PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy and Action Plan for Bolander's Quillwort (*Isoetes bolanderi*) in Canada

Bolander's Quillwort

September 2010

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/approach/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/).

Recovery Strategy and Action Plan for Bolander's Quillwort (*Isoetes bolanderi*) in Canada

September 2010

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RECOMMENDATION AND APPROVAL STATEMENT

Recovery Strategy and Action Plan for Bolander's Quillwort (*Isoetes bolanderi*) in Canada

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Date: 2010 - 09 - 15

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Date: 2010 - 10 - 19

DECLARATION

Under the *Accord for the Protection of Species at Risk* (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada. The *Species at Risk Act* (S.C. 2002, c.29) (SARA) requires that federal competent ministers prepare recovery strategies for listed Extirpated, Endangered and Threatened species.

The Minister of the Environment presents this document as the recovery strategy and action plan for Bolander's Quillwort as required under SARA. It has been prepared in cooperation with the jurisdictions responsible for the species, as described in the Preface. The Minister invites other jurisdictions and organizations that may be involved in recovering the species to use this recovery strategy as advice to guide their actions.

The goals, objectives and recovery approaches identified in the document are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives.

Success in the recovery of this species depends on the commitment and cooperation of constituencies that will be involved in implementing the actions identified in this recovery strategy and action plan. In the spirit of the *Accord for the Protection of Species at Risk*, all Canadians are invited to join in supporting and implementing this recovery strategy and action plan for the benefit of the species and of Canadian society as a whole. The Minister of the Environment will report on progress within five years.

ACKNOWLEDGMENTS

This recovery strategy and action plan was authored by members of the Bolander's Quillwort Advisory Group (listed alphabetically):

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The following people are thanked for their contributions to and / or reviews of drafts of the recovery strategy and action plan (listed alphabetically):

- Donald Britton – University of Guelph (Guelph, ON)
- Tara Carolin – Crown of the Continent Learning Center (Glacier National Park, MT)
- Paul Catling – Agriculture and Agri-Food Canada, Research Branch (Ottawa, ON)
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- Scott Mincemoyer – Montana Natural Heritage Program (Helena, MT)
- Shane Petry – Fisheries and Oceans Canada (Lethbridge, AB)

PREFACE

The Parks Canada Agency led the preparation of this joint recovery strategy and action plan for Bolander's Quillwort in Canada, in cooperation with Fisheries and Oceans Canada and the province of Alberta, and with advice from the Bolander's Quillwort Advisory Group (see Acknowledgements). Targeted consultations regarding the recovery strategy and action plan were conducted with affected stakeholders.

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

In accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals* (2004), a strategic environmental assessment (SEA) is conducted on all *Species at Risk Act* recovery strategies. 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 strategies may also inadvertently lead to environmental effects beyond their intended benefits. Environmental effects, including impacts to non-target species and the environment, were considered during recovery planning. The SEA is incorporated directly into the strategy and also summarized below.

This recovery strategy and action plan is expected to benefit the the water bodies in which Bolander's Quilwort is found, and other species existing within those water bodies. The greatest potential for negative environmental effects comes from prescribed burn and fire management activities, potentially including those aimed at recovery of Whitebark Pine, as described in the Effects on Other Species Section (Appendix A). However, coordination among fire and species at risk recovery programs is already underway as described in the Effects on the Environment and Other Species appendix. Some recovery activities, such as species re-establishment and restructuring of trails, may require project-level environmental assessment as required under the *Canadian Environmental Assessment Act*. Any activities found to require project-level environmental assessment will be assessed at that time pursuant to the provisions of the Act and mitigated to ensure that potential negative effects are minimized.

In summary, the overall impacts of the Bolander's Quillwort Recovery Strategy and Action Plan are positive for the aquatic environments in which this species is found. Potential negative effects are limited in scope and will be mitigated.

EVALUATION OF SOCIO-ECONOMIC COSTS AND BENEFITS

As per SARA section 49(1)(e), an action plan must be accompanied by an evaluation of socio-economic costs and benefits. In this section, the costs and benefits of implementing the recovery strategy and action plan for Bolander's Quillwort are described and estimated.

The entire known Canadian population of Bolander's Quillwort occurs within Waterton Lakes National Park, and is managed in accordance with Parks Canada's integrated mandate of protection, visitor experience and public education. The actions outlined in this document are expected to positively impact ecological integrity and enhance opportunities for appreciation of such special places and species by visitors and the general public. They seek a balanced approach to reducing or eliminating threats to Bolander's Quillwort populations and habitats, and include protection of individual plants and their habitat (e.g., restrictions to human activities within areas occupied by the species, combined with ongoing research and monitoring), potential species re-establishment (i.e., at Carthew Pond, if suitable) and increasing public awareness and stewardship (e.g., signage at Summit Lake, highlights in communication media). Raising awareness and stewardship through education and information dissemination is considered the primary tool to improve public understanding of issues surrounding the species' protection and recovery, and to gain compliance with protection measures.

The cost of implementing this recovery strategy and action plan (including services-in-kind) is estimated to be $70,000 to $100,000. Much of the Bolander's Quillwort recovery strategy and action plan can be executed within existing WLNP programs, but it is anticipated that co-operative undertakings with scientists will be mutually beneficial in addressing research needs, such as population recruitment studies, population trends, and the potential re-establishment of the species at Carthew Pond.

There are no social costs to including mitigation for Bolander's Quillwort within the Whitebark Pine prescribed burn plan. Potential economic costs are hypothetical. If, for example, the burn moves outside its boundary and water is required then the helicopter may need to bucket water from Cameron Lake instead of Summit Lake, and the increase travel distance would result in increased expenditures related to helicopter time and fuel.

The greatest potential for negative social or economic costs comes from restrictions to human activity in areas occupied by the species. These areas, especially the Summit Lake area, are popular destinations both for independent park visitors and for tour operators that have licenses to guide horseback (one business) and hiking (six businesses) trips into the park. As outlined in Section 1.5, physical impact along the shoreline of Summit Lake as a result of human activity is evident, and such impacts may lead to loss of habitat, damage to or destruction of plants and/or increased vulnerability of the aquatic system to a catastrophic event. For this reason, wading within areas occupied by the species is prohibited, human activity on the shoreline of areas occupied by the species is discouraged, and visitors and tour operators are encouraged to stay on the trails established and maintained by the park. Coordination with tour operators towards voluntary compliance is already underway, and negative economic implications are not expected.

It is expected that any social or economic costs that may occur due to restrictions on human activity near Bolander's Quillwort populations will be balanced by the social and economic benefits of ensuring that the species and its habitat remain unimpaired and available for appreciation by present and future generations. Ongoing trail reconstruction and maintenance are facilitating this balance of protection and public appreciation and enjoyment.

EXECUTIVE SUMMARY

Bolander's Quillwort is an endemic aquatic pteridophyte (fern ally) of mountainous landscapes between southern Alberta and northern Arizona - New Mexico, centered on the Intermountain Region of the United States. It occurs locally, growing in circumneutral, relatively sterile substrates, sometimes in considerable abundance, in higher elevation pools and streams. It typically occurs in shallow water (< 2 m) but plants can also withstand periodic emergence. High water quality and an absence of competing aquatic vegetation appear to be important to the survival of this and most other North American aquatic quillworts.

