Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Muhlenberg's Centaury (*Centaurium muehlenbergii*) in Canada

Muhlenberg's Centaury



2013

Canada

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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 recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years.

The Minister of the Environment and the Minister responsible for the Parks Canada Agency are the competent ministers for the recovery of the Muhlenberg's Centaury and have prepared this strategy, as per section 37 of SARA. It has been prepared in cooperation with Songhees First Nation and the provincial government of British Columbia.

Success in the recovery 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 strategy and will not be achieved by the Parks Canada Agency, or Environment Canada, or any other jurisdiction, alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Muhlenberg's Centaury and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by the Parks Canada Agency and/or Environment Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Muhlenberg's Centaury is a species that inhabits vernal pools associated with Garry Oak ecosystems and recovery of this species will be integrated with the recovery of species in the Recovery Strategy for Multi-Species at Risk in Vernal Pools and Other Ephemeral Wet Areas in Garry Oak and Associated Ecosystems in Canada (Parks Canada Agency 2006).

RECOMMENDATION AND APPROVAL STATEMENT

The Parks Canada Agency led the development of this federal recovery strategy, working together with the other competent minister(s) for this species under the Species at Risk Act. The Chief Executive Officer, upon recommendation of the relevant Park Superintendent(s) and Field Unit Superintendent(s), hereby approves this document indicating that Species at Risk Act requirements related to recovery strategy development have been fulfilled in accordance with the Act.

Recommended by:



Helen Davies
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Approved by:



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ACKNOWLEDGMENTS

Thank you to Matt Fairbarns and Michael Miller for writing the draft recovery strategy. The Garry Oak Ecosystems Recovery Team is the recovery team for the Muhlenberg's Centaury and was involved in the development of this recovery strategy. Further revision was the result of comments and edits provided by a number of organizations: the Province of British Columbia, Parks Canada Agency, and Environment Canada.

EXECUTIVE SUMMARY

The Canadian population of the Muhlenberg's Centaury (*Centaurium muehlenbergii*) was assessed as Endangered in 2008 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and in February 2010 the population was listed as Endangered under Canada's *Species at Risk Act* (SARA).

Muhlenberg's Centaury is a small annual plant that grows 3 to 30 cm in height from a taproot and bears small pink to white tube-shaped flowers. Its range is restricted to North America where it occurs in moisture-receiving areas, such as vernal pools and seeps along the edges of coastal salt marshes. In Canada, Muhlenberg's Centaury is known from three isolated sites, two sites on southeastern Vancouver Island and one site on an adjacent Gulf Island. The Canadian population of Muhlenberg's Centaury comprises <1% of its global range.

The key factors limiting the recovery and survival of the Muhlenberg's Centaury populations in Canada are its specificity to rare vernal depression habitats, limited dispersal abilities, weak competitive ability, predisposition to demographic failure, small area of physical occupancy, and small, highly fragmented populations that constrain genetic diversity. The Muhlenberg's Centaury populations are threatened by land conversion caused by urban development, encroachment of native and alien plants, trampling and soil compaction caused by recreational activities, grazing by introduced geese, and climate change as it relates to changes in precipitation.

In the short term, recovery activities for the Muhlenberg's Centaury will focus on the maintenance of known populations and habitat while exploring the feasibility of establishing and/or augmenting populations to increase abundance and distribution. Broad strategies to address the threats to the survival and recovery of the Muhlenberg's Centaury are presented in section 6 Broad Strategies and General Approaches to Meet Objectives.

Critical habitat for the recovery of Muhlenberg's Centaury is identified in this recovery strategy. The best available information has been used to identify critical habitat; however, there are significant knowledge gaps and additional critical habitat will need to be identified in upcoming planning documents to meet the population and distribution objectives.

Further recovery action for Muhlenberg's Centaury will be incorporated into one or more action plans by 2018.

RECOVERY FEASIBILITY SUMMARY

Recovery of this species is considered feasible based on the criteria outlined by the Government of Canada (2009):

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.

Yes. All three extant populations support at least one reproductive individual, while one population supports several thousand reproductive individuals in favourable years. The species appears to be globally secure (G5) so in the event of local extirpation, seed could be collected from populations in the United States and used to restore the Canadian population.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Yes. Existing habitats have supported self-sustaining populations of the Muhlenberg's Centaury for at least 40 years. It is likely that additional suitable habitat could be made available through active habitat stewardship or restoration, if needed.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Yes. Some threats, such as competition from invasive species, can be reduced by a regular program to maintain the sites. Other threats, such as urbanization, will be more difficult to avoid or mitigate. There may be other important threats that have not yet been identified. However, at present there is no evidence of unavoidable threats to the species or its habitat that would preclude recovery.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Yes. Recovery success will be tied primarily to threat reduction through habitat stewardship in combination with long-term population monitoring and inventory. While the feasibility of introducing/re-introducing populations at the northern edge of the range is still unknown, over the long term, recovery techniques for population establishment and augmentation are likely to be developed.

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1. COSEWIC Species Assessment Information

Date of Assessment: April 2008

Common Name: Muhlenberg's Centaury

Scientific Name: *Centaurium muehlenbergii*

COSEWIC Status: Endangered

Reason for Designation: This small annual plant occurs in only three small areas of mainly wet habitat in southwestern British Columbia. Its total Canadian population consists of fewer than 1000 plants. These are highly disjunct from the main range of the species that extends from Oregon to California and Nevada. The species is at continued risk from such factors as the spread of invasive plants and human activities including trampling in areas used for recreational activities.

Canadian Occurrence: British Columbia

COSEWIC Status History: Designated Endangered in April 2008. Assessment based on a new status report.

2. Species Status Information

The Canadian population of Muhlenberg's Centaury (*Centaurium muehlenbergii*) was assessed as Endangered in 2008 by the Committee on Status of Endangered Wildlife in Canada (COSEWIC). In February, 2010, the population was listed as Endangered under Canada's *Species at Risk Act* (SARA) affording it legal protection. Conservation ranks are provided in Table 1. The Muhlenberg's Centaury population in Canada comprises <1% of its global range.

Table 1. Conservation ranks for Muhlenberg's Centaury. Sources: B.C. Conservation Data Centre 2011, NatureServe 2010.

Location	Rank*	Rank description
Global	G5?	Secure
Canada	N1	Critically imperilled
British Columbia	S1	Critically imperilled
United States	N5?	Secure
California	SNR	Not ranked
Idaho	SNR	Not ranked
Nevada	SNR	Not ranked
Oregon	SNR	Not ranked
Washington	SH	Possibly extirpated (historical)

*NatureServe Conservation ranks are based on a one to five scale, ranging from critically imperilled (1) to demonstrably secure (5). Status is assessed and documented at three distinct geographic scales global (G), national (N), and state/province (S).

