canada Conservation Data Centre), and Jennifer Stewart (Environment Canada, Canadian Wildlife Service – Atlantic region). Many thanks to Ruth E. Newell and Marian Munro for providing their input into the development of this management plan.

EXECUTIVE SUMMARY

Prototype Quillwort is a fully submerged aquatic perennial of small, nutrient poor, usually cold, spring-fed lakes. The species was first described in 1988 from specimens collected at Holland Lake in York County, New Brunswick. Subsequent examination of herbarium specimens and significant survey efforts in potential habitat brought the total number of known occurrences to 20; 9 in Nova Scotia, 6 in New Brunswick and 5 in Maine.

Prototype Quillwort is endemic to the Acadian region, rare in all jurisdictions where it occurs, and is one of the rarest quillwort species. Over 70% of all known occurrences and well over 90% of its recorded global population is found in Canada. It was listed as Endangered under the New Brunswick *Endangered Species Act* in 1996, Vulnerable under the Nova Scotia *Endangered Species Act* in 2006, and as a Special Concern species under the federal *Species at Risk Act* in 2006.

Knowledge gaps exist with respect to the species distribution, population levels and threats. Therefore, threats identified here are based on what is known of other species in the genus and the magnitude of each threat is somewhat unclear. Identified threats are shoreline development, recreational activity, water pollution, long-term alteration of site hydrology and competition from exotic and/or more common native species.

This management plan outlines a number of recommended actions addressing monitoring and assessment, research, management, outreach and stewardship, and protection.

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1. COSEWIC* SPECIES ASSESSMENT INFORMATION

Date of Assessment: May 2005

Common Name (population): Prototype Quillwort

Scientific Name: *Isoetes prototypus*

COSEWIC Status: Special Concern

Reason for Designation: A regional endemic with almost all of its global population in Canada. The species is an aquatic perennial with very specific habitat requirements limiting its occurrence in Canada to about 12 small, unconnected lakes in Nova Scotia and New Brunswick. The species is found in nutrient-poor, cold, spring-fed lakes. Although several lakes have been shown to contain large numbers of plants, one half of the documented sites contain small populations. A wide range of potential limiting factors could impact the species, including changes in water quality, boating and shoreline development.

Canadian Occurrence: New Brunswick, Nova Scotia

COSEWIC Status History: Designated Special Concern in May 2005.

*COSEWIC: Committee on the Status of Endangered Wildlife in Canada

2. SPECIES STATUS INFORMATION

The Prototype Quillwort is ranked as globally imperiled/vulnerable (G2G3). Nationally, it is critically imperiled (N1) in the United States and imperiled/vulnerable (N2/N3) in Canada. It is considered a critically imperiled (S1) species in Maine and an imperiled (S2) species in both New Brunswick and Nova Scotia. It is listed as Endangered under the New Brunswick *Endangered Species Act*, Vulnerable under the Nova Scotia *Endangered Species Act* in 2006, and as a Special Concern species under the federal *Species at Risk Act* (SARA).

The total extent of occurrence for the species is approximately 105 000km². Over 70% of this area is within Canadian territory. The total area of occupancy of known Canadian occurrences is approximately 0.25 km².

3. SPECIES INFORMATION

3.1. Species Description

The following is adapted from the COSEWIC status report (Goltz and Bishop 2005).

Prototype Quillwort is perennial, submergent aquatic species of quillwort, an ancient order of spore-bearing vascular plants. The 10 to 25 (rarely to 75) leaves typically range from 4 to 12 cm in length, forming a dense clump from a bilaterally symmetrical two-lobed (rarely three-lobed) corm at the base. The leaves are very straight, rigid, quill-like and brittle and will often break when pressure is applied by pushing downward on their tips. The leaves abruptly taper from a swollen base and then gradually taper to a sharp tip.