Three populations of Bolander's Quillwort are known in Canada, all from a small area of Waterton Lakes National Park in southern Alberta. Approximately 24.5 million plants occur here. A fourth population, noted once in the 1940's, is considered to have been extirpated. Bolander's Quillwort populations are threatened primarily by climate change, the vulnerability of the few populations to catastrophic natural and un-natural events (intense fire, toxic spill, sedimentation, etc.), and the unintended effects of backcountry recreational activity.

The recovery of Bolander's Quillwort is technically and biologically feasible. The population and distribution objectives for Bolander's Quillwort are to maintain the three self-sustaining populations and, if feasible, to restore the extirpated population. Specific actions and timelines aimed at addressing these objectives are identified. Accomplishing the objective outlined in this recovery strategy and action plan will include restoration achievements that are unique in North America. Reintroduction of historically extirpated quillwort populations has not been attempted on this continent.

Critical habitat is identified for Bolander's Quillwort as the three water bodies currently occupied by the species, plus areas of adjacent natural landscape approximately 10 metres beyond the high water mark. All of these critical habitat areas occur within Waterton Lakes National Park.

RECOVERY FEASIBILITY SUMMARY

The recovery of Bolander's Quillwort is considered feasible based on criteria outlined in the Government of Canada's (2009) Policy on the Feasibility of Recovery:

1. **Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.**
   There are sufficient numbers of individuals present that are capable of reproduction to maintain current populations. Although small in geographic extent, each population is estimated to support millions of plants representing the full spectrum of morphological appearance and condition known for the species.

2. **Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.**
   Sufficient suitable habitat is available for the species as long as it is not degraded. Achievement of habitat protection and maintenance is greatly facilitated by the location of all known Canadian populations within WLNP.

3. **The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.**
   Significant threats to the species can be mitigated through a variety of techniques outlined within this Strategy.

4. **Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.**
   Techniques to implement recovery approaches generally exist and appear to be effective, although some uncertainties are identified in the Additional Information Requirements about the Species section (2.5). Monitoring of recovery actions will allow for adaptive management.

Overall, it is expected that maintaining existing populations and their habitat in sustainable conditions within WLNP constitutes a relatively small-scale undertaking, with the notable exception of mitigating major threats/impacts due to climate change (as indicated in point 2 above).

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1. BACKGROUND

1.1 Species Assessment Information from COSEWIC

Assessment Summary – April 2006

Common Name
Bolander's Quillwort

Scientific Name
Isoetes bolanderi

Status
Threatened

Reason for Designation
A small aquatic plant currently known in Canada from only one small lake* in southwestern Alberta. The population has a large number of plants but is prone to being extirpated by a single, unpredictable event that could affect the entire population in a short period of time. Another population in a nearby lake has already disappeared over the past 50 years.

Occurrence
Alberta

Status History
Designated Special Concern in April 1995. Status re-examined and designated Threatened in April 2006. Last assessment based on an update status report.

* Since the 2006 COSEWIC assessment, additional populations have been located in two nearby ponds. See Section 2.1.1

1.2 Species Status Information

A Threatened aquatic plant species in Canada, Bolander's Quillwort reaches the northern edge of its range in southern Alberta. The Canadian population represents a very small proportion of the global abundance of the species.

According to NatureServe (2009), Bolander's Quillwort is ranked G4 (Apparently Secure) globally, and N1 (Critically Imperiled) in Canada and N4 (Apparently Secure) in the United States. Sub-nationally, the species is ranked S1 (Critically Imperiled) in Alberta, Canada. In the United States, sub-national ranks are S1 (Critically Imperiled) in Arizona, S2 (Imperiled) in Wyoming and S3 (Vulnerable) in Nevada. It is ranked S3 in Montana, largely based on 35 collections of the species at the University of Montana Herbarium from across the mountainous portions of the state (S. Mincemoyer, pers. comm.). It has not been ranked in a number of other states (California, Colorado, Idaho, New Mexico, Oregon, Utah and Washington) (Figure 1).

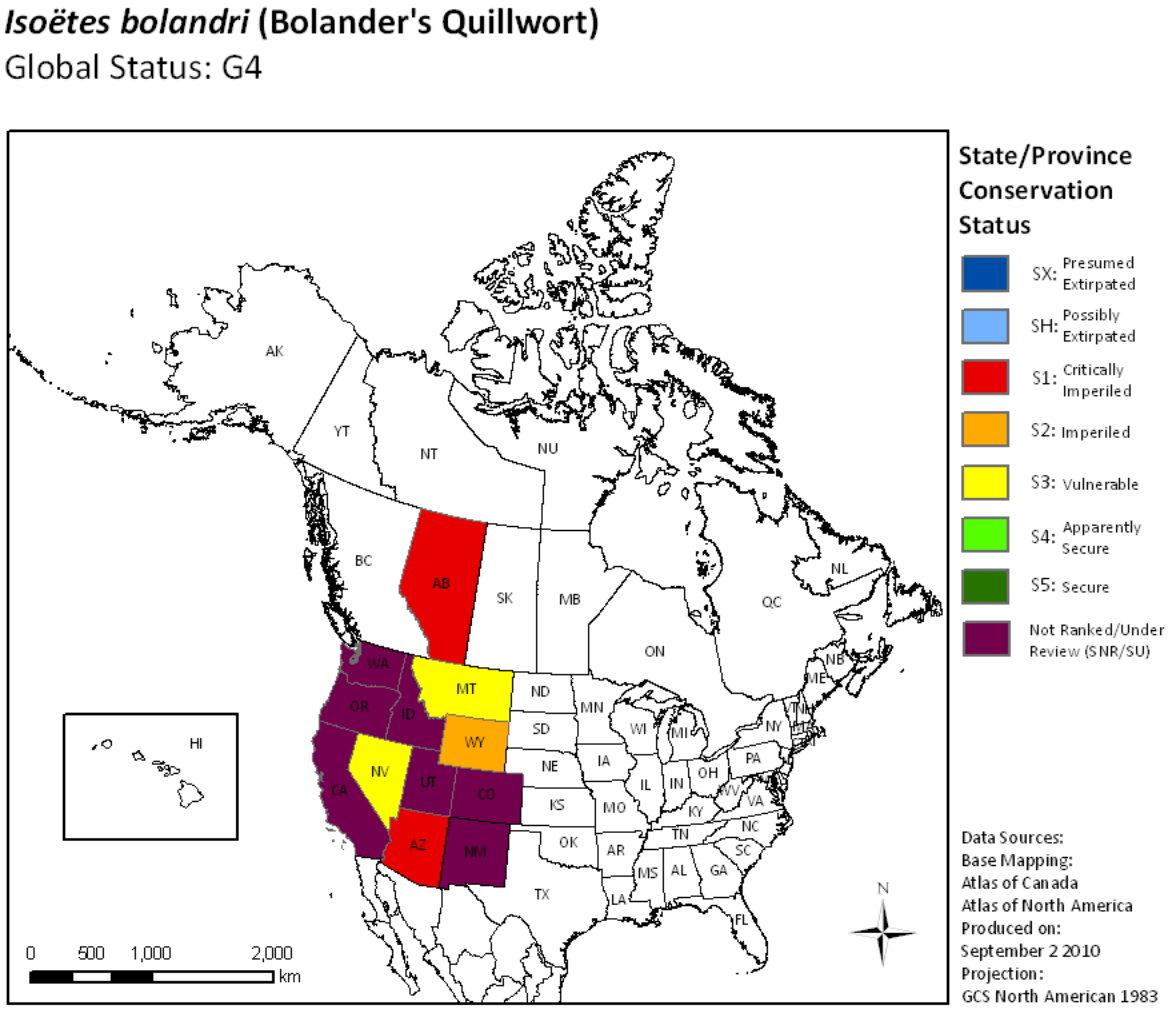

Figure 1. Sub-national status' of Bolander's Quillwort in North America (data provided by NatureServe).