3. Species Information

3.1. Species Description

Muhlenberg's Centaury is a small annual vascular plant which grows 3 to 30 cm in height from a taproot. The basal leaves form a conspicuous rosette of egg-shaped leaves (which often wither by flowering time). The upper stem leaves are oppositely arranged, narrower than the basal leaves, and pointed. The few, pink to white flowers are small and tube-shaped. A detailed description of the species is provided in the status report (COSEWIC 2008).

3.2. Population and Distribution

Muhlenberg's Centaury occurs from southwestern British Columbia south to California and Nevada (Figure 1). It is currently reported to be extirpated from Washington in spite of a 1992 report from San Juan Island (COSEWIC 2008).

In Canada, Muhlenberg's Centaury is known from three isolated sites: two on southeastern Vancouver Island and one on an adjacent Gulf Island (Figure 2). The Joan Point population near Nanaimo was first recorded in 2003, the Uplands Park population in Oak Bay in 1961, and the Gulf Islands population on the east side of Chatham Island in 1933 (COSEWIC 2008).

In 2009, the population at Joan Point consisted of only two small plants, while there were between 6,000 and 7,000 plants in the largest population at Uplands Park (Matt Fairbarns pers. obs. 2009). The Chatham Island population was not examined in 2009, but probably consists of fewer than 100 individuals since there were only 30 plants in 2003 (COSEWIC 2008) and conditions on the site do not appear to have changed significantly since then.

It is likely that Muhlenberg's Centaury was more widespread historically. Presently the species' distribution is highly disjunct over a relatively large region of southeastern Vancouver Island and the Gulf Islands (Figure 2). Further, it occupies a variety of moisture-receiving habitat types across its distribution in Canada. The preceding two points imply that the species was not historically restricted to its present small area of occupancy.

Both the Uplands Park and Chatham Island populations have persisted in small areas for at least 40 and 70 years, respectively, suggesting that population dynamics at these locations have remained relatively stable over time (COSEWIC 2008).

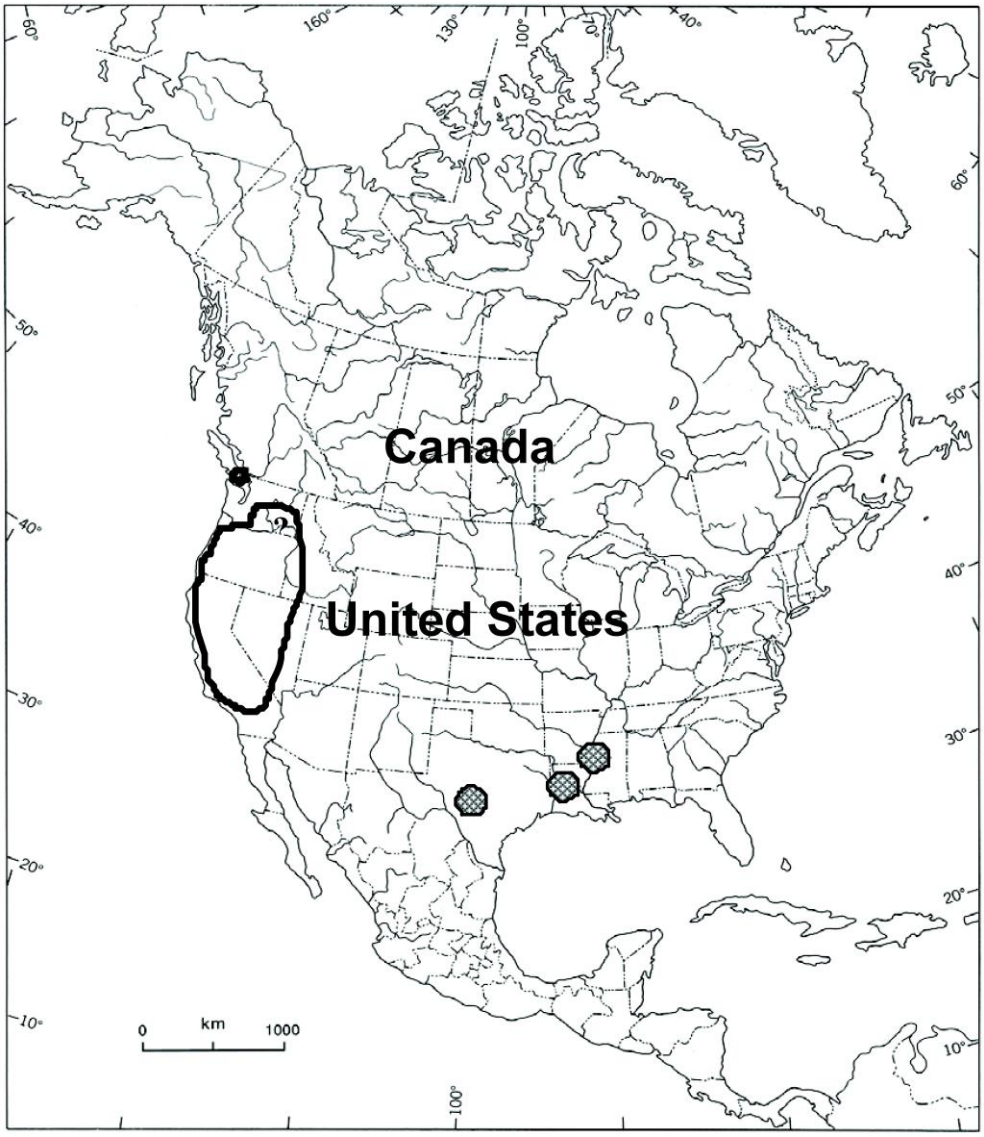


Figure 1.Distribution of Muhlenberg's Centaury in North America (from COSEWIC 2008). Possibly extirpated in Washington State and hatched circles are reported occurrences that are presumed to be incorrectly identified (COSEWIC 2008).