Viewed from above, large plants have oval-shaped crowns measuring 8.5 x 20 cm. The leaves are mainly dark green except for a reddish brown or chestnut-coloured base. Spores (which are important in identification of quillworts) are borne in the swollen bases of the leaves. The female spores (called megaspores) are white, 425 to 575 μm (averaging 500) μm in diameter, and fairly smooth, with low meandering markings sometimes reduced to molded mounds, and very pronounced triradial (three-spoked) and equatorial ridges. The ornamentation continues to the equatorial ridge (the “girdle”). The microspores are pale brown, lenticular, 23 to 32 μm in length and covered with a complex network of spinulose fibres. Spores mature in summer.

Prototype Quillwort identification is most reliably based on megaspore morphology and chromosome numbers. Based on spore morphology, *I. prototypus* is most likely to be confused with *I. acadensis* and the “*I. hieroglyphica*” morphological variant of *I. lacustris*.

3.2. Population and Distribution

An endemic of northeastern North America, Prototype Quillwort is rare in all jurisdictions in which it occurs. The species was first discovered in New Brunswick in 1988 at Holland Lake in York County. Through the examination of herbarium specimens and subsequent survey efforts in potential habitat, a number of additional populations have since been discovered. The species is presently known from a total of twenty lakes worldwide, fifteen of which are in Canada (see Figure 1).

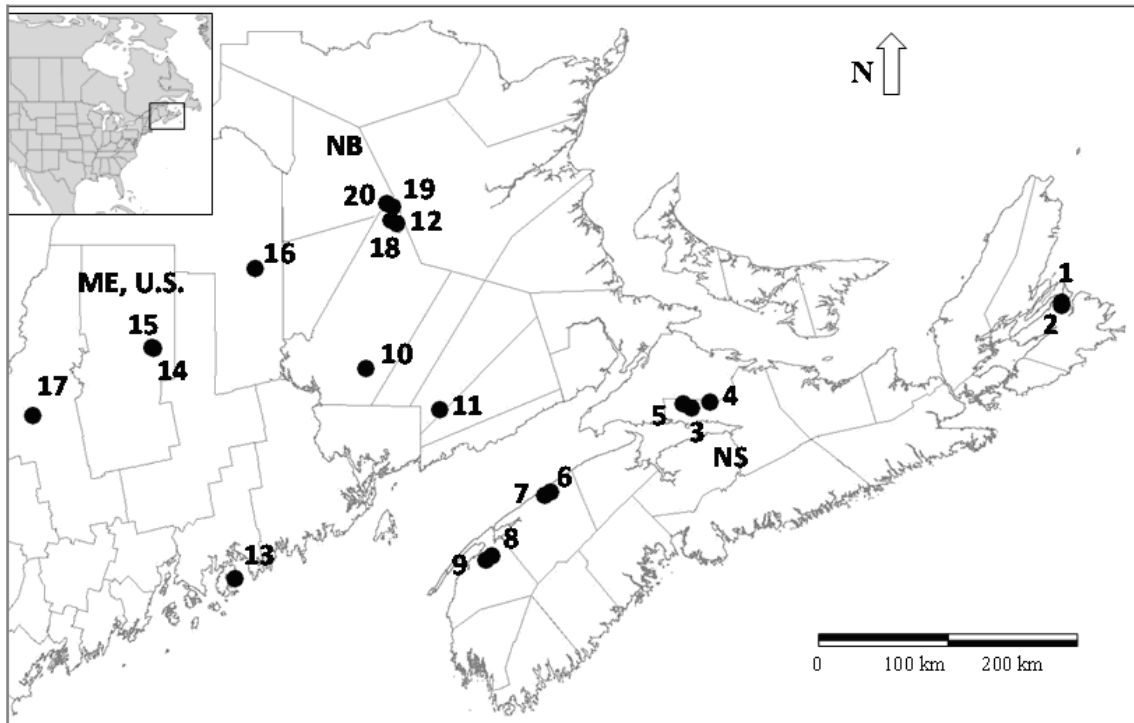


Figure 1. Global distribution of Prototype Quillwort (*Isoetes prototypus*). Population numbers correspond to those listed below.