1.3 Description of the Species and its Needs

1.3.1 Species Description

Bolander's Quillwort (*Isoetes bolanderi)* is an aquatic member of a large group of pteridophytes (fern allies), characterized by a cluster of soft-textured, straight leaves projecting to a length of 6 to 13 cm from a two-lobed corm. Corms are normally not visible and usually are buried in the lake bottom. Emergent plants have longer leaves than those of typical submerged individuals (Smith and Bradley 2008). Additional morphological information can be found in the COSEWIC (2006) status report for the species.

Bolander's Quillwort is one of several similar uncommon or rare aquatic / emergent pteridophytes of the western Cordilleran region of North America as described in COSEWIC (2006).

1.3.2 Species Needs

The availability of suitable habitat (permanent, shallow, high quality subalpine water bodies over circum-neutral substrates), dispersal mechanisms and an adequate growing season are likely the most significant needs for Bolander's Quillwort. These likely limit the abundance and range of the species in Canada. Bolander's Quillwort grows in open, unshaded, lightly- or unglaciated upper subalpine ponds and small lakes in areas with cool, relatively wet climates with a short growing season (<60 days). Bolander's Quillwort plants occupy most of the bottom of Summit Lake, being found at depths from 0 to at least 1.5 m (the maximum lake depth is ca. 2 m). They dominate the bottoms of the shallower Boundary Creek ponds as well (Smith and Bradley 2008). All known Canadian sites occur within the Upper Subalpine Ecoregion (Achuff et al. 2002), with the sites between 1950 m (Summit Lake) and 2100 m (upper Boundary Creek pond). The historical record from the Carthew Lakes area is at approximately 2200 m.

Water quality at Bolander's Quillwort sites is high, with clear, oligotrophic, water supporting little associated vegetation within *Isoetes* stands. An aquatic moss observed in some sampling quadrants at Summit Lake were tentatively identified as *Drepanacladus aduncus*, and emergent sedges (*Carex aquatilis* and *C. utriculata*) occur in patches at the water's edge in Summit Lake (Smith and Bradley 2008). The water at Summit Lake is circumneutral (pH 7.3) and the least basic of the potential Bolander's Quillwort lakes examined in WLNP; the other lakes range from pH 7.4 to 9.1 (Anderson and Donald 1976a & b). It is expected that the growing substrate around *Isoetes* roots (a 3 to 14 cm layer of silt and silty-sand on top of coarser sand) is more acidic, likely less than pH 7.3. The pH of substrate is believed to be a significant factor limiting quillwort populations (Taylor et al. 1993, COSEWIC 2006). None of the Bolander's Quillwort water bodies support fish populations.

Small, permanent subalpine waterbodies in circumneutral to slightly acidic substrates that constitute suitable Bolander's Quillwort habitat are uncommon in the predominantly calcareous mountain landscape of southern Alberta and southeastern British Columbia (Smith and Bradley 2003, 2008). In addition, the length of growing season in southern Alberta may be at the tolerance limit for this species, which may preclude its occupation of otherwise suitable habitat northward. Water levels, and fluctuations in water level, are essential features for many species of *Isoetes*. It is not known what a typical seasonal fluctuation is for waterbodies containing Bolander's Quillwort, and whether there is any evidence for past higher or lower levels in these waterbodies.

The dispersal of reproductively viable material (spores, entire plants, etc.) between widely separated and often geographically isolated areas of suitable habitat likely constitutes a significant limitation to Bolander's Quillwort's natural colonization beyond the current range, and to natural or human-assisted restoration of populations within the range. The long distance dispersal mechanisms of aquatic quillworts are poorly known (Taylor et al, 1993, Brunton 2001). The requirements for both megaspores and microspores to be present for sexual reproduction for entire plants to remain moist further reduces the likelihood of successful long distance dispersal events.

Large wading animals such as Moose could accidentally carry the somewhat adhesive *Isoetes* spores and/or mixed collections of sediment and spores during travel or feeding activity. Dispersal by waterfowl such as Barrow's Goldeneye (*Bucephala islandica*) which have been seen on Summit Lake, could also occur through the transport of whole plants or, at least, entire sporophylls in their gut or inadvertently caught amongst feathers or on the birds' legs. Wind storms (tornadoes, wind-shears or hurricanes) are considered a likely transporter of some emergent and shallow-water *Isoetes* species in the southeastern United States (Brunton 2001), but this is unlikely in the deeper water, subalpine habitat of Bolander's Quillwort in Canada and the United States.

Despite the apparent low probability of success of any single event, effective long-distance dispersal of Bolander's Quillwort can be inferred from its geographic distribution pattern, which contains some large gaps. This process is not well understood and the agents and frequency of typical dispersal events are not known. The apparent inability of three substantial populations to support natural recolonization of the Carthew Pond occurrence suggests that even local natural dispersal is difficult. Given this, it seems highly unlikely that the *rescue effect* - re-establishment of extirpated populations in Canada by naturally dispersing Bolander's Quillwort plants from US populations – would occur.

1.4 Threat Identification

Threat Classification

Table 1. Classification of threats to Bolander's Quillwort in Canada.

1 Climate change		**Threat Information**	
Threat Category	Climate and natural disasters	**Extent**	Widespread
General Threat	Climate warming and drying	**Occurrence**[1]	Imminent
		Frequency[2]	Continuous
Specific Threat	Exposure of shoreline and pond bottom area, increased fire frequency, higher water temperatures	**Causal Certainty**[3]	Medium
		Severity[4]	Unknown
Stress	Reduced population size & viability	**Level of Concern**[5]	High
2 Vulnerability to water quality degradation		**Threat Information**	
Threat Category	Habitat loss or degradation	**Extent**	Localized
General Threat	Water quality reduction	**Occurrence**	Anticipated
		Frequency	Seasonal (ice-free period)
Specific Threat	Pollution	**Causal Certainty**	Medium
		Severity	Moderate to High

Stress	Reduced population size and viability	**Level of Concern**	High
3 Human impact on shoreline		**Threat Information**	
Threat Category	Habitat loss or degradation	**Extent**	Localized
General Threat	Physical damage to shoreline, banks	**Occurrence**	Current
		Frequency	Seasonal (ice-free period)
Specific Threat	Erosion, sedimentation	**Causal Certainty**	Medium
		Severity	Low
Stress	Reduced population size and viability	**Level of Concern**	Medium
4 Natural predation		**Threat Information**	
Threat Category	Natural processes or activities	**Extent**	Localized
General Threat	Natural predation	**Occurrence**	Current
		Frequency	Seasonal (ice-free period)
Specific Threat	Loss of individuals	**Causal Certainty**	Low
		Severity	Low
Stress	Reduced population size	**Level of Concern**	Low

[1]*Occurrence* - Threat is historic (contributed to decline but no longer affecting the species), current (affecting the species now), imminent (is expected to affect the species very soon), anticipated (may affect the species in the future), or unknown.
[2]*Frequency* - Threat is a one-time occurrence, seasonal (only occurs at certain times of the year, continuous (on-going), recurrent (reoccurs from time to time but not on an annual or seasonal basis), or unknown.
[3]*Causal certainty* - Best available knowledge about the threat and its impact on population viability is high (evidence causally links the threat to stresses on population viability), medium (correlation between the threat and population viability, expert opinion, etc), or low (assumed or plausible threat only).
[4]*Severity* – Threat is high (very large population-level effect), moderate, low, or unknown.
[5]*Level of concern* –Managing the threat is an overall high, medium, or low concern for recovery of the species, taking into account all of the above factors.