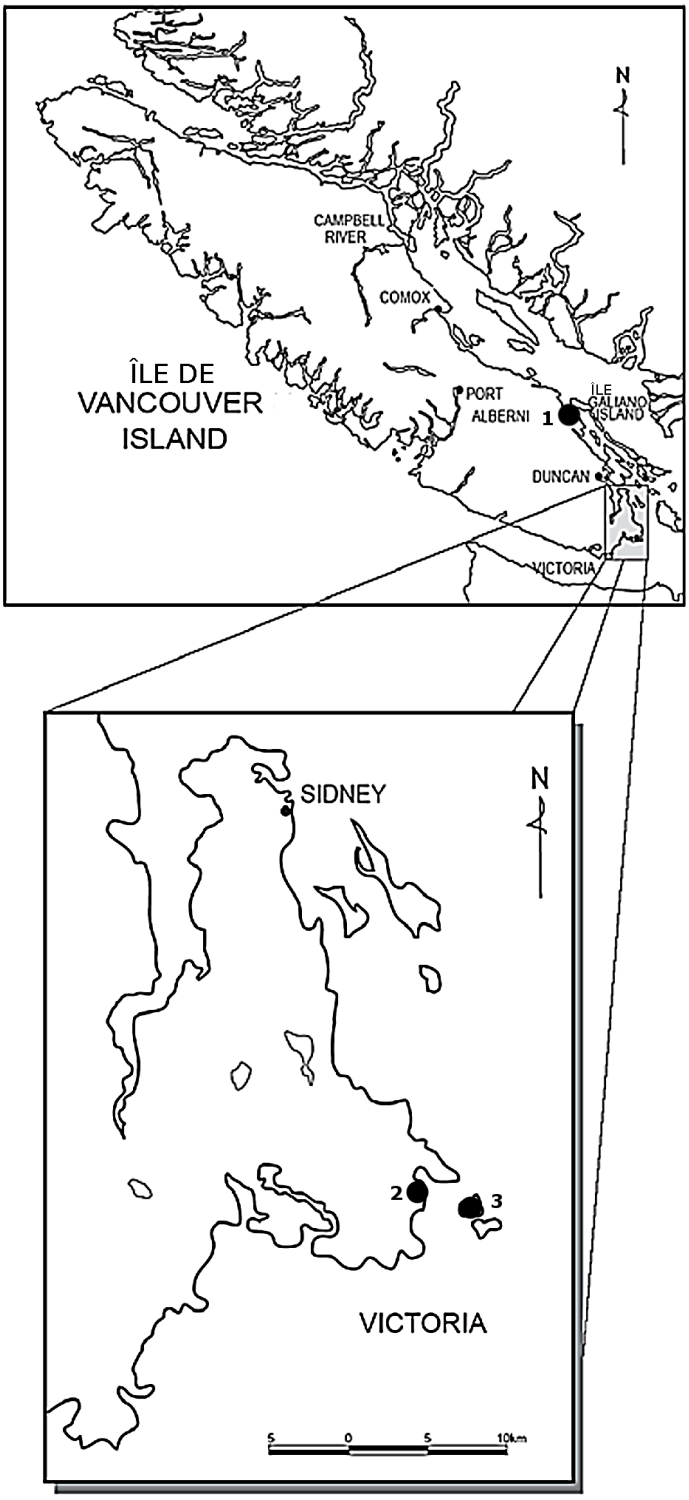


Figure 2. Range of Muhlenberg's Centaury in Canada (adapted from COSEWIC 2008). Circles indicate extant sites (1 = Joan Point, 2 = Uplands Park, 3 = Chatham Island).

3.3. Needs of the Muhlenberg's Centaury

Across its range in North America, Muhlenberg's Centaury is found within various community types where it grows in moisture-receiving areas on poorly drained Gleysol or Sombric Brunisol soils or on materials too thin to be defined as soil. The rooting zone is usually composed of silt and/or clay and drainage is impeded by a lower layer of marine clay and/or bedrock. In the U.S., where it is federally classified as a facultative wetland species (USDA-NRCS 2011), it has been reported from coastal bluffs, wet openings in woods, moist upland prairies, valley grassland, northern juniper woodland, and serpentine grassland (COSEWIC 2008).

In Canada, Muhlenberg's Centaury is found in the Coastal Douglas-fir biogeoclimatic zone where it known from three rather distinct habitat types: vernal seep, vernal swale, and saltgrass marsh. The Coastal Douglas-fir Biogeoclimatic Zone features a Mediterranean-like climate with warm, dry summers and mild, wet winters—summer drought is an important climatic feature which influences vegetation in this biogeoclimatic zone. The Joan Point population occurs on a sloping, vernal seep at the edge of a Douglas-fir (*Pseudotsuga menziesii*) and Arbutus (*Arbutus menziesii*) forest (COSEWIC 2008). The Uplands Park population is located in a vernal swale, in a seasonally flooded meadow, within a Garry Oak (*Quercus garryana*) woodland at an elevation of 10 m (Figure 3). The Chatham Island plants grow just above the high tide mark on bare, sandy ground at the edge of a saltgrass (*Distichlis spicata*) marsh.

Given the broad ecological amplitude displayed by Muhlenberg's Centaury across its range and our currently limited understanding of its physiological needs, few generalizations can be made as to specific habitat requirements. In Canada, the species appears to thrive best in moisture-receiving sites that become wetted in the winter and dry out in summer. It appears to be intolerant of shade and may depend on periodic fire to maintain open habitat and limit competition.



Figure 3. Habitat of Muhlenberg's Centaury at Uplands Park. Photos by Matt Fairbarns.

A number of factors may limit the survival and recovery of Muhlenberg's Centaury in Canada including the following:

1. Dependence on vernally moist depressions in Garry Oak and associated ecosystems (at least in Canada), most of which have been lost or damaged by habitat conversion, forest encroachment, and/or a shift to ecosystem dominance by invasive alien plants (COSEWIC 2008).
2. Lack of special structures to aid in the long distance dispersal of seeds or fruits (COSEWIC 2008).
3. Apparently weak competitive ability, especially with respect to invasive alien species (COSEWIC 2008).
4. Potential demographic failure if there are extended dry periods in the late winter and early spring, before plants can reproduce and replenish the seed bank.
5. Very small area of physical occupancy which leaves it susceptible to chance events including those which operate at a small scale.
6. Small, highly fragmented populations which may constrain the species' genetic diversity and limit the potential for local rescue effects (COSEWIC 2008).