- Nine lakes in Nova Scotia
 - Two lakes in Cape Breton County (populations 1 and 2)
 - Two lakes in Cumberland County (populations 3 and 5)
 - One lake in Colchester County (populations 4)
 - Two lakes in Annapolis County (populations 6 and 7)
 - Two lakes in Digby County (populations 8 and 9)
- Six lakes in New Brunswick
 - Five lakes in York County (populations 10, 12, 18, 19 and 20)
 - One lake in Queens County (population 11)
- Five Lakes in Maine
 - One lake in Hancock County (population 13)
 - Two lakes in Piscataquis County (populations 14 and 15)
 - One lake in Aroostook County (population 16)
 - One lake in Somerset County (population 17)

Note that in this document, the words “population” and “occurrence” are used interchangeably and that, based on NatureServe Element Occurrence delimitation standards, each lake where the species is presently known to exist is considered to contain one distinct population.

3.3. Needs of the Prototype Quillwort

3.3.1. Habitat and biological needs

Prototype Quillwort is a submerged aquatic of small, oligotrophic (nutrient poor), usually cold, spring-fed lakes. Elevation seems to be a significant habitat factor or correlate, with all known populations except for the two Cape Breton lakes at elevations over 200 m. The pH of known lakes ranges from 5.7 to 7.2 and water was clear to fairly clear at all but one lake in 2003-2004 (Goltz and Bishop 2005). Known lakes are typically quite shallow, ranging from 3.5 to 12.2 m in maximum depth. Prototype Quillwort occurs in 1.5m to 2.5m of water (minimum and maximum 0.4m and 4.0m), often near drop-offs. It most often occurs in soft, flocculent oozy sediment where a swimmer's foot or hand could easily sink 5 to 30+ cm. This sediment is usually found overlying a sandy, gravelly, or rocky bottom. According to Brunton (pers. comm. to Jim Goltz in 2004, cited in status report), the species is "quite strongly tied to ponds on small sand plain deposits and most probably in post-glacial outwash systems". No other relationship of this species with bedrock or surficial geology or soil type has been suggested. Common Pipewort (*Eriocaulon aquaticum*) is found near all known populations and other frequent associates include Lake Quillwort (*Isoetes lacustris*), Water Lobelia (*Lobelia dortmanna*) and Slender Water-Milfoil (*Myriophyllum tenellum*).

3.3.2. Ecological role

At the lakes in which it occurs, Prototype Quillwort can be among the most abundant vascular aquatics, comprising 20-50% of biomass within the mats of vegetation where it is present, and forming a large part of the windrows of flotsam that sometimes wash up on shores. Little else is known of its ecological role.

3.3.3. Limiting factors

It is unclear why Prototype Quillwort is not at least somewhat more widespread. Within the lakes in which it occurs it generally appears to be a reasonably successful competitor. There is likely no dispersal limitation since potential dispersal of Prototype Quillwort seems similar to other more common quillwort species that are nearly ubiquitous in suitable habitat throughout the same region. The apparently restricted habitat requirements (cold, clear, shallow oligotrophic lakes) potentially significantly limit the number of lakes in which the species could occur, but they do not fully explain its restricted distribution. Perhaps a very limited survival through the Wisconsinian glaciation has limited post-glacial recolonization. Within a lake, water depth and substrate type are obvious limiting factors as the species shows a limited optimum range of 1.5m to 2.5m depth and a strong affinity to flocculent ooze over sand or gravel.

Nothing is known of predation, disease or other additional potential limiting factors.

4. THREATS

Prototype Quillwort is an inconspicuous and difficult species to study and its ecology is not fully understood. Threats listed in this section are therefore based on what is known of other species in the genus. Because of knowledge gaps, it is difficult to effectively classify threats according to their severity. Level of concern for all noted threats is placed at moderate to high to indicate the importance of investigating the actual danger posed by each.

