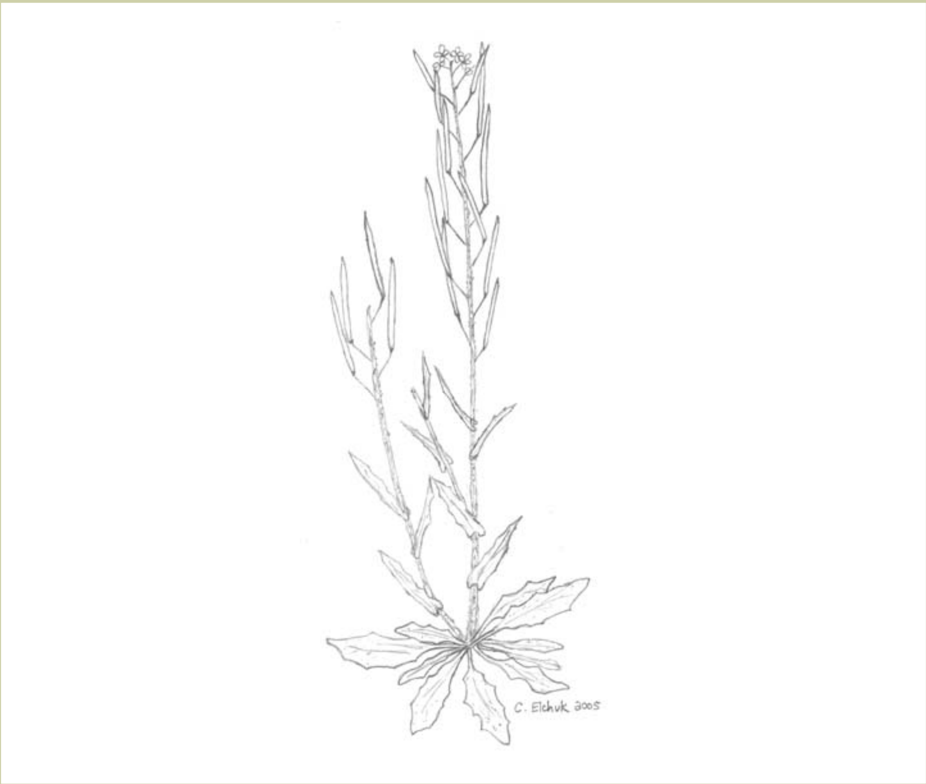
PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Slender Mouse-ear-cress (*Halimolobos virgata*) in Canada

Slender Mouse-ear-cress



2010

Environment Canada   Environnement Canada

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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 (www.sararegistry.gc.ca/approach/act/default_e.cfm) spell out 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. A period of 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

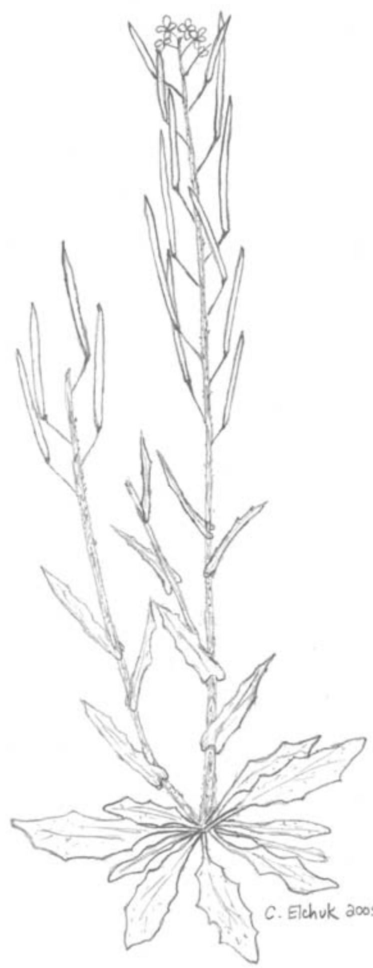
This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the Species at Risk (SAR) Public Registry (www.sararegistry.gc.ca).

Recovery Strategy for the Slender Mouse-ear-cress (*Halimolobos virgata*) in Canada (PROPOSED)

2010



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Additional copies:

You can download additional copies from the SAR Public Registry (www.sararegistry.gc.ca).

Cover illustration: Slender Mouse-ear-cress by Candace Neufeld ©.

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« Programme de rétablissement de l'halimolobos mince (*Halimolobos virgata)* au Canada [Proposition] »

ISBN
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DECLARATION

This recovery strategy has been prepared in cooperation with the jurisdictions responsible for Slender Mouse-ear-cress. Environment Canada has reviewed and accepts this document as its recovery strategy for the Slender Mouse-ear-cress, as required under the *Species at Risk Act (*S.C. 2002, c.29). This recovery strategy also constitutes advice to other jurisdictions and organizations that may be involved in recovering the species.

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

This recovery strategy will be the basis for one or more action plans that will provide details on specific recovery measures to be taken to support conservation and recovery of the species. The Minister of the Environment will report on progress within five years.

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 Environment Canada or any other jurisdiction alone.
In the spirit of the Accord for the Protection of Species at Risk, the Minister of the Environment invites all responsible jurisdictions and Canadians to join Environment Canada in supporting and implementing this strategy for the benefit of the Slender Mouse-ear-cress and Canadian society as a whole.

RESPONSIBLE JURISDICTIONS

Environment Canada
Government of Alberta
Government of Saskatchewan

CONTRIBUTORS

This strategy was prepared by Candace Neufeld and Darcy Henderson (Canadian Wildlife Service, Environment Canada).

ACKNOWLEDGMENTS

The recovery strategy was prepared by Candace Neufeld and Darcy Henderson on behalf of the Recovery Team for Plants at Risk in the Prairie Provinces. The contributors would like to thank the Recovery Team for Plants at Risk in the Prairie Provinces for their valuable comments on this document (see Section 4 for a list of members). Helpful comments were also provided by

M. Curteanu, R. Décarie, D. Duncan, R. Franken, L. Métras and M. Wayland (Environment Canada). The Saskatchewan Conservation Data Centre and the Alberta Natural Heritage Information Centre provided updated element occurrences for this species. Ian MacDonald provided insight into the species and assistance with earlier surveys. Thanks are also extended to all the landowners, lessees and land managers who allowed access to their land for surveys for Slender Mouse-ear-cress. The cover illustration was provided by Candace Neufeld.

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

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 on non-target species or habitats. The results of the SEA are incorporated directly in the strategy itself, but are also summarized below.

This recovery strategy will clearly benefit the environment by promoting the recovery of Slender Mouse-ear-cress. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. The reader should refer to the following sections of the document in particular: Needs of Slender Mouse-ear-cress; Threats; Population and Distribution Objectives; Approaches Recommended to Meet Recovery Objectives; and Effects on Other Species.

PREFACE

The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. Slender Mouse-ear-cress was listed as Threatened under SARA in June 2003. The Canadian Wildlife Service – Prairie and Northern Region, Environment Canada led the development of this recovery strategy.

This recovery strategy was developed in cooperation or consultation with:

1. Provincial jurisdictions in which the species occurs – Saskatchewan, Alberta;
2. Industry stakeholders - Canadian Cattlemen's Association, EnCana Corporation, Canadian Association of Petroleum Producers; and
3. Federal land managers – Department of National Defence (Canadian Forces Base-Suffield), Agriculture and Agri-Food Canada - Agri-Environment Services Branch (previously known as Prairie Farm Rehabilitation Administration).

This will be the first recovery strategy for Slender Mouse-ear-cress posted on the Species at Risk Public Registry.

EXECUTIVE SUMMARY

- Slender Mouse-ear-cress is a biennial plant in the Mustard family, with greyish hairs, white flowers with four petals, and erect pods (siliques). Slender Mouse-ear-cress typically inhabits sandy to loamy, short to mid-grass prairie on terrain that is flat to very gently undulating and dry to vernally moist. Plants typically grow in low depressions or at the base of slopes and low sand dune edges. In Canada, Slender Mouse-ear-cress occurs in Alberta and Saskatchewan; there are fourteen populations and seventeen populations believed extant in Alberta and Saskatchewan, respectively.

- Currently identified threats to Slender Mouse-ear-cress include cultivation, oil and gas activities, lack of grazing and/or fire regimes, alteration to hydrological regimes, invasive alien species, sand and gravel extraction, urban development, military activities and climate change.