4. Threats

4.1. Threat Assessment

Table 2. Threat Assessment Table

Threat	Level of Concern[1]	Extent	Occurrence	Frequency	Severity[2]	Causal Certainty[3]
Alien, invasive or introduced species						
Invasion by invasive alien herbaceous plants	High	Widespread	Current	Continuous	Medium-high	Medium
Grazing by introduced Canada Geese	Low	Localized	Current	Recurrent	Medium	Low
Habitat loss or degradation						
Housing and urban development	Medium	Localized	Historic and anticipated	Unknown	Medium-high	Medium
Disturbance or harm						
Trampling and soil compaction	Medium	Localized	Recurrent	Recurrent	Medium-high	Medium
Climate change and natural disasters						
Change in weather patterns, especially spring and early summer precipitation	Medium	Widespread	Anticipated	Seasonal	Unknown	Low
Changes in ecological dynamics or natural processes						
Encroachment of native and alien woody vegetation	Medium	Localized	Current	Continuous	Medium	Medium-low

[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

4.2.1. Alien, invasive or introduced species

The most serious immediate threat to Muhlenberg's Centaury in Canada is posed by the invasion of alien herbaceous plant species (Table 2). These alien species are abundant in the vernally moist areas where Muhlenberg's Centaury occurs and dominate similar habitats throughout its range in Canada. Many of the non-woody invasive alien species, including Sweet Vernal Grass (*Anthoxanthum odoratum*) and Creeping Bentgrass (*Agrostis stolonifera*), have contributed to the accumulation of thatch which provides difficult germination conditions, especially for small-seeded annual species such as Muhlenberg's Centaury. While all of the invasive alien species compete for space, tufted or rosette-forming perennials, such as Ribwort Plantain (*Plantago lanceolata*), Hairy Cat's-ear (*Hypochaeris radicata*), and Hairy Hawkbit (*Leontodon taraxacoides*), are most problematic because they pre-empt large areas of soil for many years. Invasive alien plant species compete strongly for moisture and nutrients, which disadvantages small annuals such as Muhlenberg's Centaury that possess shallow, small root systems. Accordingly, this threat is considered to be a high level of concern.

At present, grazing by introduced, resident Canada Geese presents a minor threat to populations of Muhlenberg's Centaury in Uplands Park and at the Chatham Island site. However, Goose populations appear to be increasing rapidly throughout the region and are causing damage to many coastal meadows and vernal depressions through trampling, direct grazing on most herbaceous species, and fouling by guano. This threat is considered a low level of concern at present.

4.2.2. Habitat loss and degradation

Habitat conversion caused by housing and urban development is an anticipated threat to Muhlenberg's Centaury throughout its range in Canada. Loss of suitable habitat and habitat fragmentation can result in population isolation, reducing the ability of extant populations to disperse to new sites. Further, as Muhlenberg's Centaury relies on vernal pools, hydrologic alterations caused by nearby habitat conversion can disrupt life cycle processes and cause physiological stress. While two of the three populations appear to be secure from housing and urban development over the foreseeable future, the Joan Point population lies within a proposed residential development. Consequently, this threat was considered a medium level of concern.

4.2.3. Disturbance or harm

Trampling and soil compaction caused by pedestrian, bicycle, dog, and off-road vehicle traffic can lead to altered hydrological regimes and facilitate the establishment of invasive alien species. The Joan Point population, which occurs in an opening adjacent to a hiking trail, will receive increased pressure as trail use increases along with residential development. The Uplands Park population receives heavy pedestrian, bicycle, and dog use, which can be particularly detrimental as soils dry out during the flowering and fruiting periods. Off-road vehicle traffic is not permitted at either the Joan Point or Uplands Park sites and is not likely to occur on the Chatham Island site where the third population occurs. Despite these prohibitions, trespass use may occur at the

Joan Point site, and tire tracks have been repeatedly observed at the Uplands Park. Until off-road vehicle and bicycle traffic can be controlled, it presents a direct trampling threat to Muhlenberg's Centaury. Overall, this threat is considered a medium level of concern.

4.2.4. Climate change and natural disasters

Climate change may have devastating effects on vernal pool environments. Research predicts warmer conditions and drier summers in south-western British Columbia as part of a broader pattern of global climate change (Rodenhuis *et al.* 2007). Small, vernally moist depressions such as those which support Muhlenberg's Centaury are probably at greatest risk, particularly to changes in precipitation and evaporation losses which determine the duration of continuous inundation, the frequency of inundation events suited to the reproduction of vernal pool species, and the seasonal distribution of inundation (Pyke 2005). While the loss of some vernally moist depressions may be offset by the improvement of currently marginal habitats, the latter are unlikely to develop populations of Muhlenberg's Centaury without human intervention because of the species' apparently weak powers of dispersal. This threat was considered a medium level of concern.

4.2.5. Changes in ecological dynamics or natural processes

Encroachment by native and alien woody species is of relatively less significance because woody species tend to occur only along the periphery of the moist areas where Muhlenberg's Centaury itself grows. Neither native nor alien woody species are able to grow well on microhabitats favoured by Muhlenberg's Centaury because of the prolonged saturation in winter and the extreme drought in summer. Nevertheless, woody species may encroach on better-drained microsites within the Joan Point population and along the periphery of both the Joan Point and Uplands Park populations. As woody species encroach, they may reduce the viability of Muhlenberg's Centaury populations by casting shade and altering hydrological conditions. This threat is considered to be a medium level of concern.

5. Population and Distribution Objectives

In Canada, Muhlenberg's Centaury is found in vernally moist habitats associated with Garry Oak ecosystems and as such had a naturally, highly restricted range. Within this range, significant habitat loss since European settlement (Lea 2006) has likely resulted in population reductions. Encroachment of vegetation, development, and effects resulting from recreational activities continue to exacerbate the situation (COSEWIC 2008). Given the permanent loss of most of the original habitat, it is not possible to recover the species to its natural area of occupancy or to its original probability of persistence. There are currently three known Muhlenberg's Centaury populations in Canada, one of which had two individuals at last count (COSEWIC 2008; Fairbarns 2009, pers. comm.).

In general, it is believed that multiple populations and thousands of individuals are likely required to attain a high probability of long-term persistence for a species (Reed 2005; Brook *et al*. 2006; and Traill *et al*. 2009). In an analysis of several published estimates of minimum viable population (MVP) sizes, Traill *et al*. (2007) found that the median population size required for plants to achieve a 99% probability of persistence over 40 generations was approximately 4,800

individuals (but see Flather *et al.* 2011, Garnett and Zander 2011, and Jamieson and Allendorf 2012 for critical evaluations of the analyses and the applicability of the results). Such information provides a useful guide, but developing specific quantitative and feasible objectives must consider more than just generalized population viability estimates, including the historic number of populations and individuals, the carrying capacity of extant (and potential) sites, the needs of other species at risk that share the same habitat, and whether it is possible to establish and augment populations of the species (Parks Canada Agency 2006; Flather *et al.* 2011; Jamieson and Allendorf 2012). Because not enough of this information is available for Muhlenberg's Centaury, it is currently not possible to determine to what extent recovery is feasible and therefore, it is not possible to establish quantitative long-term objectives. Recovery planning approaches (see Section 6) are designed to respond to knowledge gaps so that long-term, feasible, and quantitative recovery objectives regarding size and number of populations can be set in the future. At this time it is possible to set short-term objectives that focus on maintaining known populations and habitat while exploring the feasibility of establishing and/or augmenting populations to increase abundance and distribution:

Objective 1: Maintain the Uplands Park and Chatham Island populations of Muhlenberg's Centaury.