Description of Threats

Climate change:

Model predictions with the 2X CO_2 scenario (Bradley et al. 2004) indicate particularly intense summer warming at higher elevations and at latitudes between 35^o and 55^o N. If an increasingly unstable global climate results in local WLNP weather conditions that include increased ambient temperatures in the near future, the likely result is higher incidence of drought, increased fire frequency, extreme weather events (such as intense storms with higher slope erosion potential), higher water temperatures and a longer ice-free period for the Bolander's Quillwort populations. This would likely lead to shrinkage in pond water volumes, increased potential vascular and non-vascular plant competition in the ponds, and an overall reduction of Bolander's Quillwort population viability due to plants being exposed to temperatures beyond the normal range of

variability. Climate change impacts likely will also result in a longer growing season in the Cordilleran region. This may increase the number of potentially suitable sites for new populations over the long term.

A decline in overall stream flow has been detected in rivers and streams in the WLNP area of the southern Rocky Mountains over the last century. The downward trend is accelerating in the WLNP area, likely related to climate change (Rood et al 2005). There is also potential for additional sedimentation due to increased fire frequency and intensity as a result of warmer, drier conditions. Recent weather data indicate that higher elevation landscapes in the WLNP area (e.g. Akamina Pass) are warming at a faster rate than lower elevations (i.e., more thawing degree days; Parks Canada 2008b).

Vulnerability to water quality degradation:

The exceptionally concentrated nature of the population of this ecologically fragile species could render serious consequences from even a single pollution event on a single population. In particular, a pollution event on the largest (Summit Lake) population, which is more exposed to human activity than either of the other populations, would likely have dramatically negative population-level effects. Inappropriate disposal of human waste and/or littering of degradable garbage could constitute a local problem for near-shore quillwort plants close to the Carthew-Alderson recreational trail. Of particular concern, however, would be the accidental or malicious spillage of even a small volume of a toxin (such as a herbicide or petroleum fuel), into this nutrient-poor aquatic habitat.

No North American research exists regarding the nutrient tolerances of *Isoetes* species. However, European studies of aquatic *Isoetes* species summarized in Voge (1997) suggest they and other Isoetid species are amongst the most sensitive of aquatic plants to such stresses.

Human shoreline impact:

Physical impact along the shoreline of Summit Lake from the resting or meal-time activities of passing recreational hikers is evident near some areas occupied by Bolander's Quillwort. Human activities at Summit Lake include wading or bathing in the shallow water within the quillwort population, and accompanying dogs swimming in the water. Negative impacts from this include trampling of shoreline (bank) vegetation at the pond edges and damage to aquatic vegetation. Shore and bank erosion and degradation from physical disturbance likely leads to loss of habitat, physical impact on plants and increased vulnerability of the aquatic system to a catastrophic event.

Natural predation and physical damage on plants:

Moose regularly enter the shallow water of Bolander's Quillwort habitat in Summit Lake and have been observed to trample, uproot and browse upon dense concentrations of quillwort plants (COSEWIC 2006, Smith and Bradley 2008). Large quantities of dislodged, floating plants are slurped up from the surface of the pond and consumed by feeding moose (Smith and Bradley 2008, P. Achuff, pers. comm.) and white-tailed deer (*Odocoileus virginianus*). Such impact has

presumably been long-standing in this area. There is little evidence (tracks or observations) of ungulates visiting the Boundary Creek Ponds. Interestingly, these plants are almost twice the length of those at Summit Lake (C. Smith and P. Achuff, pers obs), which may be evidence of herbivory at the latter location. No examples of herbivores or other predators eliminating *Isoetes* populations have been documented. However, it is conceivable that abnormally high ungulate populations in response to unusual or unnatural landscape events (exceptionally frequent fire, hunting activity influences from beyond WLNP, etc.) might result in local degradation of one or more of the known Bolander's Quillwort populations.

2. RECOVERY

2.1 Population and Distribution

2.1.1 Population and Distribution Context

Bolander's Quillwort is endemic to the Cordilleran region of western North America in the United States and adjacent southern Canada (Figure 2). It is still known from throughout its historical range, although it is considered to be common only in California and Utah (Cronquist et al 1972, USDA 2008). The species is rarely common over a large area, though it is often locally abundant in these scattered occurrences.

Figure 2. Distribution of Bolander's Quillwort in North America (from COSEWIC 2006). The arrow points to Canadian locations.

The entire known Canadian range of Bolander's Quillwort is within the southern portion of WLNP (Figure 3). The first record was established in 1946 when National Museum of Canada botanists A. E. Porsild and A. J. Breitung collected *Isoetes* plants from a *"pond northeast of the Carthew Lakes*" (Brunton 1995), hereafter referred to as Carthew Pond. A second, larger population was discovered at nearby Summit Lake by Breitung in 1953 (Breitung 1957). Many observers have subsequently documented the latter population but no further observations have been made of the Carthew Pond population despite repeated surveys there.

Field investigations of 30 potential Bolander's Quillwort sites within WLNP between 2000 and 2006 by C. Smith, C. Bradley and P. Achuff (Figure 3) resulted in the discovery of two additional populations in close proximity to one another in the upper Boundary Creek watershed (Smith et al., 2004, Smith and Bradley 2008). Although only 130 m apart, the Boundary Creek populations are not connected by surface water flow, are situated at different elevations, and are separated by unsuitable forest habitat. The potential for reproductive exchange between these populations on a regular basis appears to be very limited. Accordingly, it is consistent with NatureServe/ COSEWIC definitions to consider these to represent two separate populations.

The quillwort population in Summit Lake was surveyed in 2002, 2004 and 2006 (Smith and Bradley 2008). The 2002 population was estimated to be 11,940,000 (± 267,293) plants. While no detailed count was made of the two Boundary Creek populations, the cover of quillworts within those populations was measured, and calculations can be made from the Summit Lake findings to estimate the number of plants occurring in the two Boundary Creek populations (Table 2). The total of these three populations within 2.74 ha of suitable habitat, is approximately 24,500,000 plants. Comparison of 2002, 2004 and 2006 data from Summit Lake suggests that the Bolander's Quillwort population at that site is stable, at least over the short term (Smith and Bradley 2008).

Aquatic quillwort populations are long lived and have been recorded at particular sites for well over a century (Britton and Brunton 1989). However, above ground, visible plant numbers can vary within 10% above or below the long-term (20 year) mean population size depending on water levels, local physical activities etc. (D. Brunton pers. obs.).