- Recovery of Slender Mouse-ear-cress is deemed biologically and technically feasible. The population and distribution objectives for the Slender Mouse-ear-cress are to maintain the persistence of known naturally occurring populations within the current range of the species in Canada. Five recovery objectives have been identified for Slender Mouse-ear-cress:
    1) Determine area of occupancy and extent of occurrence of additional Slender Mouse-ear-cress populations, to the extent possible by 2013.
    2) Develop beneficial management practices to reduce threats to Slender Mouse-ear-cress by 2013.
    3) Fill the knowledge gaps by 2013 on potential habitat, habitat associations, effects of anthropogenic features or invasive alien species, and size and longevity of the species soil seed bank.
    4) Promote beneficial management practices and stewardship agreements by 2013 to reduce threats and conserve habitat for Slender Mouse-ear-cress.
    5) Obtain, by 2017, the dataset necessary for the determination of fluctuations in area of occupancy and population size of known populations.

- Critical habitat is identified in this recovery strategy for the known naturally occurring Slender Mouse-ear-cress populations in Canada.

- An action plan for Slender Mouse-ear-cress will be completed by 2013.

TABLE OF CONTENTS

1. BACKGROUND

1.1. Species Assessment Information from COSEWIC

Common Name: Slender Mouse-ear-cress

Scientific Name: *Halimolobos virgata*

Assessment Summary: May 2000

COSEWIC Status: Threatened

Reason for designation: A biennial species known from fewer than ten sites in very localized areas of southeastern Alberta and southwestern Saskatchewan. There its populations vary considerably in size, from place to place, and yearly, depending on rainfall.

Canadian Occurrence: Alberta, Saskatchewan

COSEWIC Status History: Designated Endangered in April 1992. Status re-examined and designated Threatened in May 2000.

1.2 Description

Slender Mouse-ear-cress (*Halimolobos virgata* [Nutt.] O.E. Schulz) is a member of the Mustard family (Brassicaceae). It produces a basal rosette and taproot during the germination year and a flowering stalk the next year. Although Slender Mouse-ear-cress is thought to be a biennial, it may also complete its growth cycle within one season like an annual (Moss 1994, Alberta Sustainable Resource Development 2005). Plants are densely hairy, covered with greyish forked, multi-branched and often simple hairs (Scoggan 1978, Looman and Best 1979, Smith 1992, Moss 1994). Basal rosette leaves are toothed with stalks (petioles), while leaves on the stem are clasping with ear-like lobes at the base. Leaves get smaller towards the top of the plant. Stems can be branched or single and grow 15-40 cm high (Looman and Best 1979, Moss 1994). Slender Mouse-ear-cress flowers from late May to early June. Its flowers have four whitish petals, measuring 4-8 mm across (Looman and Best 1979, Moss 1994). The fruits pods (siliques) form in June to July, growing up to 4 cm long and 1 mm wide (Fig. 1) (Scoggan 1978, Moss 1994). The pods

Figure 1. Slender Mouse-ear-cress flowers and fruit pods © Environment Canada, Photo: J. Neudorf.

are circular or very slightly compressed in cross-section and are hairless, with the exception of some of the populations in Saskatchewan in which the pods are hairy like the stem (C. Neufeld, pers. obs., T. Sample, pers. comm.); genetic testing may be required to determine whether these are a different species or subspecies. Pods are erect with the stalks usually forming a 45 degree angle with the stem (Fig. 1) (Looman and Best 1979, Smith 2000). When the pods ripen, they turn reddish-brown and split open before mid-July, releasing numerous tiny seeds (Alberta Sustainable Resource Development 2005).

1.3 Populations and Distribution

1.3.1 Global

Slender Mouse-ear-cress is native to North America, occurring in both Canada and the United States (Fig. 2). In Canada, Slender Mouse-ear-cress is found in Alberta and Saskatchewan. In Alberta, Slender Mouse-ear-cress is ranked as critically imperilled to imperilled (S1S2), while in Saskatchewan, it is ranked as critically imperilled (S1) (NatureServe 2009). Nationally in Canada, it has a rank of imperilled N2 (NatureServe 2009). COSEWIC designated Slender Mouse-ear-cress as Endangered in 1992, and reassessed it as Threatened in 2000, based on an updated status report with new information on locations (Smith 1992, COSEWIC 2000, Smith 2000). In the United States, Slender Mouse-ear-cress has a national status of vulnerable (N3), and occurs in seven states (NatureServe 2009). In California, Colorado, and Utah, Slender Mouse-ear-cress is ranked as critically imperilled (S1), in Montana and Wyoming it is ranked as vulnerable (S3), and in Idaho and Nevada a conservation status has not been assessed (SNR) (NatureServe 2009). Globally, despite the imperilled or critically imperilled designations over most of its range, Slender Mouse-ear-cress is ranked as apparently secure (G4), as recommended by Montana botanist, B. Heidel (NatureServe 2009).

Figure 2. Known range of Slender Mouse-ear-cress in North America (from Alberta Sustainable Resource Development 2005).

The nearest known location in the United States is in the Sweetgrass Hills in Montana, only about 10 km from the Alberta and Saskatchewan border (Alberta Sustainable Resource Development 2005). No information is available on the abundance of Slender Mouse-ear-cress in the United States; it is not known what percent of the species global distribution and abundance currently is found in Canada, although it is likely a small proportion (Fig 2).

1.3.2 Canada

In Canada, Slender Mouse-ear-cress is known in localized areas of southeastern Alberta and southwestern Saskatchewan. In Alberta, there are fourteen populations[1] believed to be extant, although two of those do not have accurate and/or precise location information to relocate; three additional populations are historic (>25 years old) and have never been relocated (Fig. 3, Table 1). In Saskatchewan, Slender Mouse-ear-cress is known from seventeen populations, although two of those do not have accurate and/or precise location information to relocate; five additional populations are historic locations (Fig. 3, Table 1).

There is insufficient historical and long-term data collected for this species to determine a population trend. In the case of annual and biennial plants, the location and density of mature plants one year reflects patterns of seed dispersal in previous years. However, because seed can remain dormant in the soil for numerous years, it is difficult to predict the location and density of plants in subsequent years (Chambers and McMahon 1994). Experience thus far indicates boundaries of Slender Mouse-ear-cress populations rarely remain fixed in space or time for this reason.

Another complicating factor is a detection bias where the observers' ability to detect plants differs among years (Pollock *et al.* 2004). With Slender Mouse-ear-cress, this may be caused by the interaction of precipitation stimulating germination and the search efficiency of people looking for these plants. In years with abundant precipitation, more plants germinate and form larger patches of plants which are more easily detected and discovered. In drought years, it is less likely that new occurrences[2] will be discovered, because plants occur as more widely separated and inconspicuous clusters or isolated individuals. These factors present a problem for establishing population and distribution trends because known locations must be revisited and enumerated for three or more years (Brigham and Thomson 2003), preferably with similar growing conditions.

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[1] Using the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) definition, populations are defined as geographically or otherwise distinct groups within a species that have little demographic or genetic exchange (typically one successful breeding immigrant individual or gamete per generation or less) (COSEWIC 2009). NatureServe (2009) uses a set of criteria to determine habitat-based element occurrences for plants, but in the absence of information on seed and gene dispersal we are erring on the side of defining separate populations for distances great than 1 km and for barriers separating occurrences like large waterbodies or rivers. With further research, it may be found that genetic exchange occurs at distances further or less than 1 km, and therefore, our definition of a population may change; this may result in splitting or lumping of sites which will change the number of populations (Table 1), but this itself should not be interpreted as an increasing or decreasing trend. The Canadian population, or total population, is the total number of mature individuals in Canada (equivalent to the term "population" employed by the World Conservation Union) (COSEWIC 2009).

[2] Occurrence is estimated using the guidelines for habitat-based element occurrence definitions by NatureServe (2004). This is the data standard used by NatureServe and all regional conservation data centers from which Environment Canada obtains much of their data on the distribution and abundance of plants. An occurrence is a spatial distribution element, which can vary in both spatial extent and density of plants within. Each population of plants is composed of one or more occurrences.

Several occurrences of Slender Mouse-ear-cress in Saskatchewan and Alberta have been enumerated on two or more occasions, although not always in consecutive years or during similar growing conditions. Resurveys of such sites in years with higher precipitation could lead to reports of increasing trends while resurveying sites after a drought often leads to reports of declining trends, which may just reflect declining precipitation or natural succession of the vegetation, and not necessarily represent a threat to survival of the species throughout its range. The degree to which these sources of bias may affect the data is difficult to evaluate. However, no overall trend in population size or area of occupancy[3] can yet be established throughout the Canadian range of this species; more data is required to establish long-term trends and identify explanatory factors although it is likely that cultivation has reduced the habitat availability and population size.