Objective 2: Maintain the habitat at the Joan Point site while the feasibility of population restoration is assessed for Muhlenberg's Centaury.

Objective 3: Establish and/or augment populations to increase abundance and distribution[1] if determined to be feasible and biologically appropriate for Muhlenberg's Centaury.

6. Broad Strategies and General Approaches to Meet Objectives

Broad strategies and approaches to meet the population and distribution objectives for Muhlenberg's Centaury include:

- Habitat and species protection: protect existing populations and their habitat from destruction (e.g., from land conversion) by developing mechanisms/instruments for protection;
- Stewardship: engage and involve landowners, land managers, and First Nations in recovery activities and decisions for Muhlenberg's Centaury;
- Population restoration: develop and test population (re)introduction/augmentation techniques to recover the species;
- Public education and outreach: increase public awareness of the species threats and harm reduction measures, needs, and conservation value;
- Population monitoring: inventory existing populations and other suitable sites and address knowledge gaps pertaining to population trends, population viability, population augmentation, and restoration techniques;
- Research: address knowledge gaps pertaining to genetic diversity, threats, and habitat requirements.

[1] The intent is to increase the area of occupancy and maintain the extent of occurrence.

6.1. Strategic Direction for Recovery

Table 3. Recovery Planning Table

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
Housing and urban development	High	Habitat and species protection	• Identify protection mechanisms/instruments for critical habitat. • Describe habitat for Muhlenberg's Centaury and refine critical habitat attributes.
Invasion by invasive alien herbaceous plants Encroachment of native and alien woody vegetation Trampling and soil compaction Grazing by introduced Canada geese Knowledge gaps concerning reproductive mechanisms Limitations of habitat specificity, competitive ability, demographic failure, and fragmented populations.	High	Stewardship	• Prepare Best Management Practices for Muhlenberg's Centaury to support landowners, municipal park staff, and First Nations in stewardship activities. • Engage landowners, land managers, and First Nations in recovery decisions and activities.
	High	Population restoration	• Develop and implement population restoration plans for locations with existing populations (including a monitoring component). • Identify a list of priority sites for restoration/establishment of new population(s) as per the population and distribution objectives.
	High	Research	• Population biology research to support population restoration (e.g., pollination mechanism and limitations). • Develop population establishment/augmentation techniques and priorities to establish new population(s). • Determine long-term species-specific population thresholds. • Determine total number of populations required to maintain a suitable chance of survival in Canada.
	Medium	Public education and outreach	• Increase public awareness of the existence and conservation value of Muhlenberg's Centaury and associated species at risk, as well as threats to the species and harm reduction measures. • Develop priorities to deliver public education and outreach concerning species at risk and their management (e.g., volunteer organizations, First Nations, landowners, and land managers).
Knowledge gaps concerning population size and extent Change in weather patterns, especially spring and early summer precipitation	Medium	Population monitoring	• Design and implement an inventory and monitoring program to track population trends for 10 successive years, with subsequent monitoring as required. • Identify the demographic criteria that would trigger immediate re-evaluation of recovery priorities and activities. • Report on population trends, area of occupancy, and habitat condition every 2 years.
Knowledge gaps concerning genetic diversity, and threats	Low	Research	• Assess and conserve genetic diversity of extant populations of Muhlenberg's Centaury in Canada • Investigate potential herbivory effects by insects or vertebrate grazers on the population

6.2. Narrative to Support the Recovery Planning Table

Protection of the species and its habitat at the three extant sites is a first priority for the recovery of Muhlenberg's Centaury (Table 3). Diligence must be exercised to prevent extirpation at extant sites due to preventable causes (including benign neglect). In addition, adequate environmental conditions for plant growth and establishment must be maintained at these sites, this includes control of both invasive alien species and encroaching native woody species and maintenance of hydrological processes. Despite uncertainties regarding the potential for (re)introducing the species into unoccupied areas, identifying alternative sites with the ability to support Muhlenberg's Centaury populations will be an important component of recovery. Where possible, overgrown, degraded, or otherwise non-functioning vernally moist sites should be identified and restored to a point where they can serve as future recovery habitat for this species, as has been recommended for other vernal pool species at risk (Parks Canada 2006). The choice of poor condition vernal pools will limit or avoid impacts on at-risk vernal pool species and community types.

As the three extant populations occur on a variety of land tenures, stewardship, public education, and outreach are important to ensure recovery of the species and its habitat. At the Joan Point site, the first priority will be to ensure stakeholders are alerted to the presence of Muhlenberg's Centaury so that the species can be adequately protected from the effects of urban land development or other land use activities. At Uplands Park, municipal park staff must be engaged in recovery activities to ensure the incorporation of the Muhlenberg's Centaury population into park management and planning processes. For the Chatham Island population, the full engagement of First Nations will be a priority.

Research will be important for recovery as there are key knowledge gaps which currently limit recovery. Techniques for population restoration and/or new population establishment will need to be developed. Further, population biology research will be critical to fill knowledge gaps such as pollination limitations and to determine recovery targets for number and size of populations. Additional beneficial research includes gene conservation and studies that address other aspects of its autecology.

Design of the monitoring program is an important consideration, especially for rare annual plants which are likely to exhibit population fluctuations or rely on seed banks (Bush and Lancaster 2004). Data should be collected regularly over several years to account for population fluctuations. Further, data should be collected in years when plants are absent as well as when they are present to provide information on the species responses to environmental conditions. When seed banks are involved, they are an important part of the lifecycle and must be considered in estimates of population size—the presence of even one individual may indicate a viable seed bank is present (Bush and Lancaster 2004).