2.1.2 Population and Distribution Objectives

The population and distribution objectives for Bolander's Quillwort are to maintain the three self-sustaining populations (Summit Lake, Upper and Lower Boundary Creek Ponds) and, if feasible, to restore the extirpated population (Carthew Pond).

'Self-sustaining' is defined by the persistence populations in habitats with ecological integrity levels sufficiently high to support reproducing Bolander's Quillwort plants without human intervention. 'Restoration' means the re-establishment of populations in historically known but presently unoccupied habitat, where the habitat is still suitable.

Bolander's Quillwort is intrinsically rare in Canada, and is a small northern extension of

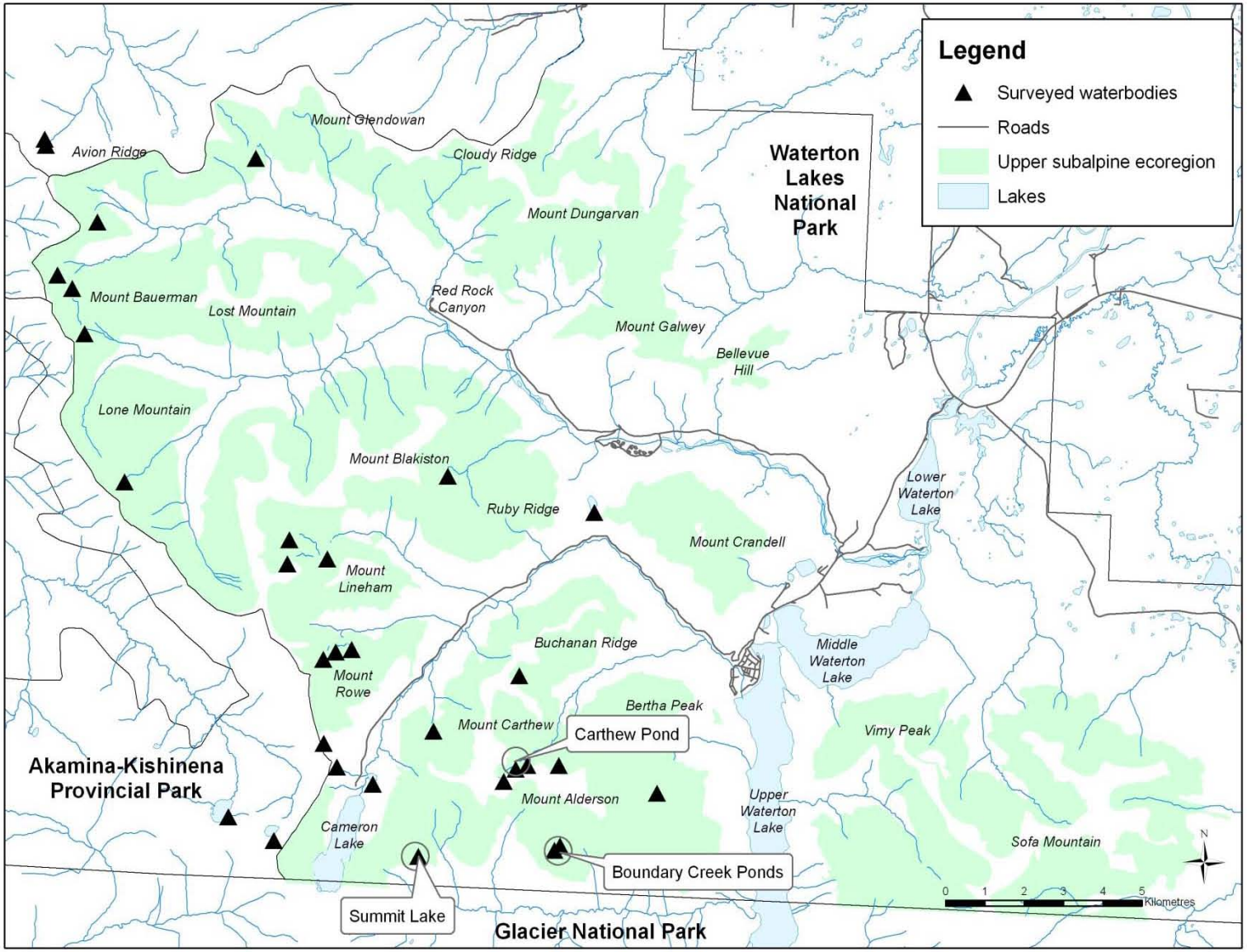

Figure 3. Locations of historical (Carthew Pond) and current (Summit Lake and Boundary Creek Ponds) Bolander's Quillwort populations (circles) in Waterton Lakes National Park, compared with survey effort (triangles) (adapted from Smith and Bradley 2008).

Table 2. Population estimates for Bolander's Quillwort in Waterton Lakes National Park (adapted from Smith and Bradley 2008).

Population	Mean cover of quillworts / quadrat	Density (number of quillworts / ha)	Area of suitable quillwort habitat (ha)	Estimated total number of quillwort plants
Summit Lake	24.5%	5,882,350 *(calculated from sampling along transects)*	2.03	12,000,000
Upper Boundary Creek Pond	70.4% (*2.92x greater than Summit Lake cover*)	16,882,344 *(calculated based on cover-density ratio of Summit Lake data)*	0.44	7,500,000
Lower Boundary Creek Pond	76.9% (*3.17x greater than Summit Lake cover*)	18,470,579 *(calculated based on cover-density ratio of Summit Lake data)*	0.27	5,000,000
				Total estimate: 24,500,000

populations in the US. It is therefore recognized that the population and distribution objectives and approaches to recovery outlined in this document may never result in down- or de-listing.

2.2 Approaches to Recovery

Considerable monitoring has been conducted in recent years on the distribution and population dynamics of Bolander's Quillwort in WLNP (Smith and Bradley 2003, Smith et al. 2004, Smith and Bradley 2008). Preliminary work has been conducted on population trends in Bolander's Quillwort in WLNP (the first such population studies conducted on any *Isoetes* population in North America).

Some restructuring of the section of the Carthew-Alderson Trail adjacent to Summit Lake designed to direct lakeshore users away from ecologically more sensitive areas was undertaken in 2007 (C. Smith, pers. comm.). This involved the strategic placement of rock and large logs as access barriers. The burn plan for Whitebark Pine restoration in the Summit Lake area recognizes the protection needs of Bolander's Quillwort. Only the outlet of the lake will be used if water supplies are required during the burn operation (Parks Canada 2008a).

The recovery strategy and action plan for Bolander's Quillwort in Canada will be implemented as follows:

Table 3. Recovery actions, outcomes and scheduling to achieve population and distribution objectives for Bolander's Quillwort in Canada.