4.1. Threat Assessment

Table 1. Threat Assessment Table

Threat	Level of Concern ¹	Extent	Occurrence	Frequency	Severity ²	Causal Certainty ³
I. Habitat Loss or Degradation						
A. Shoreline development	Moderate to high	Widespread	Current; Anticipated	Continuous	Moderate-High	Medium
II. Disturbance or Harm						
B. Recreational activity (Boating, ATV (all-terrain vehicle) traffic, PWC (Personal watercraft) traffic, fishing, swimming)	Moderate to high	Widespread	Current; Anticipated	Seasonal	Moderate	Medium
III. Pollution						
C. Alteration of water quality/chemistry	Moderate to high	Widespread	Anticipated	One-time, seasonal, recurrent or continuous	Moderate	Medium
IV. Changes in Ecological Dynamics or Natural Processes						
D. Alteration of hydrological processes	Moderate to high	Widespread	Anticipated	One-time	Moderate-High	Medium
V. Exotic, Invasive, or Introduced Species/Genome						
E. Interspecific competition from exotic species	Moderate to high	Widespread	Anticipated	Continuous	Moderate	Medium

¹ Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all the information in the table.

² Severity: reflects the population-level effect (High: very large population-level effect, Moderate, Low, Unknown).

³ Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g. expert opinion; Low: the threat is assumed or plausible).

4.2. Description of Threats

Shoreline development

Cottage and shoreline development as well as encroachment upon lake borders by roadways and causeways were identified in the COSEWIC status report as being potential threats to populations. Of the 15 lakes where Prototype Quillwort is known to occur in Canada, at least seven have been altered to varying degrees by development. Significant shoreline deforestation and cottage development were documented at lakes near populations 4, 8, 6 and 7, while shoreline roadway and/or causeway construction was observed near populations 1, 2 and 4 (Goltz and Bishop 2005). Given the fact that lakeshore properties are generally in high demand both for cottage development and for recreational purposes, it is anticipated that the level of impact from this threat and the number of populations affected will increase in the future.

Recreational activity

Lakes adjacent to developed areas commonly experience higher levels of recreational activity such as boating, fishing, swimming, personal watercraft (PWC), and all-terrain vehicle (ATV) traffic. These activities could directly or indirectly impact populations. On-shore ATV traffic could lead to loss of shoreline vegetation, destabilization of banks and erosion which can contribute to increased runoff and siltation. Movements in the water column caused by boat and PWC traffic could uproot individuals. Although the species typically grows in relatively deep water, swimmers could also destroy or uproot individuals, as could boat anchors.

Alteration of water quality / chemistry

Lakes located in residential, recreational and agricultural areas are affected by nutrient enrichment through effluent and surface runoff. This represents a considerable threat to populations as accumulation of nutrients from anthropogenic sources can degrade habitat by increasing plant and algal growth to the point that their decay severely reduces available oxygen in the water body. Under such conditions floating and emergent competitor species often reduce light availability and outcompete submergent species and could thus cause quillwort population declines and local extinctions.

Erosion and larger runoff volumes can modify underwater substrates and increase water turbidity, thereby reducing light penetration in the water column. Diminished light availability could result in poorer quillwort performance and lower recruitment.

Lakeshore roadways and causeways can also result in toxic runoff containing road salt or petroleum products and their presence increases potential for major toxic spill events. Aquatic quillworts in general are regarded as being quite vulnerable to water pollution (Brunton and Britton 1993). Herbicides, either from direct application to the water body to control aquatic weeds or from surface runoff, could negatively impact individuals and populations. Any contamination leading to a significant change in water pH or salinity could also be detrimental.

Alteration of hydrological processes

Prototype Quillwort appears to have a very limited range of water depth in which it occurs (typically 1.5-2.5m). Lakes located near developed areas or roads could be affected by lasting alterations to lake water levels such as draining, damming or disturbance of tributaries or outflows or the filling or disturbance of shoreline wetlands, all of which could have a significant impact on populations. It is thought that any lasting alteration of hydrological processes could result in declines in population size and viability and even localized extinctions.