An important component of the monitoring program will be to identify criteria with respect to rate of population decline (size/distribution) that would trigger immediate re-evaluation of recovery priorities and activities. These criteria can then be incorporated into management plans. In addition, regular population monitoring is needed to track the current viability of the species, its response to threats and management activities, and the success of restoration and augmentation techniques. There are also significant risks associated with new population

establishment which, therefore, must be accompanied by a program to monitor the impacts of new population establishment on non-target species, communities, and ecological processes.

7. Critical Habitat

Areas of critical habitat for Muhlenberg's Centaury are identified in this recovery strategy. Critical habitat is defined in the *Species at Risk Act* as "...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" (Subsection 2(1)). Habitat for a terrestrial wildlife species is defined in the *Species at Risk Act* as "…the area or type of site where an individual or wildlife species naturally occurs or depends on directly or indirectly in order to carry out its life processes or formerly occurred and has the potential to be reintroduced" (Subsection 2(1)).

7.1. Identification of the Species' Critical Habitat

Critical habitat for Muhlenberg's Centaury is identified in this recovery strategy to the extent possible based on best available information. It is recognized that the critical habitat identified below is insufficient to achieve the population and distribution objectives. While habitat can be fully identified for two known occurrences (Uplands Park and Joan Point), additional information is required to identify critical habitat at the one remaining location (Chatham Island). The schedule of studies section (Section 7.2; Table 4) outlines activities required to identify additional critical habitat necessary to support the population and distribution objectives of the species.

The habitat of Muhlenberg's Centaury in Canada occurs in the Coastal Douglas-fir Biogeoclimatic Zone and is generally characterized as moisture-receiving areas, such as vernal pools and seeps along the edges of coastal salt marshes (Matt Fairbarns pers. obs. 2005; COSEWIC 2008). Field investigations, conducted in 2009 at two (Uplands Park and Joan Point) of the three extant locations, provided additional information required to identify critical habitat at those sites.

Muhlenberg's Centaury likely depends directly on canopy openings to provide high light levels for germination. These openings must be large enough that Muhlenberg's Centaury plants and seed bank area are not sheltered by surrounding vegetation. The minimum size of the openings can be determined based on the height of vegetation likely to grow in the area and cast shade on the Muhlenberg's Centaury (Spittlehouse *et al.* 2004). An additional consideration with regard to canopy opening is that when tall vegetation falls it covers an area of ground for a distance equal to its height.

In addition to openings, specific hydrological characteristics are critical to the survival of this species. These hydrological characteristics are directly tied to rainfall (Graham 2004). Muhlenberg's Centaury grows in level or depressional open areas that collect water from the surrounding area, called the catchment area. Surface water flow and subsurface seepage from this catchment area is essential to the survival of the Muhlenberg's Centaury plants. These catchment areas are generally small and isolated within landscape scale catchments.

Critical habitat required for the survival of each patch[2] of Muhlenberg's Centaury (includes both plants and seed bank area) is composed of two habitat features: the minimum canopy opening and the catchment area. These features are always connected to a plant or patch of plants and in all cases will overlap to some degree (no special status is applied to areas of overlapping critical habitat). The default minimum canopy opening required for light to reach the plants is the area bounded by a 20 m distance surrounding each plant or patch of plants in all directions (20 m is generally the maximum height attained by trees in the soils surrounding Muhlenberg's Centaury). The catchment is delineated by following the upslope high point of land which divides water flowing towards the plants from water flowing away from the plants; these catchment areas are generally relatively small and isolated within landscape catchments.

Within the geographical boundaries identified in Figure 4 and Figure 5, critical habitat for Joan Point and Uplands Park consists of the minimum canopy openings and any catchment areas associated with the recorded location of each Muhlenberg's Centaury plant or patch. The critical habitat for these locations was mapped in 2009 (Fairbarns unpublished data 2009).

While the BC Conservation Data Centre has an element occurrence for this species on Chatham Island, neither the occurrence nor habitat has been recently confirmed. No critical habitat is identified for this occurrence, pending further studies.

The critical habitat attributes below cover the range of attributes for some but not all of the known sites, and may not exclude some habitat types that are unsuited to the species. Critical habitat attributes are as follows:

- Shallow depression with slope angles of < 2% that occur between 0.5-90 m above sea level.
- The lowest portion of the depression is sunny with short or sparse vegetation, woody plants may be found on areas less prone to winter flooding.
- Soils at the lowest point are poorly drained, generally shallow (< 10 cm deep) and usually have a negligible component of coarse fragments.
- Soils tend to be moist during the winter and are very dry by mid-summer (June/July).

[2] Patch is a term used to refer to a group of several plants in close proximity. A specific mapping scale and minimum separation distance have not been used to quantitatively define a patch; the identification of patches is based on survey work performed by a biologist familiar with the species. Lacking any detailed information on seed bank extent, the seed bank is assumed to be included within each patch: the only information pertaining to the spatial extent of the Muhlenberg's Centaury seed bank is derived from the physical characteristics of the seeds, and dispersal distance is probably very limited (COSEWIC 2008).