Priority	Threats addressed	Broad strategy to address threat	Recovery Actions	Outcomes and Scheduling
Mitigate threats to populations through protection mechanisms and communication and outreach initiatives, to maintain population levels within the natural range of variability				
High	Climate change, vulnerability to water degradation	Research	Investigate environmental tolerance (e.g., water chemistry, temperature, nutrients)	Understanding of ecological requirements achieved (2013)
Medium	Climate change	Research	Investigate potential for suitable habitat beyond current range	Long-term potential for mitigation of habitat displacement by climate change understood (2015)
High	Human impact on shoreline, vulnerability to water degradation	Legal protection & enforcement	Prohibit wading by people and domestic animals (e.g., dogs, horses) and access by machinery or vehicles within areas occupied by Quillwort	Prohibition measures in place (2011)
High	Human impact on shoreline, vulnerability to water degradation	Legal protection & enforcement, monitoring	Restructure trail activity and monitor trail condition within and near critical habitat at Summit Lake, and monitor effectiveness	Restructuring and monitoring program in place (2012)
High	Human impact on shoreline, vulnerability to water degradation	Legal protection & enforcement, communication & outreach	Ensure protective measures are in other park documents (e.g., Prescribed Burn plans, wilderness zoning, environmental impact processes, trail planning)	Protective measures are in relevant park documents (2015)
High	All	Communication & outreach	Write communication strategy (consider signage at Summit lake to encourage appropriate behaviour & stewardship; highlights in communication media)	Communication strategy completed and implemented (2012)
High	Human impact on shoreline, vulnerability to water degradation, natural predation	Monitoring	Monitor human activities & natural predation using remote cameras (pre and post implementation of mitigations)	Baseline trends understood (2011). Evidence that mitigations have been effective (2015)
Medium-High	Human impact on shoreline	Monitoring	Monitor disturbance using plots (biennially)	Decreasing trend in disturbance of plots (2015)
Low	Climate change,	Research	Investigate feasibility	Additional

Priority	Threats addressed	Broad strategy to address threat	Recovery Actions	Outcomes and Scheduling
	human impact on shoreline, vulnerability to water degradation		of spore-banking or other *ex situ* conservation measures	knowledge on propagation potential gained (2015)
Determine feasibility of re-establishing the historically-known Carthew Pond population and implement if appropriate				
High	All	Research	Collect & analyze sediment cores from Summit Lake and Carthew Pond to investigate historical presence	Spore sampling technique confirmed to be effective; historic presence of Bolander's Quillwort at Carthew Pond potentially confirmed (2011).
Moderate	All	Research	Where feasible and appropriate, collect naturally dislodged plants (ungulate action, etc.) for cultivation and / or translocation	Confirm potential and ease of transplantation from existing populations; provide ex-situ population as a secure source of reintroduction material
High if historically present, medium otherwise	All	Research	Determine why the population was historically extirpated and if the Carthew Pond is suitable habitat for re-establishment of Quillwort	Potential for successful restoration of extirpated historic population clarified (2013)
Low	All	Research	Determine genetic relationships among populations in WLNP and Glacier NP	Identification of most genetically preferred long-distance sources for restoration; improved understanding of historic patterns of dispersal range-wide, (2014)
High if historically present, medium otherwise	All	Landscape restoration	If Carthew Pond is suitable, proceed with re-establishment of population	Restoration program implemented (2014)
Medium	All	Research	If re-establishment is undertaken, publish results in peer-reviewed publication	Publication accepted; scientific awareness of restoration potential documented (2015)
Monitor populations as per established protocol to establish firm understanding of population trends and short-term fluctuations				

Priority	Threats addressed	Broad strategy to address threat	Recovery Actions	Outcomes and Scheduling
High	All	Population monitoring; research	Establish monitoring protocol including thresholds for changing protocol to reflect changes in habitat conditions (including pH of all ponds, natural water level fluctuations, associated vascular and non-vascular flora) and available management techniques	Flexible monitoring protocols available for application as needs be (2011)
High	All	Population monitoring; research	Conduct monitoring of known populations to determine natural range of variability	Better understanding of population performance achieved (2014)
Conduct surveys of suitable habitat to detect additional populations				
Low	All	Population monitoring; research	Conduct surveys in suitable habitat for unknown populations within the Upper Subalpine Region within the Oldman River Basin in cooperation with partners and stakeholders	Entire potential Canadian range investigated and full contemporary population distribution documented (2015)
Low	All	Population monitoring; research	Encourage searches of suitable habitat for undocumented populations in Glacier National Park	Improved regional knowledge and enhanced potential resources for conservation management and restoration.

The elements identified in the above table address the threats and knowledge gaps related to the long-term survival of Bolander's Quillwort populations in Canada. Maintenance of the known, self-sustaining populations within natural, high-quality habitat will be sufficient to secure the long term protection of the species against most threats. The threat of climate change appears to be imminent and potentially severe, however, and as our understanding of its effect on this species improve, a re-evaluation of recovery actions may be necessary.

2.3 Critical Habitat Identification

Critical habitat is defined in section 2(1) of the *Species at Risk Act* (SARA) (2002) as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". For Bolander's Quillwort in Canada, the critical habitat that is necessary for the survival and recovery of the species is identified within this recovery strategy and action plan.

Information used to identify critical habitat locations and attributes

The habitat supporting all existing Bolander's Quillwort populations is considered to be necessary for the survival and recovery of the species, and therefore satisfies the definition of critical habitat under SARA. This supporting habitat includes the three water bodies currently occupied by the species, plus areas of adjacent natural landscape approximately 10 metres beyond the high water mark of these water bodies that may also be occupied by the species.

Critical habitat identification

Summit Lake population:

Summit Lake, as identified on the National Topographic Series (NTS) map 82 G/1, is located about 10 km southwest of the Waterton Park townsite, east of Cameron Lake, within the South East ¼, Section 2, Township 1, Range 1, West of the 5th Meridian. Critical habitat for the Summit Lake population of Bolander's Quillwort is defined as the body of water and the adjacent natural landscape approximately 10 m beyond the high water mark within the area illustrated in Figure 4 as critical habitat parcel 243_1.

Upper Boundary Creek Pond population:

The unnamed pond, referred to in this document as the Upper Boundary Creek Pond, is located about 6 km south-southwest of the Waterton Park townsite, west of Upper Waterton Lake, within Section 5, Township 1, Range 30, West of the 4th Meridian. Critical habitat for the Upper Boundary Creek Pond population is defined as the body of water and the adjacent natural landscape approximately 10 m beyond the high water mark within the area illustrated in Figure 5 as critical habitat parcel 243_2.

Lower Boundary Creek Pond population:

The unnamed pond, referred to in this document as the Lower Boundary Creek Pond, is located about 6 km south-southwest of the Waterton Park townsite, west of Upper Waterton Lake, within Section 5, Township 1, Range 30, West of the 4th Meridian. Critical habitat for the Lower Boundary Creek Pond population is defined as the body of water and the adjacent natural landscape approximately 10 m beyond the high water mark within the area illustrated in Figure 5 as critical habitat parcel 243_3.