Interspecific competition from exotic species

Disturbances related to shoreline development and recreational activities typically lead to increases in the number and abundance of exotic species present, through habitat alteration that favours exotics and through deliberate or inadvertent introduction of exotic species. Exotic species can also spread into undisturbed lakes through natural dispersal. Several invasive aquatic exotic species could pose a threat to Prototype Quillwort populations. These include Yellow Floating-heart (*Nymphoides peltata*), Eurasian Water-milfoil (*Myriophyllum spicatum*), Curly Pondweed (*Potamogeton crispus*) and European Frog-bit (*Hydrocharis morsus-ranae*). The former three species are rare in Atlantic Canada while the fourth has been reported near the Quebec-New Brunswick border but remains unconfirmed in New Brunswick. Although they are considered highly invasive in other regions, it is uncertain to what extent these species could become established and proliferate in cool, oligotrophic lakes supporting Prototype Quillwort.

5. MANAGEMENT OBJECTIVES

The long term goal of this management plan is to ensure the persistence and viability of all known Canadian populations and to maintain or improve habitat quality for each population.

Management objectives for Prototype Quillwort are as follows:

1. Develop a more complete understanding of distribution and abundance.
2. Increase knowledge on the ecological requirements of Prototype Quillwort and the threats faced by the species.
3. Identify and evaluate threats to the species and its habitat for each occurrence and develop approaches to reduce, mitigate, or remove these threats.
4. Ensure protection of all populations and their habitat.

Prototype Quillwort is a globally rare regional endemic with over 70% of all known occurrences and well over 90% of its global population in Canada. Given its restricted range, specific habitat requirements, and the fact that some of the documented occurrences may contain relatively small populations (a few hundred or less), the prevention of declines in population sizes, areas of occupancy and habitat quality is a priority.

6. BROAD STRATEGIES AND ACTIONS TO MEET OBJECTIVES

6.1. Actions Already Completed or Currently Underway

To date, few if any direct management initiatives have been undertaken. All efforts concerning this species have until now been directed towards the surveying of potential habitat. In recent years, a significant number of lakes have been surveyed for the presence of Prototype Quillwort, both in Nova Scotia and New Brunswick.

D.M. Britton, 1989-2000

Surveyed a total of 43 lakes, one river and one creek in Nova Scotia and resulted in the discovery of two previously unknown populations (3 and 7) (Goltz and Bishop 2004).

J. Goltz and G. Bishop, 2003-2004

Surveyed all lakes where species is known to occur and 34 previously unsurveyed lakes: 19 in Nova Scotia and 15 in New Brunswick. These surveys led to the discovery of four previously unknown populations in Nova Scotia (2, 5, 8 and 9) and two previously unknown New Brunswick populations (11 and 12).

Atlantic Canada Conservation Data Centre, 2006

Surveyed 29 lakes in New Brunswick. No Prototype Quillwort populations were found during these surveys. It should be noted that lakes for this project were selected randomly and did not specifically target potential habitat for the species, although a number of selected lakes had qualities similar to those found at lakes with Prototype Quillwort present.

Canadian Forces Base (CFB) Gagetown

One of the known New Brunswick populations (11) is located on Department of National Defence land in the Gagetown Range and Training Area. As a result, CFB Gagetown has devoted resources to various initiatives concerning the protection of this species, including the mapping of lakes potentially containing Prototype Quillwort habitat and the surveying of a number of these sites (pers. comm. with D. McCullum, CFB Gagetown Biologist).

D. Sabine, 2002

Discovered population 12 during a verification of lake habitat.

Finally, in recent years, a number of lakes have also been verified in a more cursory and less methodical fashion by people knowledgeable about the species. Although only detailed surveys including underwater checks can rule out the presence of Prototype Quillwort at a lake, any information collected through these checks can be beneficial in identifying sites of interest and can lead to the discovery of unknown populations.

6.2. Knowledge Gaps

An incomplete understanding of the species' full distribution is perhaps the most important gap in knowledge. Several lines of evidence suggest that Prototype Quillwort is truly very uncommon and not simply overlooked. This is supported by the fact that a large number of surveys aimed at detecting the species on suitable lakes and rivers in the Maritimes have detected only ten additional populations (as described in section 6.1).

However, the species is highly cryptic and the number of unsurveyed Maritimes lakes with apparently similar habitat conditions to those in which Prototype Quillwort is known is still fairly high. Because the species does not appear to have a high level of immediate threats, its COSEWIC status is largely determined by the number of lakes in which it occurs, and the discovery of additional lakes could considerably change our understanding of the global conservation status of the species.