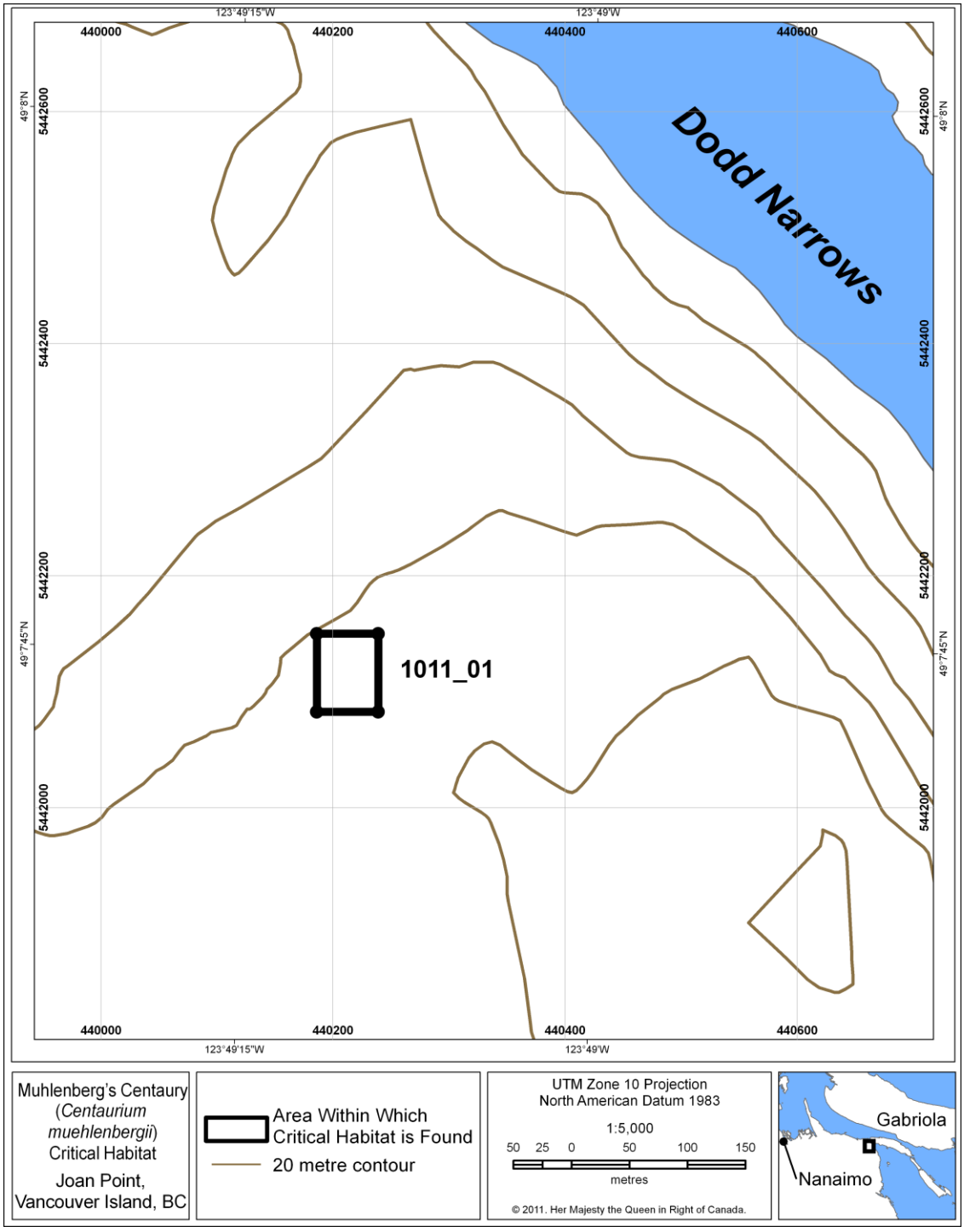


Figure 4. Area (~ 0.36 ha) within which critical habitat for Muhlenberg's Centaury is found at Joan Point near Nanaimo and is located entirely on private lands. The area of critical habitat within this area is approximately 0.1 ha.

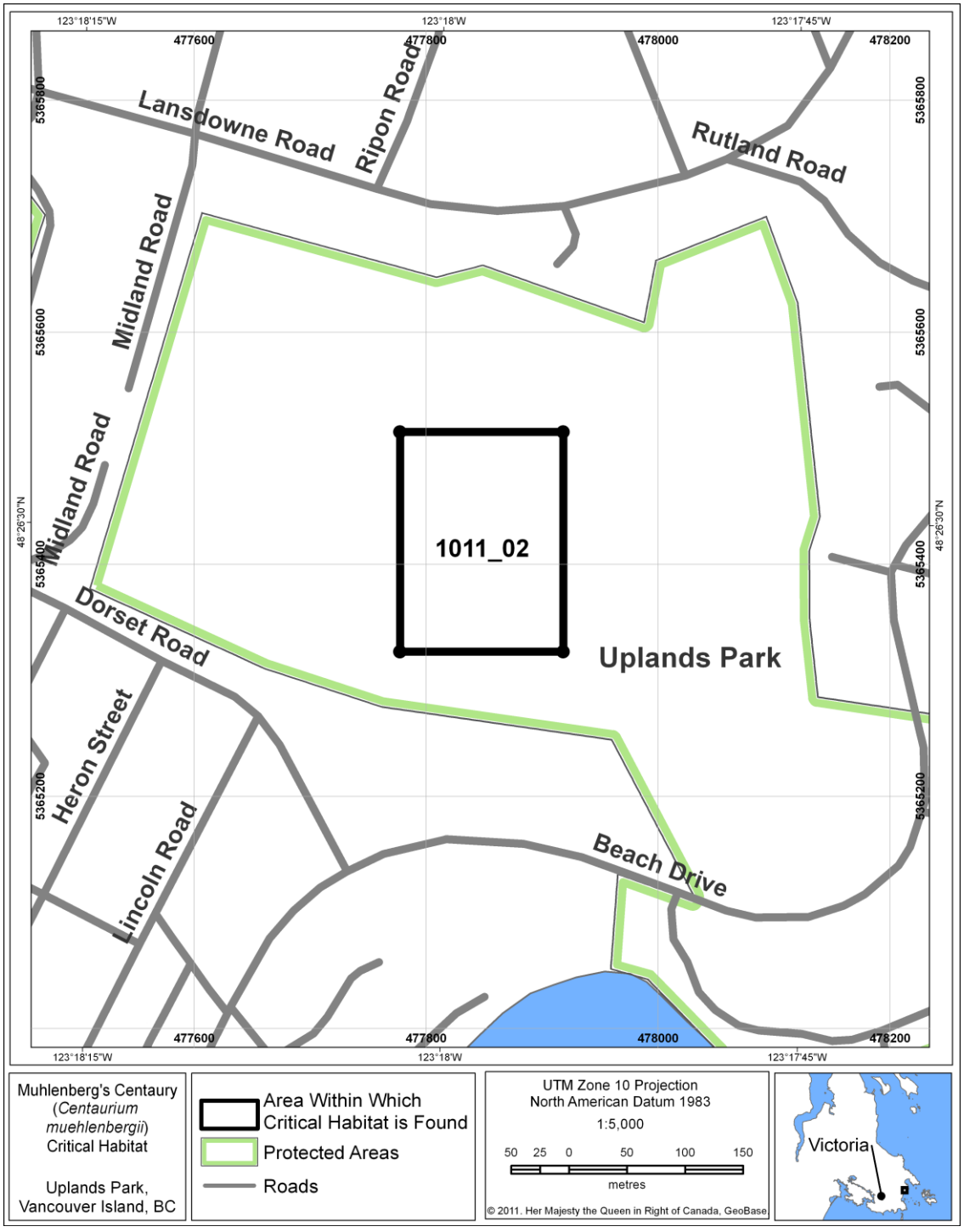


Figure 5. Area (~ 2.7 ha) within which critical habitat for Muhlenberg's Centaury is found in Uplands Park in Victoria and located on municipal park land. The area of critical habitat within this area is approximately 1.42 ha.