Biophysical attributes of critical habitat

Within the identified critical habitat boundaries, the biophysical attributes include the following:

- open, unshaded areas with cool, relatively wet climates and a short growing season (< 60 days), within the Upper Subalpine Ecoregion (as described in section 1.3.2) and between elevations of 1950 and 2100 metres,
- lightly- or un-glaciated upper subalpine ponds (< 2 metres deep),

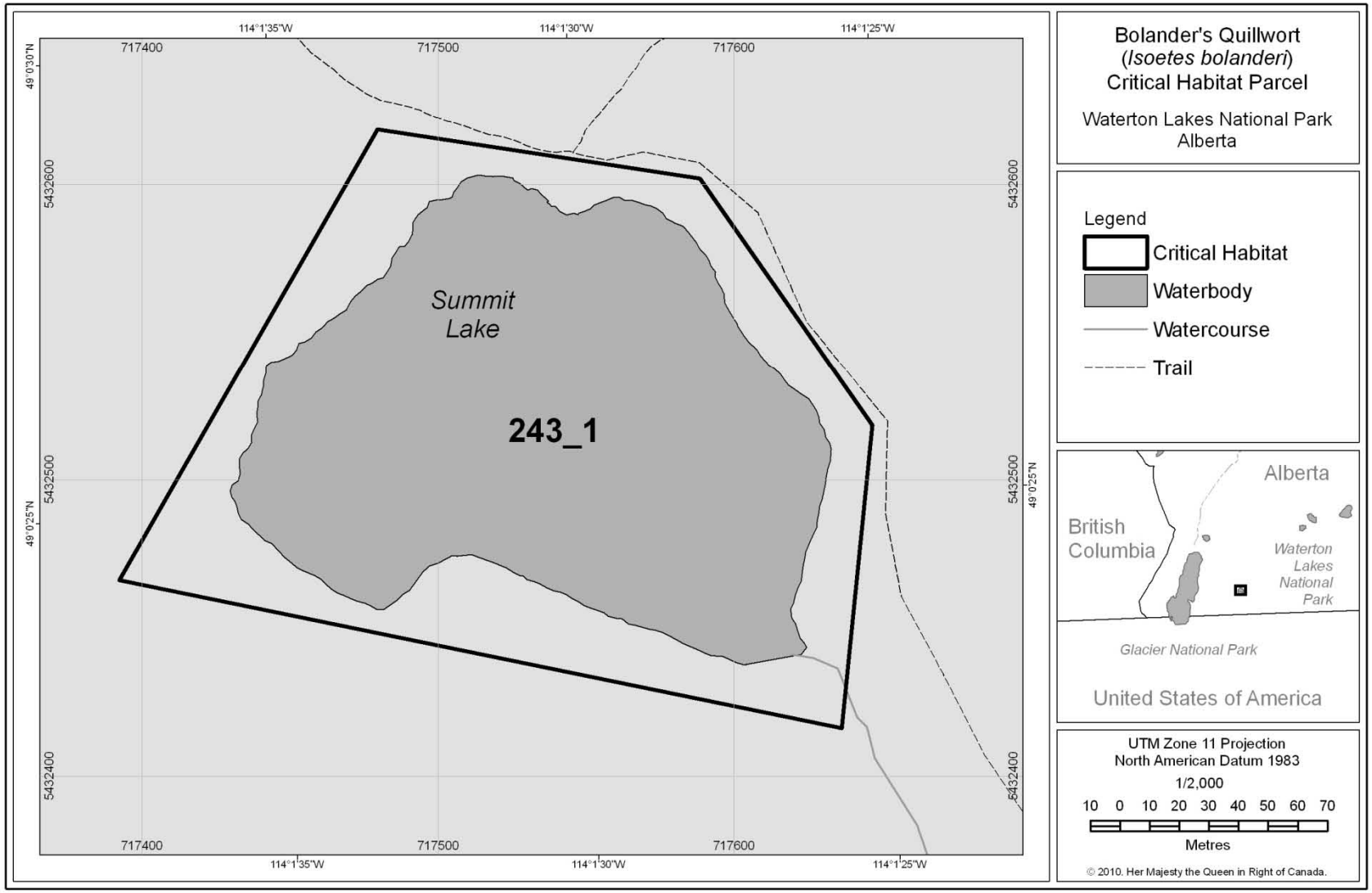

Figure 4. Area within which critical habitat parcel # 243_1 for Bolander's Quillwort is found at Summit Lake, Waterton Lakes National Park. Please refer to Section 2.3 for the description of biophysical attributes to help locate the critical habitat within this area.

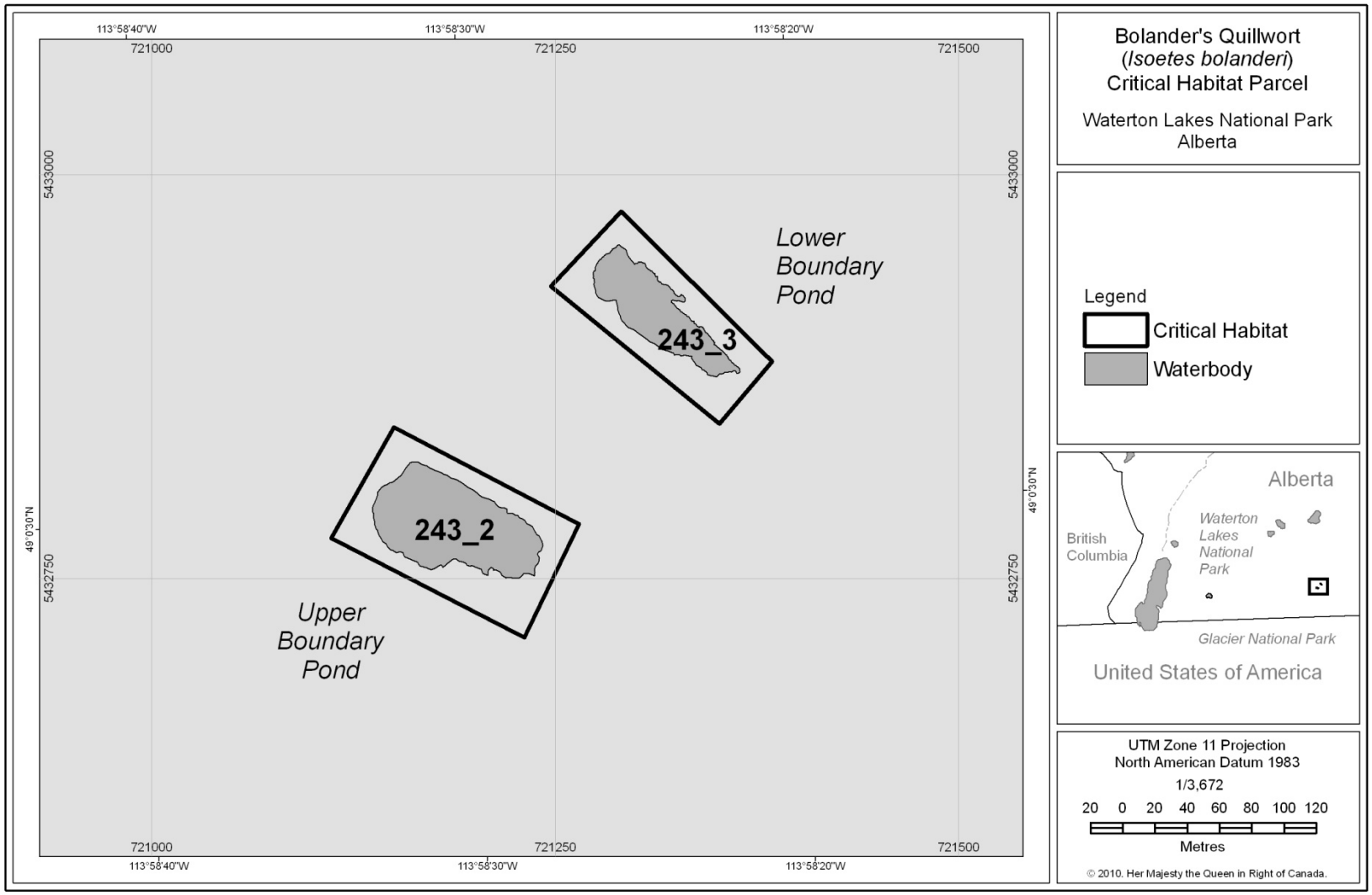

Figure 5. Area within which critical habitat parcels # 243_2 and 243_3 for Bolander's Quillwort are found at the Upper and Lower Boundary Creek Ponds, Waterton Lakes National Park, respectively. Please refer Section 2.3 for the description of biophysical attributes to help locate the critical habitat within this area.