Other important knowledge gaps are:

Limited understanding of the actual numbers of individuals present. This is related to the difficulty in making comprehensive counts because of uncertainty with field identifications, underwater habitat with poor visibility, difficulty in recording precise complete information using reliable and easily reproduced methods, and the very time consuming nature of underwater surveys. Lack of good population numbers makes monitoring and detecting trends more difficult.

Very limited information on population fluctuation and trends. This is primarily because of a lack of repeated visits to known populations, but also because of the difficulties in counting populations noted above. This limits our ability to detect and understand any changes in numbers.

Limited understanding of the species' ecological requirements and limiting factors. The ecological requirements and natural limits to population and distribution are important to understanding any species' conservation status and our understanding of those at present is almost completely speculative.

Limited understanding of the level of threat posed by each of the human-induced threat types listed in this document. The impact and severity of particular threats to individual populations is poorly known. Better knowledge of threats would lead to improved management efforts, resource allocation and prioritization of field work.

6.3. Actions and Implementation Schedule

Table 2. The management actions required to meet the objectives and the implementation schedule, including level of priority and timeline

No.	Management Action ¹	Priority ²	Threats or concerns addressed	Timeline
1. Broad Strategy: Monitoring and Assessment				
1.1	Develop and implement a standardized population monitoring protocol, outlining appropriate methods and establishing routine population surveys to monitor changes in abundance, distribution and habitat characteristics.	High	Need for accurate population information	5 years
1.2	Develop and implement a habitat monitoring protocol addressing water quality, pH, dissolved oxygen, temperature, light penetration, sedimentation, condition of shoreline and riparian zones, disturbances and presence/abundance of invasive species.	Moderate	Shoreline development	5 years
2. Broad Strategy: Research				
2.1	Identify and prioritize lakes of potential occurrence based on current knowledge of broad habitat requirements and undertake systematic surveys at these lakes.	High	Shoreline development	5 years
2.2	Acquire accurate and detailed baseline data through systematic detailed surveys on all known Canadian populations.	High	Shoreline development	5 years
2.3	Complete a detailed study of the species' ecological requirements and tolerance to various disturbances and stressors.	High	All threats	5 years
2.4	Encourage and support research on Prototype Quillwort biology and ecology.	Moderate	Need for ecological information	Ongoing
3. Broad Strategy: Management				
3.1	Establish and implement an appropriate population ranking system using criteria such as population size, area of occupancy, habitat quality and presence of threats; implement ranking system in order to identify priority populations for active protection and intensive monitoring.	High	Shoreline development	5 years
3.2	Develop detailed baseline distribution maps for all populations.	High	Shoreline development	Completed, Continuous
3.3	Produce a standard best practice guide for the management of populations and habitat.	Low	Shoreline development, Recreation activities	5 years
4. Broad Strategy: Outreach and Stewardship				
4.1	Implement a landowner contact program for property owners along Prototype Quillwort lakes.	High	Shoreline development, Alteration of water quality/chemistry	2 years

No.	Management Action ¹	Priority ²	Threats or concerns addressed	Timeline
4.2	Encourage capacity building by providing educational opportunities for federal and provincial agencies and NGOs, including workshops and training in field identification.	Moderate	Does not apply	2 years
4.3	Organize public information and consultation sessions for targeted community and stakeholder groups such as cottage owner associations, recreational anglers, amateur naturalist groups, environmental NGOs, and school groups.	Moderate	Shoreline development, Recreation activities, Alteration of water quality/chemistry	5 years
4.4	Create and distribute/post educational tools such as a fact sheet, pamphlets, media releases, and signage.	Low	Shoreline development, Recreation activities, Alteration of water quality/chemistry, Interspecific competition	5 years
4.5	Educate waterfront landowners about natural riparian zones and encourage them to properly restore disturbed shorelines.	Moderate	Alteration of water quality/chemistry	5 years
4.6	Promote habitat conservation initiatives at all known locations that discourage alteration of hydrological processes such as damming of tributaries or outflows and draining.	High	Shoreline development, Alteration of hydrological processes	Ongoing
4.7	Support and encourage the installation of docks and similar structures away from areas where individuals are located.	High	Shoreline development, Recreation activities	Ongoing
5. Broad Strategy: Protection				
5.1	Support and encourage compliance with existing laws and policies.	High	Shoreline development. Recreation activities Alteration of water quality/chemistry, Alteration of hydrological processes	Ongoing