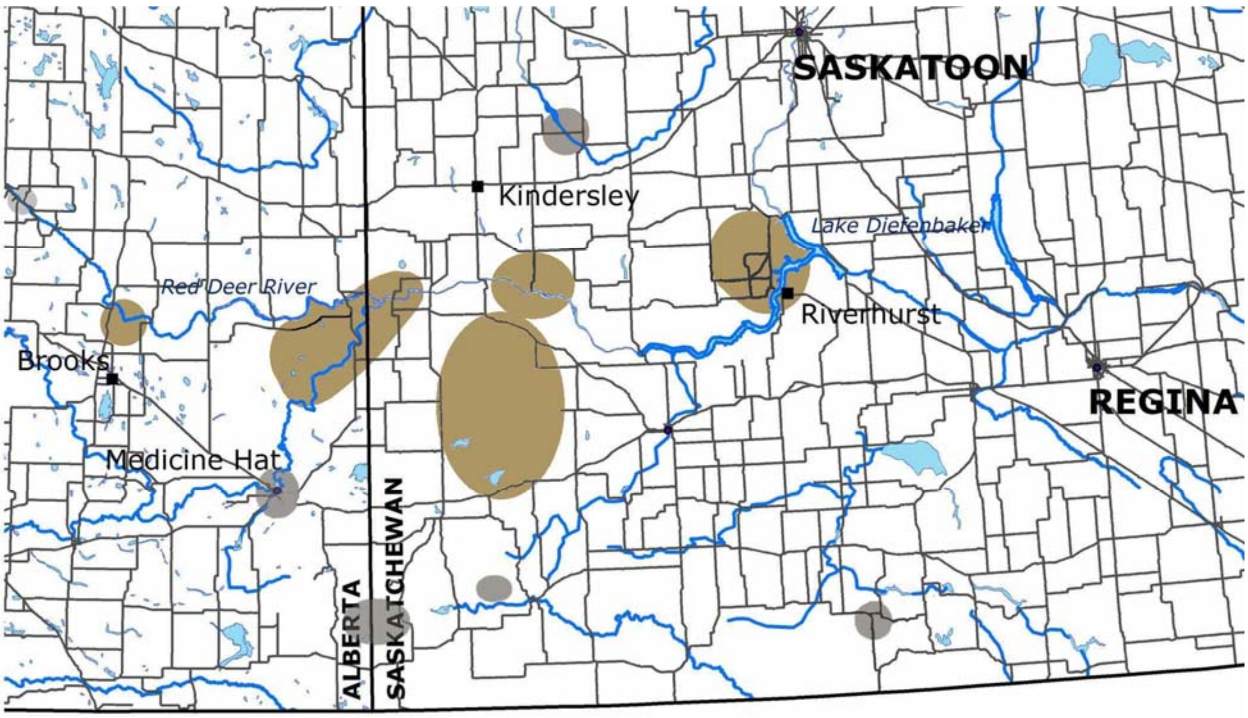

Figure 3. Known range of Slender Mouse-ear-cress in Canada. Note that the brown areas represent recent locations, while the grey areas represent historic locations.

[3] Area of occupancy is the portion within the 'extent of occurrence' (see footnote 5), or range of a species that is actually occupied by the species (COSEWIC 2009). This can also be viewed as the area within a polygon surrounding an occurrence.

Table 1. Summary of Slender Mouse-ear-cress populations in Canada [a,b]. .

Site	Recent Pop. Estimate (Year)[b]	Max. Recorded Pop. (Year) [b]	First Observation Date[b]	Land Tenure	Threats
ALBERTA					
McNeill 1	190 (2004) + 249 (2007) + 59 (2008)[c]	498 (2004/07/08)[c]	1997	Leased AB Crown	Oil and gas activity
McNeill 2	2 (2007) + 7 (2004)[c]	9 (2004/07)	2004	Private	Oil and gas activity
McNeill (Northwest)	13 (2008)	13 (2008)	2008	Leased AB Crown	Oil and gas activity
Remount South	>25 (2008)	398 (2004)	1997	Leased AB Crown	Oil and gas activity
Remount Southeast	919 (2004)	919 (2004)	1997	Leased AB Crown	Oil and gas activity
Remount Northeast	15 (2008)	96 (2007)	2007	Leased AB Crown	Oil and gas activity
Remount Northwest	87 (2008)	87 (2008)	2008	Leased AB Crown	Oil and gas activity, invasive aliens (Crested Wheatgrass)
West of Remount	47 (2008)	47 (2008)	2008	Leased AB Crown	Oil and gas activity, invasive aliens (Crested Wheatgrass)
West of Bindloss	133 (2007) + 1 (2008)[c]	134 (2007/08)[c]	2007	Leased AB Crown	Unknown
South of Empress 1	7 (2008)	7 (2008)	2008	Leased AB Crown	Oil and gas activity, invasive aliens (Crested Wheatgrass)
South of Empress 2	15 (2008)	15 (2008)	2008	Leased AB Crown	Oil and gas activity; invasive aliens (Leafy Spurge, Crested Wheatgrass)
CFB Suffield NWA, Linstead	0 (2005)	20 (1995)	1995	Federal	Oil and gas activity
South SK River, W side	0 (2004)	>100 (1997)[d]	1997	Leased AB Crown	Oil and gas activity
Duchess (Matzhiwin Creek)	0 (2008)	54 (1997)[d]	1997	Private	Oil and gas activity
South SK River, Hwy 41	0 (2002)	>0 (1978)[e,f]	1978	Private, Leased AB Crown	Oil and gas activity, invasive aliens
Rosedale (unconfirmed)	n/a	>0 (1914) [e,f]	1914	Unknown	Unknown
Medicine Hat, Police Point (unconfirmed)	0 (2002)	>0 (1894)[e,f]	1894	Municipal	Urban development
SASKATCHEWAN					
Riverhurst	26+ (2005)	26+ (2005)	1974	Leased SK Crown	Invasive aliens
Macrorie	116 (2005)	116 (2005)	1974	Leased SK Crown	Invasive aliens, past sand/gravel extraction
Coteau	2 (2004)	2 (2004)	2004	Federal	Invasive aliens
Lucky Lake	1 (2005)	34 (1996)	1990	Private	
Great Sandhills – Golden Prairie	100 (2006)[g]	100 (2006)[g]	2006	Private	Oil and gas activity

Table 1 (continued). Summary of Slender Mouse-ear-cress populations in Canada [a,b].

Site	Recent Pop. Estimate (Year)[b]	Max. Recorded Pop. (Year)[b]	First Observation Date[b]	Land Tenure	Threats
Great Sandhills -Prairie National Wildlife Area, Unit 20	1060 (2008)	3678 (2007)	2003	Federal	Invasive aliens
Great Sandhills – East Fox Valley	1 (2006)[g]	1 (2006)[g]	2006	Leased SK Crown	Oil and gas activity
Great Sandhills – East Liebenthal 1	194 (2008) + 132 (2006)[c]	326 (2006/08)[c]	2006	Leased SK Crown, Private	Oil and gas activity, invasive aliens
Great Sandhills – East Liebenthal 2	13 (2008)	13 (2008)	2008	Leased SK Crown	Oil and gas activity, invasive aliens
Great Sandhills – East Liebenthal 3	5 (2008)	5 (2008)	2008	Leased SK Crown	Oil and gas activity
Great Sandhills – East Liebenthal 4	121 (2006)[g]	121 (2006)[g]	2006	Leased SK Crown	Oil and gas activity, invasive aliens
Northeast Lancer	5 (2007)	5 (2007)	2007	Private	Unknown
Lancer	8 (2007)	8 (2007)	2007	Private	Oil and gas activity
South Eston 1	6 (2007)	6 (2007)	2007	Leased SK Crown	Oil and gas activity
South Eston 2	6 (2007)	6 (2007)	2007	Leased SK Crown	Oil and gas activity
S SK River (N Estuary)	2 (1997)	2 (1997)[d]	1997	Leased SK Crown	Unknown
Alkali Creek	21 (1997)	21 (1997)[d]	1997	Private	Unknown
Birsay	0 (2005)	>0 (1974)[e,f]	1974	Private	Invasive aliens
Stranraer	0 (2005)	>0 (1985)[e,f]	1985	Leased SK Crown	
Fairwell Creek (unconfirmed)	n/a	>0 (1895)[e,f]	1895	Unknown	Unknown
Cypress Hills Upland (Sucker Creek) (unconfirmed)	n/a	>0 (1895)[e,f]	1895	Unknown	Unknown
Wood Mountain (unconfirmed)	n/a	>0 (1895)[e,f]	1895	Provincial Park?	Unknown

[a] Note that population sizes are difficult to quantify because of yearly fluctuations in population size and the use of different census techniques. Values and occurrences in the table are those known to Environment Canada as of October 2009.
[b] Sources: Smith (1992, 2000), Robson (1997), MacDonald (2004), ASRD (2005), Godwin and Thorpe (2005), Bradley (2008), ANHIC (2009), Saskatchewan Conservation Data Centre (2009), D. Bush (unpubl. data), C. Neufeld (pers. obs.), T. Freeman (pers. comm.).
[c] These estimates are from multiple occurrences within the same population surveyed during different years.
[d] These occurrences do not have precise and/or location information provided with them and have not been relocated. For the purposes of this strategy they will not be considered for critical habitat identification until they are relocated and precise location information is provided.
[e] No estimate of population size was given with the reported location so it is recorded here as >0.
[f] Plants at these occurrences have not been relocated since first reported, sometimes because the location information provided is not accurate and/or precise enough to relocate the site. They are ≥ 25 years old and for the purposes of this strategy are considered historic and will not be considered for critical habitat identification until they are relocated.
[g] Populations are for a 50 meter radius circular plot; plants outside the plot were not included.