7.2. Schedule of Studies to Identify Critical Habitat

Table 4. Schedule of Studies

Description of Activity	Rationale	Timeline
Identification of critical habitat for the Chatham Island population, by confirming continued existence, location, and describing habitat attributes required for the species establishment and persistence, including hydrological conditions where Muhlenberg's Centaury occurs.	Required in order to identify the critical habitat.	2014
Identification of habitat conditions associated with the northernmost U.S. populations of Muhlenberg's Centaury.	Needed to refine understanding of the conditions and processes necessary to support the species.	2015
Identify sites for Muhlenberg's Centaury (re)introduction and augmentation experiments.	Required to determine the feasibility of establishing and/or augmenting populations to increase abundance and distribution.	2016

7.3. Activities Likely to Result in the Destruction of Critical Habitat

Examples of activities likely to destroy critical habitat are provided below (Table 5). It is important to note that some activities have the potential to destroy critical habitat from outside the critical habitat. Destruction of critical habitat will result if any part of the critical habitat is 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 point in time or from the cumulative effects of one or more activities over time.

Table 5. Examples of activities likely to result in destruction of critical habitat.

Activity	Effect of activity on critical habitat	Most likely sites
Site development or land use changes	This activity can cause direct land conversion, soil compaction, shading (e.g., by introduced plants or nearby structures), altered moisture regime (e.g., impounded drainage, or reduced water flow to the plants through ditching or diversion of subsurface water by built structures), introduction of alien species (e.g., intentional plantings or accidental introduction such as facilitated by unclean machinery). Some landscape / construction activities may destroy critical habitat even if they occur outside of the critical habitat. For example tall buildings may still cast shade on plants. Also, some activities such as road or trail construction, ditching, or irrigation may alter hydrological regimes within the critical habitat area.	Chatham Island Joan Point

Activity	Effect of activity on critical habitat	Most likely sites
Vehicle traffic	This activity can cause indirect impacts through soil compaction and loss of vegetation leading to changes in hydrology, such as decreased water infiltration and increased runoff. Habitat is likely to be directly lost due to increased erosion and plants may become stressed and die due to impaired ability of the habitat to provide a suitable moisture regime. In addition, this activity is likely to introduce or spread alien species. Invasive alien plants compete with Muhlenberg's Centaury and alter the availability of light, water, and nutrients in the habitat, such that the habitat would not provide the conditions required by Muhlenberg's Centaury.	Joan Point Uplands Park
Damaging recreation use (e.g., bicycle, pedestrian and dog walking)	Nitrogen enrichment from dog feces leading to changes in nutrients that provide the necessary habitat conditions for Muhlenberg's Centaury. Soil compaction and introduction of invasive alien species (see vehicle traffic for effects of soil compaction and invasive alien plant species).	Joan Point Uplands Park

8. Measuring Progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. Progress towards recovering Muhlenberg's Centaury in Canada will be assessed using the following measures:

Objective 1: Maintain the Uplands Park and Chatham Island populations of Muhlenberg's Centaury.

- By 2018 best management practices are developed and implemented at one or both sites.
- The populations remain extant.
- By 2023, both populations show a stable or increasing trend in population size[3].

Objective 2: Maintain the habitat at the Joan Point site while the feasibility of population restoration is assessed for Muhlenberg's Centaury.

- By 2018 best management practices are developed and implemented.
- Habitat suitable for Muhlenberg's Centaury remains extant at Joan Point.

Objective 3: *Establish and/or augment populations to increase abundance and distribution if determined to be feasible and biologically appropriate for Muhlenberg's Centaury*.

- By 2018, additional sites have been identified for establishment or restoration of Muhlenberg's Centaury population(s).
- By 2018, propagation techniques have been developed.
- By 2023, one or more (re)introduction or augmentation experiments are underway at suitable site(s).

[3] Note that populations are expected to fluctuate and require long term datasets to estimate (Bush and Lancaster 2004).

9. Statement on Action Plans

One or more action plans will be completed by 2018.

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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 strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process, based on national guidelines, directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

The range of Muhlenberg's Centaury overlaps with a suite of other plants and invertebrates at risk, the totality of which comprise one of the most unique species assemblages known in Canada (GOERT 2002). Because locations for potential introductions of Muhlenberg's Centaury have not yet been determined, and because of the high concentrations of co-occurring species at risk in some locations, it is not possible to anticipate all of the possible positive and negative impacts stemming from recovery activities. However, many of these species are threatened by the same primary factors (i.e., development activities and introduced species) that threaten Muhlenberg's Centaury. Thus, most of the recovery activities proposed (e.g., protection and habitat restoration) are expected to have a net positive effect on non-target native species, communities, and their habitats.

Nevertheless, if not planned and implemented carefully, large-scale management actions, such as invasive species removal or the use of herbicides, may have a negative effect on other plants at risk (e.g., through trampling, poisoning, increased herbivory, and inadvertent dispersal of alien species). Trampling due to on-site recovery activities (e.g., surveys, research, restoration, and management) poses a threat to co-occurring at-risk species that occur in or near sites with Muhlenberg's Centaury or that are proposed for Muhlenberg's Centaury establishment. Further, augmenting populations with non-local genotypes may harm existing populations (McKay *et al.* 2005).

The potentially negative effects of recovery can be mitigated or eliminated at the project implementation phase through proper field procedures and/or strong involvement of Parks Canada Agency and the Garry Oak Ecosystems Recovery Team. Further, all population augmentation/establishment must take a precautionary approach, and research should involve experimental establishment trials (Maslovat 2006). One approach to ensure that potential negative impacts of augmentation/establishment are minimized would be to select restoration/establishment sites that are already degraded to the point that they no longer support viable populations of other species at risk. Some recovery strategy activities may require project-level environmental assessment as required under the *Canadian Environmental Assessment Act*.

Any activities found to require project-level environmental assessments will be assessed at that time pursuant to the provisions of the *Act*.

Actions taken to aid in the recovery of this species should, if conducted in an open, informative manner, provide benefits for all species at risk and their habitats by increasing public awareness of the negative environmental consequences associated with invasive alien species, the need to maintain natural ecological processes, and the need to protect natural habitats from the effects of development. This recovery strategy benefits the environment by promoting the conservation and recovery of the Muhlenberg's Centaury, a natural component of biodiversity. In addition, it is likely that habitat restoration for Muhlenberg's Centaury will benefit other co-occurring native species which occupy the same habitat. The SEA process has concluded that this recovery strategy will likely have several positive effects on the environment and other species. There are no obvious adverse environmental effects anticipated with the implementation of this recovery strategy.