¹ Actions: Not all actions identified are applicable to all lakes

² Priority level:

- High – immediate action required
- Moderate – immediate action not required but necessary for successful long term management
- Low – immediate action not required but could be necessary or beneficial for successful long term management

6.4. Narrative to Support Actions

Broad Strategy 1: Monitoring and Assessment

Given the difficulties associated with assessing fully submerged aquatic plant populations, the development and implementation of a standardized population monitoring protocol should be a priority. The protocol produced through this initiative should outline appropriate techniques and offer recommendations pertaining to monitoring frequency.

Appropriate methods for assessing populations would involve canoe and snorkel-based work, where areas known to be occupied by the species would be surveyed intensely by snorkeling and the remaining areas would be surveyed through snorkeling dives at suitable habitat locations. Efforts to evaluate total population size and area of occupancy should be augmented with additional surveys using permanent monitoring transects or plots. Through this more systematic method, detailed counts of individuals would provide a more statistically sound measurement of population densities and declines in population size or area of occupancy.

It is recommended that monitoring also address habitat quality and include measurements of water quality, pH, dissolved oxygen, temperature, light penetration, sedimentation, condition of shoreline and riparian zones, disturbances and presence and abundance of invasive species.

Broad Strategy 2: Research

The many knowledge gaps in the species' distribution and ecology need to be addressed through research. Perhaps most importantly, resources should be devoted to the identification of all lakes of potential occurrence based on our current knowledge of broad habitat requirements, followed by the prioritizing and systematic survey of these lakes.

Also a high priority, systematic surveys should be carried out at all known populations with the objective of obtaining accurate plant counts and acquiring detailed and reliable baseline data on which to base a monitoring plan.

Lack of information on the ecology of the species and the factors limiting its distribution, including the impacts of invasive aquatic species, is an important obstacle. Detailed study of the species' ecological requirements and tolerance to various disturbances and stressors is therefore necessary. Such efforts would lead to a better understanding of suitable habitat and the significance of particular threats. This would in turn contribute to improving the effectiveness and efficiency of threat mitigation measures and conservation measures in general.

Any additional studies focusing on Prototype Quillwort biology and ecology should be encouraged and supported.

Broad Strategy 3: Management

At present, there is a significant lack of information needed to develop tools for effective management. In an effort to contribute to better informed decision-making and prioritization of active conservation measures, it would be useful to establish and implement an appropriate population ranking system using criteria such as population size, area of occupancy, habitat quality and presence of threats.

To support this initiative, detailed maps accurately identifying areas occupied by the species should be developed. To a certain extent, maps have already been produced through the preparation of the COSEWIC status report (Goltz and Bishop 2005) and species at risk mapping recently done by the Atlantic Canada Conservation Data Centre. These are however based on incomplete information, as many populations have never been thoroughly surveyed. Further research and monitoring is an important step towards the creation of such management tools.

In the longer term, as new information on the biology and ecology of the species becomes available, resources should be devoted to the production of a standard best practice guide for the management of populations and habitats.

Broad Strategy 4: Outreach and Stewardship

Outreach and communication are key in the conservation of Prototype Quillwort populations. Several potential threats to the species involve the behavior of landowners and other lake users and could be at least partially mitigated through education and advocacy for more appropriate land-use and stewardship practices. The implementation of contact programs targeting landowners with properties adjacent to lakes with Prototype Quillwort is an essential step towards raising awareness and discouraging potentially detrimental activities.