1.4 Needs of Slender Mouse-ear-cress

1.4.1 Habitat and biological needs

Slender Mouse-ear-cress occurs mostly in the Mixed Grassland Ecoregion, but also on the fringe of the Moist Mixed Grassland and potentially the Cypress Uplands, of the Prairie Ecozone in Saskatchewan and Alberta (Wiken 1986, Ecological Stratification Working Group 1995). This area is dominated by a steppe climate (northern cool-temperate zone), characterized as having chronic water deficits resulting from low precipitation, high evaporation, and rapid surface run-off (Fung *et al*. 1999, Smith 1992). There is a strong seasonal pattern in both precipitation and temperature. Mean annual precipitation ranges from 330 to 360 mm, but most of this occurs in summer with a peak in June; winters are relatively dry. Summers are warm with mean July temperature ranges from 18 to 19°C, while winters are cold with mean January temperature ranges from -8 to -11°C (Environment Canada 2009).

Slender Mouse-ear-cress inhabits a range of vernally moist upland sites in flat to very gently undulating terrain, often in low depressions or at the base of slopes and sand dune edges. Soil parent materials include a full range of glacial moraine, fluvial and lacustrine deposits as well as more recent aeolian loess and dunes or colluvial slopes. The varying stages of soil development result in a range of soil suborders from orthic brown and dark-brown chernozems to rego chernozems and orthic regosols. One apparently consistent soil characteristic where Slender Mouse-ear-cress occurs is a sand to loam texture (Ellis *et al.* 1968, Ayres *et al.* 1985, Kjearsgaard and Pettapiece 1986, Saskatchewan Soil Survey 1987, 1990, 1992, and 1993, Alberta Sustainable Resource Development 2005).

Slender Mouse-ear-cress typically inhabits areas that have been lightly disturbed by grazing (Smith 2000, Alberta Sustainable Resource Development 2005, C. Neufeld pers. obs.). For a list of associated plant species, refer to Smith (2000) and Alberta Sustainable Resource Development (2005).

1.4.2 Limiting factors

Slender Mouse-ear-cress relies on ephemeral flushes of resources like moisture and nitrogen for germination and growth. These flushes may be associated with seasonal climate cycles, unusual climatic events, or disturbance that reduces competition for these resources with co-occurring plant species (Harper 1977, Silvertown and Charlesworth 2001). It is probable that seedlings will desiccate if not enough moisture is received in critical growing periods, and seeds may fail to germinate during these times (Alberta Sustainable Resource Development 2005). Since the plants flower in late May to June (Smith 1992; C. Neufeld, pers. obs.), a crucial time for the germination of seeds and/or growth of seedlings might be late April to early May. At a few sites, Slender Mouse-ear-cress was found in relatively large numbers after receiving normal levels of precipitation in May, following a drought year. Other than these few field observations, no research has been done on the germination requirements of Slender Mouse-ear-cress, or on the time of year that seeds germinate and seedlings are produced.

Although typically biennial, some Slender Mouse-ear-cress plants in the United States produce flowers and seeds in the first year, and some biennials may be able to survive more than two seasons if seed is not produced in the second year (Harper 1977, Alberta Sustainable Resource Development 2005). Like most biennial and annual plant species, Slender Mouse-ear-cress may not disperse to new habitable sites quickly, but seeds can remain viable for numerous years until conditions become suitable for seedling establishment at the parent site. Biennials of this nature often produce large numbers of seeds after a local disturbance or unusual climatic event (Harper 1977, C. Neufeld, pers. obs.).

It was thought that Slender Mouse-ear-cress was not able to become re-established on cultivated soil (Smith 2000). However, the species was recently observed on a previously cultivated pasture seeded to Crested Wheatgrass (*Agropyron cristatum*)(Godwin and Thorpe 2005, B. Godwin pers. comm.). Absences of Slender Mouse-ear-cress on other cultivated lands may be from dispersal distance limitations, or lack of adequate time since cultivation to develop conditions suitable for seed germination and growth. There are numerous cases of pipeline right-of-ways adjacent to Slender Mouse-ear-cress populations where plants grow up to the edge of, but not within, the pipeline right-of-way (Smith 2000, C. Neufeld, pers. obs.) This suggests that the disturbance has made the area unsuitable for Slender Mouse-ear-cress, or possibly buried seeds too deep for seedling emergence. Future monitoring of these sites will determine if this effect is temporary.

1.5 Threats

The major threats to Slender Mouse-ear-cress relate to habitat loss and degradation, and changes to ecological dynamics or natural processes. There is also the threat from invasive alien species, and a potential threat from climate change. These are discussed in more detail below in order of importance, with a categorization of the threats in Table 2.

1.5.1 Threat classification

Table 2. Threat Classification Table

1	**Cultivation**	**Threat Information**		
Threat Category	Habitat loss and degradation	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Crop production, cultivation, conversion to tame forages	**Occurrence**[b]	Historic and Current	
		Frequency[c]	One-time/Recurrent	
Specific Threat	Population and habitat permanently reduced, further fragmented, and isolated. Introduction of invasive alien species.	**Causal Certainty**[d]	High	
		Severity[e]	High	
Stress[a]	Plant and seed mortality, reduced population size, loss of habitat.	**Level of Concern**[f]	High	

Table 2 (continued). Threat Classification Table.

2	**Oil and Gas Activities**	**Threat Information**		
Threat Category	Habitat loss or degradation	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Oil and gas activities	**Occurrence**	Current	
		Frequency	One-time/ Recurrent	
Specific Threat	Habitat conversion, habitat fragmentation, disturbance/removal of substrate, introduction of invasive alien species	**Causal Certainty**	Medium-High	
		Severity	Medium	
Stress	Plant and seed mortality, reduced population size, loss of habitat.	**Level of Concern**	High	
3	**Alteration to, or lack of, grazing and/or fire regimes**	**Threat Information**		
Threat Category	Changes in ecological dynamics or natural processes, ultimately leading to habitat loss or degradation	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Alteration to, or lack of, grazing and/or fire regimes	**Occurrence**	Current	
		Frequency	Seasonal and Continuous	
Specific Threat	Plant competition, alteration of habitat characteristics (e.g. litter, bare ground, vegetation height), changes in species community	**Causal Certainty**	Low-Medium	
		Severity	Low-Medium	
Stress	Reduced reproductive output, recruitment and population size, increased mortality, loss of habitat	**Level of Concern**	Medium	
4	**Alteration to hydrological regimes**	**Threat Information**		
Threat Category	Changes in ecological dynamics or natural processes	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Alteration to hydrological regimes (dams, roads, irrigation)	**Occurrence**	Current	
		Frequency	One-time/Continuous	
Specific Threat	Alteration of habitat characteristics (e.g., nutrients, moisture levels); changes in species community (e.g. subxeric community to mesic community); conversion of native prairie to irrigated land; plant competition; reduced water flow; flooding events and sediment deposition downstream of dam; flooding from reservoir inundation	**Causal Certainty**	Medium	
		Severity	Low-Medium	
Stress	Reduced population size, increased mortality	**Level of Concern**	Medium	

Table 2 (continued). Threat Classification Table .