- high water quality (clear, oligotrophic) that supports little or no vegetation other than Bolander's Quillwort and that has a pH of approximately 7.3 to 9.1, and
- moist growing substrate (3 to 14 cm layer of silt and silty-sand on top of coarser sand), likely with a pH of less than 7.3.

2.4 Activities Likely to Result in the Destruction of Critical Habitat

Destruction of critical habitat would result if any part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from single or multiple activities at one time or from the cumulative effects of one or more activities over time.

Outlined below are examples of activities that are likely to destroy critical habitat (Brunton and Britton 1993, Brunton and Britton 1998, COSEWIC 2005), the potential effects of those activities (Proctor 1949, Britton and Brunton 1989; Taylor et al. 1993, Voge 1997, Bradley et al. 2004, COSEWIC 2005, Brunton and Britton 2006) and the site(s) where each activity is likely to occur:

Table 4. Examples of activities likely to result in the destruction of critical habitat for Bolander's Quillwort in Canada.

Examples of activities likely to destroy critical habitat	Potential effect of the activity	Site(s) where each activity is likely to occur
• Physical impact by foot traffic within or adjacent to the wetland habitat	• Disturbance or compaction of substrate • Increased sedimentation in the aquatic habitat	• Summit Lake
• Mismanagement of human or animal waste (including that from horse traffic)	• Over-nitrification of the aquatic habitat • Changes to the microclimate of the aquatic habitat (e.g., temperature, pH)	• Summit Lake
• Spillage of a toxin (e.g. petroleum products)	• Over-nitrification of the aquatic habitat • Changes to the microclimate of the aquatic habitat (e.g., temperature, pH)	• Summit Lake
• Water pumping or equipment storage and movement associated with fire management	• Reduction of water levels within aquatic habitat	• Summit Lake • Boundary Creek Ponds
• Prescribed burning within the critical habitat	• Over-nitrification of the aquatic habitat • Increased sedimentation in the aquatic habitat	• Summit Lake • Boundary Creek Ponds
• Large scale landscape changes (e.g., increase in tree cover)	• Shading of habitat	• Summit Lake • Boundary Creek Ponds
• Infrastructure and other anthropogenic development	• Disturbance or compaction of substrate	• Summit Lake

2.5 Additional Information Requirements about the Species

Understanding the long-term population trends of Bolander's Quillwort at the sites in WLNP is particularly important to recovery and restoration planning because such data do not exist for any *Isoetes* population in North America. Indeed, the larger population and ecological dynamics of Bolander's Quillwort and most *Isoetes* species are poorly known, although the sensitivity of these species to rapid environmental change is well documented (e.g., Taylor et al. 1993). The potential impact of increased nutrient loading within the three small water bodies where Bolander's Quillwort occurs in WLNP, for example, is expected to be severe but particular details on this potential impact and the species' probable response, are lacking. Is is likely also important to determine typical season fluctuations in water levels. This may become important for management if vegetation changes lead to water input or if climate change alters water levels.

In coming years, human-caused climate change may constitute the largest threat to the viability of this and similar species. It is unknown what the species' tolerance in these shallow, seasonally-exposed, aquatic habitats may be as average annual temperatures increase. Catastrophic decline across the small Canadian range is not inconceivable.

The tolerance of Bolander's Quillwort to physical disturbance and transplantation is unknown. The density of Bolander's Quillwort plants in areas frequented by large ungulates and the ability of some *Isoetes* species to survive and produce viable spores in cultivation for periods of a decade or more (D. Brunton pers obs.), suggest this species is tolerant of relatively low levels of physical disturbance so long as water quality is maintained. Confirmation of this would be helpful in assessing the viability of restoration techniques for the Carthew Pond populations.

The historic record of a population in the "*shallow pond northeast of Carthew Lakes* " (Brunton 1995) remains unclarified. In addition, a better understanding of genetic relationships among WLNP populations and with Bolander's Quillwort populations in adjacent Glacier NP (USA) would be useful for considering restoration and enhancement options.

2.6 Habitat Conservation

Legal protection is already afforded to the habitat of all current Canadian Bolander's Quillwort populations under the *Canada National Parks Act.* All known Canadian populations also occur within the declared wilderness area of WLNP, which further regulates the type of activities than can and cannot occur in such areas. Upon publication of this document and subsequent publication of the critical habitat description in the Canada Gazette, the areas described as critical habitat will also be afforded legal protection under the *Species at Risk Act*.

Additional existing and recommended habitat protection measures are as follows:

- No facility development exists or is proposed in or near any known Canadian populations.
- Many trails have already been re-routed and improved to reduce erosion; these should be monitored to measure effectiveness.

- Other fire / prescribed burn plans and wilderness plans should incorporate considerations of the species' critical habitat, as demonstrated already with the prescribed burn plan for Whitebark Pine near Summit Lake.
- Communication and outreach programs, to foster public support and engagement in protecting the species' habitat.
- The Boundary Creek Ponds are naturally remote and human use (including the construction or designation of trails) should not be encouraged.

2.7 Measuring Progress

Actions that will be taken to implement the recovery strategy and action plan for Bolander's Quillwort, including anticipated outcomes and scheduling, are provided in section 2.2.

Demonstrative progress towards achieving the population and distribution objective for Bolander's Quillwort includes:

- Monitoring programs are implemented to detect human disturbance at sites and changes in population and distribution over time by December 2014
- Decrease in human disturbance at Summit Lake by December 2015
- Maintenance or increase in the population and distribution by December 2015

Much of the Bolander's Quillwort recovery strategy and action plan can be executed within existing WLNP programs. Co-operative undertakings with scientists will be mutually beneficial in addressing research needs, such as population recruitment studies, population trends, and the potential re-establishment of the species at Carthew Pond.

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APPENDIX A

Effects on the Environment and Other Species

Bolander's Quillwort occupies a low nutrient environment shared with relatively few other aquatic species, none of which are currently assessed as being at risk. However, the upper subalpine habitat of Bolander's Quillwort is within the larger landscape where prescribed burns are used for habitat restoration. In particular, prescribed burning will likely be an activity towards the recovery of Whitebark Pine, which has been assessed both provincially and nationally as Endangered. Protection of Bolander's Quillwort critical habitat, and limitations on the use of water bodies containing Bolander's Quillwort to control prescribed burns or to fight unanticipated fires, will affect logistical considerations for fire management programs. However, coordination among park management programs is already underway. For example, prescribed burning for Whitebark Pine recovery near Summit Lake will only occur outside of Bolander's Quillwort critical habitat and greater than 90 metres from Summit Lake, to minimize the potential for runoff and increased sedimentation in the lake. In addition, if water is required to control a fire, it will be taken from the creek draining Summit Lake (where Bolander's Quillwort does not occur) instead of the lake itself, or from Cameron Lake, where the species does not occur at all.