Prototype Quillwort is an obscure and difficult to identify species. It would therefore be beneficial to enhance expertise and provide for the transfer of knowledge necessary to identify the species. Providing educational opportunities to develop necessary skills through workshops and field outings would increase the capacity to carry out effective survey and monitoring efforts.

Public outreach efforts should be implemented near populations in order to foster a climate of cooperation with targeted community and stakeholder groups such as cottage owner associations, recreational anglers, amateur naturalist groups, environmental non-governmental organizations (NGOs), and school groups. Efforts could take the form of public information and consultation sessions serving as a venue for presentations and the voicing of any concerns by members of the public. As part of a cooperative approach to the planning and implementing of conservation measures, this process should aim to actively engage specific groups and the general public to take part in the conservation of Prototype Quillwort.

Educational tools such as fact sheets, pamphlets, media releases and signage would help increase awareness of the species and its threats to greater audiences in areas where the species occurs. Educational material should focus on threats such as exotic species and what can be done to help stop the spread of invasive aquatic species. Educational signage should be developed and installed near all known populations. Beyond indicating the nearby presence of a protected plant species, these signs should clearly identify potentially detrimental activities such as the use of motorized vehicles on shorelines and in riparian zones as well as the impacts of recreational activities and the use of anchors in areas where the species is found.

The importance of stewardship in the conservation and management of Prototype Quillwort populations must be recognized. As many populations are immediately adjacent to waterfront private lands, voluntary and cooperative conservation efforts are essential. Ultimately, the persistence of populations may largely depend on landowners, NGOs, municipalities and members of the public acting as responsible stewards who engage in the conservation of Prototype Quillwort. There is a great potential for the public to play an important role in the protection of this species.

Stewardship activities should be promoted that encourage:

- minimally destructive land use;
- the restoration of heavily disturbed shorelines and riparian zones;
- the conservation of undisturbed sections of shoreline and riparian zones; and
- the adequate disposal of waste-water.

To conserve habitat, conservation initiatives at all known locations should be promoted to discourage the alteration of hydrological processes such as damming of tributaries or outflows and draining. In addition, efforts should be made to construct docks and similar structures away from areas where individuals occur.

Broad Strategy 5: Protection

The Prototype Quillwort is listed as Vulnerable under the Nova Scotia *Endangered Species Act* and is listed as Endangered under the New Brunswick *Endangered Species Act*. Compliance promotion with these laws as well as laws and policies regulating shoreline development and pertaining to the protection of water quality, watercourses, wetlands and riparian buffer zones will protect both the Prototype Quillwort and its habitat. Therefore, compliance promotion programs consistent with existing laws and policies should be a priority.

7. MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the management objectives for the Prototype Quillwort. Success of the implementation of this management plan will be evaluated every five years against the following indicators:

- Improved understanding of the species distribution and abundance
- Improved information on the species ecological requirements
- Reduced, mitigated, or removed threats
- Secured populations and their habitats

8. REFERENCES

- Britton, D.M. and J.P. Goltz. 1991. *Isoetes prototypus*, a new diploid species from eastern Canada. *Canadian Journal of Botany* 69: 277-281.
- Brunton, D.F. and D.M. Britton. 1993. *Isoetes protypus* (Isoetaceae) in the United States. *Rhodora* 95: 122-128.
- Goltz, J.P. and G. Bishop. 2005. COSEWIC Status Report on Prototype Quillwort (*Isoetes prototypus*). Committee on the Status of Endangered Wildlife in Canada. 32 pp.

9. CONTACTS

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APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on 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 environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans 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 upon non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

This management plan will clearly benefit the environment by promoting the conservation of the Prototype Quillwort. The potential for the plan to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this plan will clearly benefit the environment and will not entail any significant adverse effects. The actions proposed in this report are believed to have no significant detrimental effect on any other species. The population and habitat conservation measures outlined in this management plan will also benefit other plant and animal species found in lake and lakeshore habitats. Moreover, outreach and communication efforts carried out may foster good habitat stewardship practices which could be beneficial to natural communities and the species they contain. The reader should refer to the following sections of the document in particular: Habitat and biological needs; Ecological role; Limiting factors; and Actions and implementation schedule.