5	Invasive Alien Species	Threat Information		
Threat Category	Exotic, invasive or introduced Species	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Invasive alien species (e.g. Crested Wheatgrass, Smooth Brome, Kentucky Bluegrass)	**Occurrence**	Current	Current/Anticipated
		Frequency	Continuous	Continuous
Specific Threat	Plant competition, alteration of habitat characteristics (e.g. litter, bare ground, vegetation height), changes in species community	**Causal Certainty**	High	High
		Severity	Medium	Low-Medium
Stress	Reduced population size, reduced reproductive output and recruitment, increased plant mortality	**Level of Concern**	Medium	Low-Medium

6	Sand and Gravel Extraction	Threat Information		
Threat Category	Habitat loss or degradation	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Sand and gravel extraction	**Occurrence**	Historical	Anticipated/Unknown
		Frequency	Recurrent	One-time/Recurrent
Specific Threat	Disturbance/removal of substrate and/or seed bed, habitat altered (fragmentation, isolation, degradation), establishment of invasive alien species	**Causal Certainty**	High	High
		Severity	Low	Unknown (could start small and expand)
Stress	Mortality of plants and seeds, reduced population size, loss of habitat	**Level of Concern**	Low-Medium	

7	Urban Development	Threat Information		
Threat Category	Habitat loss or degradation	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Urban development	**Occurrence**	Current	Unknown
		Frequency	One-time	.
Specific Threat	Habitat conversion, fragmentation, isolation, disturbance/removal of substrate and/or seed bed	**Causal Certainty**	High	
		Severity	Low	
Stress	Mortality of plants and seeds, reduced population size, local extinctions	**Level of Concern**	Low	

Table 2 (continued). Threat Classification Table .

8	Military Activities	Threat Information		
Threat Category	Habitat loss or degradation	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Military activities	**Occurrence**	Unknown/Anticipated	
		Frequency	One-time/Continuous	
Specific Threat	Disturbance of substrate, disturbance to plants, alteration of habitat characteristics from military operations and heavy machinery	**Causal Certainty**	Unknown	
		Severity	Low	
Stress	Mortality of plants and seeds, reduced population size	**Level of Concern**	Low	

9	Drought/ Climate Change	Threat Information		
Threat Category	Climate and natural disasters	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Drought/ climate change	**Occurrence**	Currently periodic/Anticipated	
		Frequency	Unknown	
Specific Threat	Change in rainfall and weather patterns, alteration of habitat characteristics (moisture regimes, plant communities), temperature extremes	**Causal Certainty**	Unknown	
		Severity	Unknown	
Stress	Reduced fitness or productivity, plant mortality, increased seed dormancy, decreased seed bank, local extinctions	**Level of Concern**	Low	

[a] Indicators of stress listed in this table are mostly speculative, as research is still needed on the threats and how they impact the species.
[b] Occurrence is defined as 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.
[c] Frequency is defined as a one-time occurrence, seasonal (either because the species is migratory or the threat 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.
[d] Causal certainty is defined as whether the 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).
[e] Severity is defined as high (very large population-level effect), medium, low, or unknown.
[f] Level of concern is defined as to whether managing the threat is an overall high, medium, or low concern for recovery of the species, taking into account all of the above factors.

1.5.2 Description of threats

Cultivation

Fifty-four percent of the Mixed Grassland Ecoregion in Alberta, and 31.3 % in Saskatchewan, is estimated to remain uncultivated (Gauthier *et al.* 2002, Alberta Sustainable Resource Development 2000). The remaining native prairie is fragmented, and most remnant patches are small and isolated from other suitable habitat patches by cropland (James *et al.* 1999). This threatens the natural patterns of seed dispersal and gene flow within former populations and between extant populations. Some of the loamy sand to sandy loam textured soils that Slender Mouse-ear-cress inhabits may not be suitable for agriculture because of low soil moisture, low water-holding capacity, low soil fertility, and susceptibility to wind erosion (Saskatchewan Soil Survey 1993, Geological Survey of Canada 2001); as such, these lands are relatively secure from the threat of cultivation. However, many sandy loam to loam textured soils may still be converted to cropland, perennial forages, hayfields, or potato crops. As well, irrigation and the use of some chemicals (e.g., herbicides, fertilizers, pesticides) on adjacent cultivated areas have the potential to alter the habitat on the native prairie (e.g., change species composition, canopy cover, hydrology, and soil stability, degrade pollinator populations). Cultivation has probably reduced overall habitat availability, population size, and genetic diversity of this species to the point where full recovery to its historical range is no longer possible.

Oil and Gas Activities

Oil and gas activities include a number of processes including exploration, drilling, completion, production and transportation, abandonment and reclamation. The specific threats posed to plant species at risk can vary depending upon the type of petroleum resources extracted[4]. In the Prairie Ecozone, the two most common petroleum resources extracted are crude oil and natural gas. Some process activities are similar between these two. For example, seismic exploration involves single passes overland with trucks >1 tonne, and the creation of very small holes in the soil for equipment. If this occurs between October 31 and March 31, it may pose little harm to plants or their habitat. The drilling process results in the production of waste which can cause localized soil contamination, but it always requires the construction of *surface waste* or *waste plant facilities*. These activities and facilities can directly destroy plants and their habitat.

In almost every other process, crude oil and natural gas activities differ. Natural gas drilling is usually faster because resources occur at shallower depths, and lighter equipment can be used relative to crude oil. In the Prairie Ecozone of Alberta, the Energy Resources Conservation Board (ERCB) in Alberta allows a greater density of oil wells per pool, per section of land (n = 8), than shallow natural gas wells per pool, per section of land (n = 4), or than conventional natural gas wells per pool, per section of land (n = 2). Where pockets of oil resources occur it is possible to have up to 64 wells per section of land due to multiple underlying pools; while natural gas has thus far resulted in maximum densities between 16 and 32 wells per section. Natural gas is more widespread in the dry mixed-grass prairie where most plant species at risk occur, and thus there are more natural gas wells and kilometres of pipeline in total and a greater probability of natural gas wells occurring within or adjacent to Slender Mouse-ear-cress habitat.

Pipelines are needed in nearly all cases to ship petroleum from wells to other facilities. It is possible to minimize the depth, width and duration of soil disturbance and resulting reclamation challenges for many gas pipelines. This is done by installing small-diameter flexible plastic pipes using “plowed-in” techniques, requiring a few passes of vehicles less than and greater than one tonne. For oil or larger volumes of both oil or gas, larger trenches are excavated using many

[4] These “type” categories are those used by the Alberta Energy and Resources Conservation Board (ERCB) to describe oil and gas facilities. A number of “subtypes” are also identified by the ERCB, and are indicated by *italics*.

passes of vehicles greater than one tonne, and there is the creation of compacted "work" and covered "spoil" areas adjacent to the trench. Also, the duration of this type of activity is longer than for small-diameter pipes (Sinton 2001). The more intense soil disturbance associated with trenching has greater potential to promote the colonization of invasive alien species, but the greater linear extent of gas pipelines on the landscape may have a greater potential to promote the spread of invasive alien species after colonization. In addition, plants are always at risk from pipeline ruptures, and the associated equipment traffic needed to fix the rupture and further reclaim the site. The probability or likelihood of these rupture-based threats is unknown.

Completion and production from natural gas wells usually results in a visible pipe valve at the surface, while crude oil not under pressure may require *enhanced recovery facilities* like artificial lifts (i.e. pump-jacks) on site which cover more of the ground's surface. *Gas plants* and *compressor stations* are commonly associated facilities in natural gas fields, and the most *acidic* (a.k.a. sour) gas will require flaring to avoid corrosion of pipelines that transport gas outside the fields. Deposition of sulphurous and nitrogenous compounds in proximity to these facilities can pose a threat to plants and their habitat (see Appendix B). Crude oil is sometimes trucked from the well to the central processing facility. In such cases, above-ground *storage tanks*, all-weather gravel roads, nearly daily truck traffic, and the construction of *terminals* and *tank farms* becomes necessary. Natural gas on the other hand normally requires a decreasing frequency of well site visits to inspect and maintain facilities. Well-site visits can go from up to a dozen the first year down to a single visit per year during most of the well's life span (EnCana personnel, pers. comm.). As a result, dry weather two-track trails are more common access developments for these natural gas wells.

Abandonment and reclamation are more challenging to evaluate as mitigations because criteria and practices have changed frequently, and in the past, for reasons of seed availability, ease of cultivation and use as forage, involved the purposeful introduction of alien invasive species that pose threats to plant species at risk (Sinton 2001).

Overall, the impact intensity of crude oil production is greater than that of natural gas production because of the need for all-weather gravel roads, daily transportation, and increased risk of spills and soil contamination. However, the impact extent of natural gas production is greater than crude oil, because of the widespread occurrence of natural gas relative to the smaller pockets of crude oil production. Where the two activities overlap, operators will share the same transportation networks. The increased traffic that almost always follows from initial development is a concern because habitat will change within a certain distance adjacent to roads, and these changes may be threats to plant species at risk (see Appendix B). Where new resources are discovered as a result of further exploration, the density of facilities can further increase and add to a cumulative effect on the landscape. For these reasons it is difficult to separate oil or gas activities for consideration as threats at this time.

Alteration to, or Lack of, Grazing and/or Fire Regimes

Prairie plants evolved with the ecological processes of fire and grazing which were important for maintaining ecosystem function. However, there has been a reduction in the frequency and extent of prairie fires, as well as a more homogenous pattern of grazing after European settlement (Higgins *et al*. 1989, Frank *et al*. 1998, Brockway *et al.* 2002). It is not known how Slender Mouse-ear-cress populations respond to fire, but they appear to thrive in areas with low to moderate grazing intensity (Alberta Sustainable Resource Development 2005, C. Neufeld pers. obs.). Cattle do not appear to selectively graze Slender Mouse-ear-cress, although incidental grazing and trampling occasionally occur (C. Neufeld, pers. obs.). Light disturbance by cattle or other livestock may assist in opening up small patches of bare sand for seed establishment and in reducing litter and surrounding vegetation to assist in germination. Slender Mouse-ear-cress is classified as an increaser in range surveys in Wyoming (Alberta Sustainable Resource Development 2005), which indicates that it prospers under a modest grazing regime. Over time, a lack of grazing can lead to increased litter depth and vegetation height, resulting in decreased light levels on the soil (Hayes and Holl 2003), which may in turn negatively affect Slender Mouse-ear-cress. It is unknown whether high intensity, long-term grazing that exceeds the carrying capacity of the rangeland would negatively affect Slender Mouse-ear-cress.

Alteration to Hydrological Regimes

Changes to the moisture regime at a site could adversely affect Slender Mouse-ear-cress growth and survival. Developments or disturbance that restrict natural periodic floods, cause unnatural flooding, inhibit channel meandering, or divert water could alter the disturbance regime beyond the range of natural variability, potentially negatively impacting the creation and maintenance of Slender Mouse-ear-cress habitat. The creation of Gardiner Dam in Saskatchewan in 1967 flooded a considerable area of habitat where populations of Slender Mouse-ear-cress are suspected to have occurred (Smith 1992). Other anthropogenic alterations, such as roads, urban developments, and irrigation can also change the hydrology of habitat by modifying drainage patterns and water flow in an area.

Invasive Alien Species

Some invasive alien species can displace native species and decrease species diversity or richness through their superior competitive ability and their negative effects on ecosystem functioning (Wilson 1989, Wilson and Belcher 1989, Reader *et al.* 1994, Christian and Wilson 1999, Bakker and Wilson 2001, Henderson 2005, Henderson and Naeth 2005). There are multiple sites where Crested Wheatgrass and Kentucky Bluegrass (*Poa pratensis*) could threaten populations of Slender Mouse-ear-cress in Saskatchewan and Alberta. Slender Mouse-ear-cress has been found growing among Crested Wheatgrass and Kentucky Bluegrass where it has invaded native prairie, as well as among Crested Wheatgrass in a previously cultivated field (C. Neufeld pers. obs., B. Godwin pers. comm.). However, long-term impacts of these invasive aliens on Slender Mouse-ear-cress presence are not known. There is also the potential for Slender Mouse-ear-cress plants to be killed, or its habitat negatively altered, by indiscriminate use of herbicides intended to control invasive species.

Sand and Gravel Extraction

Sand and gravel extracted from sand dunes is used for road construction, oil and gas activities, agriculture (e.g., potato farming), and personal use. Removal of the soil substrate can not only kill living plants, but also permanently removes all of or portions of the seed bank; this can have

substantial implications for the future survival of populations at those sites. This type of disturbance to the habitat can also lead to introduction and/or invasion by alien species. The former can be mitigated through avoidance of plants and their habitat, while the latter is a cumulative effect of all land uses, including sand and gravel extraction.
Gravel extraction occurred in the past at one occupied site in Saskatchewan, and although the gravel pile still exists it is not in use. An invasive alien (*Poa pratensis*) has invaded the habitat around the gravel pit including the area where Slender Mouse-ear-cress is growing (Smith 2000, C. Neufeld pers. obs.).

Urban Development

Urban development results in direct, irreversible damage to habitat and plants, and indirect damage to adjacent undeveloped habitat. For example, a Slender Mouse-ear-cress population located on adjacent undeveloped land could suffer from the loss of a large portion of the seed bank, invasion by alien species from construction sites or residential areas, and changes to species composition or surrounding vegetation height from increased urban water runoff and fertilizer. In 2004 and 2005, the municipality of Medicine Hat extended its urban development into an area where Slender Mouse-ear-cress may have historically occurred. A historical record from 1894 reported Slender Mouse-ear-cress in the Police Point area of Medicine Hat (Table 1). Plants were never relocated in this area to confirm this record, and it was thought that the site had been already extirpated by a park and golf course. However, an incidental survey conducted prior to the residential development in 2004 resulted in the findings of two endangered species (Tiny Cryptanthe [*Cryptantha minima*] and Small-flowered Sand-verbena [*Tripterocalyx micranthus*]) which were also historically reported for the Police Point area (Environment Canada 2006); it is possible that this was the area referred to in the historical location for Slender Mouse-ear-cress as well. Much of this area has been cleared for roads and housing. Urban developments are effectively permanent, and there is little or no opportunity to mitigate this type of disturbance.

Military Activities

It is not clear how military activities may affect Slender Mouse-ear-cress. Activities such as road creation, use of heavy tracked or wheeled machinery, and military operations can alter native prairie, particularly in sand habitats, by reducing vegetation cover, altering species composition and directly disturbing plants and the seed bed (McKernan 1984, Wilson 1988, Severinghaus 1990). Some minor disturbances, however, may benefit populations by opening habitat and suppressing competition from other plant species. A recent analysis of North American and European military training areas indicates these areas contain large numbers of species at risk and high biodiversity, potentially due to the large tracts of natural vegetation and the heterogeneous disturbance that results in a plethora of different habitats in space and time (Warren *et al.* 2007). Although Slender Mouse-ear-cress has been found only within Canadian Forces Base (CFB) Suffield National Wildlife Area (NWA) where no military activities occur (MacDonald 1997), the potential exists for it to also occur within the adjacent CFB Suffield training area, due to its proximity and very similar habitat characteristics.

Drought/ Climate Change

There is only speculation about what effects climate change will have on this species. A shift towards a warmer climate within its Canadian range as predicted by climate change projections (Government of Canada 2004), may negatively impact Slender Mouse-ear-cress if this results in extended periods of drought. Although Slender Mouse-ear-cress is likely adapted to withstand periodic droughts, it is unknown whether long periods of drought may exceed the longevity of seeds in the seed bank. Seedlings and mature plants may flourish after a sporadic rainfall in spring or fall, but then prematurely die from desiccation in hot, dry summer conditions (Alberta Sustainable Resource Development 2005). Repeated years of this cycle would likely reduce the number of seeds in the seed bank.

1.6 Actions Already Completed or Underway

Slender Mouse-ear-cress status reports for Canada (Smith 1992, COSEWIC 2000, Smith 2000) and Alberta (Alberta Sustainable Resource Development 2005) have been written. The Recovery Team for Plants at Risk in the Prairie Provinces was formed in 2003; recovery of the Slender Mouse-ear-cress is one of the plant species the recovery team addresses. Recovery activities to date have mainly dealt with surveys to assess population size and area of occupancy, and to determine the extent of occurrence within Canada. In 2009, Environment Canada staff started monitoring Crested Wheatgrass encroachment into the Prairie National Wildlife Area, Unit 20, in Saskatchewan where critical habitat is identified for Slender Mouse-ear-cress.

1.7 Knowledge Gaps

One of the main factors that will impede recovery planning activities, in addition to the threats, is a lack of knowledge about this species in terms of basic biology, habitat associations, distribution and abundance, and population viability. Further studies will be an essential component of the overall strategy to recover the species. The sections on approaches recommended to meet recovery objectives, and the recovery planning table provide an indication of how these knowledge gaps will be addressed.

Currently, information that is unknown but required to adequately address threats and recovery objectives includes a need for knowledge on:

1) Standardized guidelines for inventory and monitoring.
2) Area of occupancy, extent of occurrence[5], number of populations and seed bank distribution.
3) Factors affecting population size and area of occupancy fluctuations.
4) Habitat associations and requirements.

[5] Extent of occurrence, as defined by COSEWIC, is “the area included in a polygon without concave angles that encompasses the geographic distribution of all known populations of a species” (COSEWIC 2009).

5) Effect and extent of factors influencing Slender Mouse-ear-cress habitat (e.g., timing and intensity of grazing, idling, fire control, invasive species) and best management practices to reduce threats.
6) Population dynamics and life-history of Slender Mouse-ear-cress including seed production, seed germination rates, seed germination requirements, seed viability, seed dispersal and dispersal distances, mortality rates, predation, seed bank age structure/longevity, pollinators, and genetics (population dynamics). This information is necessary to understand the population viability of the species.
7) Degree and effect of isolation from other populations.
8) Genetic testing for taxonomic clarification with regards to the phenotypic difference in siliques (i.e., hair on pods) seen in some populations in Saskatchewan; this will determine whether they are a different species or subspecies.

2. RECOVERY

2.1 Recovery Feasibility

Under the *Species at Risk Act* (Section 40), the competent minister is required to determine whether the recovery of the listed species is technically and biologically feasible. Based on the following criteria established by Environment Canada (2009) for recovering species at risk, recovery of the Slender Mouse-ear-cress is considered biologically and technically feasible:

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. Reproducing individuals have been found at almost all known locations in recent years, and is it likely a viable soil seed bank also occurs at these locations. Further surveys of suitable habitat may result in the discovery of additional locations. Recent efforts to locate the species have been unsuccessful in some years due to unsuitable weather conditions for germination, difficulty detecting the species where it is known to occur, and uncertainty regarding habitats within which to target search efforts. It is probable that more populations exist than those currently known.

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

Yes. Although the specific habitat requirements for Slender Mouse-ear-cress survival and reproduction are not entirely understood, all known locations consist of native mixed-grass prairie vegetation on coarse-textured soils. This habitat type exists in much greater supply than the area currently known to be occupied by Slender Mouse-ear-cress. For that reason alone, sufficient suitable habitat appears to be available.

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

Yes. The main threats to Slender Mouse-ear-cress recovery are cultivation, oil and gas activities and changes in ecological dynamics or natural processes due to an alteration of grazing and/or fire regimes, ultimately contributing to increased litter cover, or increased abundance of invasive alien species, both of which can reduce habitat availability for annual and biennial plants. Threats can be mitigated through beneficial management practices, habitat protection, or stewardship agreements.

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

Yes. Slender Mouse-ear-cress, like other annual and biennial plants in semiarid environments, is adapted to disturbances such as grazing and fire that reduce litter cover and increase bare soil cover needed for germination and establishment. The main recovery techniques will be maintaining native-dominated mixed-grass prairie vegetation with some bare soil exposure (proportion unknown at this time) using fire, livestock and other tools; and control of invasive alien species with chemical, biological and cultural tools. Measures to reduce the threat of invasive alien species with integrated weed management have been implemented elsewhere in the region, and could be targeted for the recovery of Slender Mouse-ear-cress.

2.2 Population and Distribution Objectives

The population and distribution objectives for the Slender Mouse-ear-cress are to maintain the persistence of known naturally [6] occurring populations within the current range of the species in Canada.

For biennial and annual plants the population size normally fluctuates by one or more orders of magnitude, which complicates setting any achievable or reliable population objectives based on current information (see Section 1.3.2). In addition, the largest and most genetically diverse component of the population of biennials or annuals normally exists as seed in the soil seed bank (Harper 1977, Silvertown and Charlesworth 2001). Therefore, an enumeration of mature individual plants is usually an unreliable indicator of actual population size in the short-term (Brigham and Thomson 2003). Based on its restricted area of occupancy and extent of occurrence, and the naturally rare and fragmented nature of its habitat, this species is naturally rare in Canada. However, by promoting beneficial management practices and stewardship agreements, and mitigating threats, risks to this species can be reduced. Therefore, maintenance of known populations of this threatened species is the most realistic population objective.

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[6] Naturally occurring population refers to any population within the native range on naturally occurring habitat. It excludes horticultural populations or those that are dispersed by humans and establish themselves outside the native range or on unnatural habitats. Note that if a population hasn't been relocated within 25 years, or does not have precise or accurate enough location information for relocation, it is not included in these population and distribution objectives until such time as it is relocated.

Previously-unknown occurrences of Slender Mouse-ear-cress are discovered nearly every year, and much of the available habitat has not been searched using targeted survey methods. Thus, any quantitative distribution objective provided in this recovery strategy would be an underestimate and likely out of date within a year. Further, extrapolation of results from the Great Sand Hills Regional Environmental Study in Saskatchewan indicates at least 101 km^2 of habitat may support Slender Mouse-ear-cress in that 2029 km^2 review area[7] (Government of Saskatchewan 2007). Similar probabilistic sample designs have simply not been implemented elsewhere in adjacent sand dune habitats in Alberta and Saskatchewan, and it is not clear how such a large potential area of occupancy could be effectively monitored. Due to uncertainties regarding the actual area of occupancy, feasibility of monitoring and reporting on that index, and increasing number of newly-discovered occurrences for this species, only a general statement can be provided for a distribution objective.

2.3 Recovery Objectives

Objective 1: Determine area of occupancy and extent of occurrence of additional Slender Mouse-ear-cress populations, to the extent possible by 2013 (Priority - Urgent).

The rationale for this objective is to discover new populations, which is considered reasonable within the time frame considering the challenges associated with surveys for Slender Mouse-ear-cress. This species is difficult to detect, can fluctuate an order of magnitude between years, and has a wide extent of occurrence within which there are large areas of potentially suitable habitat that have not been searched. Because of these factors, and the fact that it is unknown what proportion of Slender Mouse-ear-cress has already been found, it is not possible to predict how many additional plants or populations might be found.

Objective 2: Develop beneficial management practices to reduce threats to Slender Mouse-ear-cress by 2013 (Priority – Urgent).

Objective 3: Fill the knowledge gaps by 2013 on potential habitat, habitat associations, effects of anthropogenic features or invasive alien species, and size and longevity of the species soil seed bank (Priority – Necessary).

Objective 4: Promote beneficial management practices and stewardship agreements by 2013 to reduce threats and conserve habitat for Slender Mouse-ear-cress (Priority – Necessary).

Objective 5: Obtain, by 2017, the dataset necessary for the determination of fluctuations in area of occupancy and population size of known populations (Priority – Necessary)

This objective is aimed at gaining further knowledge into factors influencing fluctuations in population size, identifying the distribution of the seed bank, and assessing the area identified as

[7] Slender mouse-ear-cress occurred in 6 of 120 circular plots, each with a 50 m radius, randomly distributed on native grasslands within a 2028.9 km^2 "review area" that was sampled in 2006. Not all plots were sampled prior to the middle of June, so this is an underestimate because the species is difficult to detect after mid-June (Government of Saskatchewan 2007).

critical habitat. The fluctuating nature of this species would likely prevent analysis in terms of area of occupancy or population size trends until sometime after 2017.

2.4 Approaches Recommended to Meet Recovery Objectives

The intent of this recovery strategy is to provide a general description of the studies and management activities recommended to meet the objectives and address the threats (Table 3). Performance measures to evaluate progress in meeting the recovery objectives are also included in Table 3. The action plan(s) will contain more detailed information on the actions and the implementation schedule.

Table 3. Recovery Planning Table

Threats addressed	Priority	Broad strategy	Recommended approaches to meet recovery objectives	Performance Measures
Objective 1: Determine area of occupancy and extent of occurrence of additional Slender Mouse-ear-cress populations, to the extent possible by 2013.				
Habitat loss and degradation Changes in ecological dynamics and natural processes, Invasive alien species	Urgent	Population inventory	• Develop and apply guidelines to inventory new populations. • Coordinate inventory activities through the Recovery Team to ensure effective and efficient use of funds and labour.	• Guidelines document is created and adopted by all organizations/agencies doing inventory work on this species (EC document in progress). • Additional inventory results in area of occupancy and extent of occurrence mapped for additional populations (ongoing to 2013).
Objective 2: Develop beneficial management practices to reduce threats to Slender Mouse-ear-cress by 2013.				
Habitat loss and degradation, Changes in ecological dynamics and natural processes, Invasive alien species	Urgent	Research	• Determine the impact of threats and management practices on populations and habitats through scientific field investigations, in-situ or ex-situ manipulated experiments. • Apply research findings to develop beneficial management practices (BMPs) for the species.	• Proposals to conduct field investigations, in-situ or ex-situ manipulated experiments will be submitted to funding agencies by qualified researchers (2010-2013). • Proposals to apply research findings for developing BMPs will be submitted to funding agencies by qualified resource management professionals (2010-2013). • BMP literature is written and modified as necessary based on findings from ongoing research and monitoring (2012-2013).
Objective 3: Fill the knowledge gaps by 2013 on potential habitat, habitat associations, effects of anthropogenic features or invasive alien species, and size and longevity of the species soil seed bank.				
Habitat loss and degradation, Changes in ecological dynamics and natural processes, Invasive alien species	Necessary	Research, Habitat Protection	• In addition to identifying or refining area of occupancy above, determine area of potential habitat for Slender Mouse-ear-cress. • Determine effects of anthropogenic features on aspects of Slender Mouse-ear-cress or invasive alien species occurrences • Determine size and longevity of Slender Mouse-ear-cress soil seed banks. • Describe habitat associations.	• Proposals to conduct field investigations, in-situ or ex-situ manipulated experiments will be submitted to funding agencies by qualified researchers (2010-2013). • Recovery team reviews research findings to refine action plan development and critical habitat identification by 2013. • An ex-situ seed bank is established at Plant Gene Resources Canada (Saskatoon) for ongoing research activities (ongoing -2013)..

Table 3. Recovery planning table (continued).

Threats addressed	Priority	Broad strategy	Recommended approaches to meet recovery objectives	Performance Measures
Objective 4: Promote beneficial management practices and stewardship agreements by 2013 to reduce threats and conserve habitat for Slender Mouse-ear-cress.				
Habitat loss and degradation, Changes in ecological dynamics and natural processes, Invasive alien species, Climate change	Necessary	Outreach, Habitat and Species Protection, Management	• Communicate beneficial management practices and recognize existing supportive land management practices and stewardship of habitat where appropriate. • Establish conservation and stewardship agreements with affected landowners, land managers and title holders • Communicate set-back distance guidelines for disturbances to appropriate regulatory agencies.	• BMP literature is published and distributed in various media appropriate for communicating with affected land owners, land managers, industry and stakeholders (2010- 2013); this requires review and input by communications experts. • Conservation or stewardship agreements are in place with affected land owners, managers and title holders. Evaluation criteria includes number of populations protected by stewardship or conservation agreements and an increase in the proportion of habitat conserved (2010-2013). • Meeting with regulatory agencies, industries and other stakeholders to develop set-back distance guidelines appropriate to the recovery needs of the species and activities of the aforementioned partners (2010-2013). • Set-back distance guidelines are distributed in various media appropriate for communicating with affected regulatory agencies, industries and other stakeholders by 2013; this requires review and input by legal and communications experts.
Objective 5: Obtain, by 2017, the dataset necessary for the determination of fluctuations in area of occupancy and population size of known populations.				
All threats	Necessary	Population Monitoring	• Develop and apply guidelines to monitor existing populations. • Coordinate monitoring activities through the Recovery Team to ensure effective and efficient use of funds and labour. • Monitor and map known occurrences over multiple years to increase information on area of occupancy.	• Guidelines document is created and adopted by all organizations/agencies doing monitoring work on this species (EC document in progress). • Additional monitoring results in area of occupancy mapped for populations with data collected on fluctuations in population size (ongoing to 2017).

2.5 Critical Habitat

Critical habitat is defined in the *Species at Risk Act* (S.C. 2002, c.29) section 2(1) 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".

2.5.1 Approaches to Identifying Critical Habitat

The approach used for identifying critical habitat for Slender Mouse-ear-cress is based on a decision tree developed by the Recovery Team for Plants at Risk in the Prairie Provinces, as a guidance for identifying critical habitat for all terrestrial and aquatic prairie plant species at risk (see Appendix A).

The first decision is regarding the quality of available information on Slender Mouse-ear-cress occurrences in Canada, with the choice of accepting or rejecting any given occurrence for consideration as critical habitat based on three criteria that were used to define the quality of information. The three criteria relate to the number of years since the last known occurrence was relocated and/or revisited, the precision and accuracy of the geographic referencing systems used to locate the occurrence and an evaluation of whether the habitat, in its current condition, remains capable of supporting the species. If the result of this first decision is that a given occurrence is accepted for consideration as critical habitat, then the second decision can be considered. If the result of this first decision is that a given occurrence is not accepted for consideration, then the location of the postulated occurrence is excluded from consideration as critical habitat at this time. However it may be considered in future identification of critical habitat, depending on the outcome of future surveys.

The second decision is based on how well the habitat is defined. If habitat is not well defined, as in the case of the Slender Mouse-ear-cress, critical habitat consists of the area encompassing the occurrence (area of occupancy of the population) and all natural landform, soil, and vegetation features within a 300 m distance of the occurrence.

Slender Mouse-ear-cress habitat is certainly restricted to semi-arid, unconsolidated and barren sandy soils, with no shrub or forest overstory. These areas are influenced by some level of disturbance and are poorly defined in space and time. Thus, critical habitat for the Slender Mouse-ear-cress at this time is identified as the area encompassing the occurrence (area of occupancy of the population) and all natural landform, soil, and vegetation features within a 300 meter distance of those plants. All existing human developments and infrastructure within the area identified as critical habitat are exempt from consideration as critical habitat. The 300 m represents the minimum distance needed to maintain the habitat required for long term survival of the species at this occurrence. This specific distance was based upon a detailed literature review that examined edge-effects of various land use activities that could affect resource availability for native prairie plants generally, and could contribute to negative population growth (see Appendix B).

2.5.2 Identification of the Species' Critical Habitat

Critical habitat is identified for Slender Mouse-ear-cress in this strategy. A map showing the location and extent of the critical habitat is provided in Appendix C. The total area of critical habitat identified is 1372 hectares (13.7 km^2), with 648 hectares identified in Alberta and 724 hectares identified in Saskatchewan; the actual area of critical habitat will be slightly less with the above-mentioned exclusions. This occupies or overlaps into 109 quarter sections of land in the Dominion Land Survey System (57 in Saskatchewan, 52 in Alberta) (see Appendix D). In Saskatchewan, 27 quarter sections contain portions of critical habitat that are provincially owned, 12 that are privately owned, 7 that are federally owned (Environment Canada and Agriculture and Agri-Food Canada), 2 that have both federal and privately owned portions, and 9 that have both provincial and privately owned portions. In Alberta, 2 quarter sections are privately owned, 42 are provincially owned and 8 are federally owned. Out of the total number of quarter sections with critical habitat, 13 are found within federal protected areas, including 8 within the Suffield National Wildlife Area, Alberta, owned and administered by the Department of National Defence, and 5 within a National Wildlife Area in Saskatchewan, owned and administered by Environment Canada. The critical habitat boundaries displayed in Appendix C have not excluded existing human developments and infrastructure, cultivated land, rivers, wetlands and unsuitable natural vegetation and landforms but these are exempt from the identification of critical habitat as per the approach described above (Section 2.5.1).

In accordance with Section 124 of the *Species at Risk Act*, the precise locations of Slender Mouse-ear-cress occurrences are not included in this document to protect the species and its habitat. In order to locate this critical habitat, a list of quarter sections is provided (Appendix D). All jurisdictions and landowners who are controlling surface access to the area, or who are currently leasing and using parts of this area, will be provided with Geo-referenced Information System spatial data or large-format maps delineating the critical habitat delineated in Appendix C upon request. No permanent signs have been, or will be, placed in the field to delineate this critical habitat. The location information is housed with Environment Canada, Prairie and Northern Region, Environmental Stewardship Branch, Edmonton, Alberta.

2.5.3 Examples of Activities Likely to Result in Destruction of Critical Habitat

Destruction is determined on a case by case basis. Destruction would result if 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 a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time (Government of Canada 2009).

Examples of activities that may result in destruction of critical habitat include, but are not limited to:

1) Compression, covering, inversion, or excavation/extraction of soil – Examples of compression include the creation or expansion of permanent/temporary structures, trails, roads, repeated motorized traffic, and objects that concentrate livestock activity and alter current patterns of grazing pressure such as spreading bales, building new corrals, adding

more salting stations, or adding more water troughs. Compression can damage soil structure and porosity, or reduce water availability by increasing runoff and decreasing infiltration. Examples of covering the soil include the new creation or expansion of permanent/temporary structures, spreading of solid waste materials, or roadbed construction. Covering soil prevents solar radiation and water infiltration. Examples of soil inversion and/or excavation/extraction include new or expanded cultivation, sand and gravel extraction pits, dugouts, road construction, pipeline installation, and stripping of soil for new well pads or fireguards. Soil inversion or extraction can alter soil porosity, and thus temperature and moisture regimes, such that vegetation communities change to those dominated by competitive weedy species. Activities required to manage, inspect and maintain existing facilities and infrastructure, which are not critical habitat but whose footprints may be within or adjacent to the identified critical habitat, are not examples of activities likely to result in the destruction of critical habitat due to soil compression, covering, inversion, or excavation/extraction, provided that they are carried out following the most current guidelines aimed at protecting the critical habitat of the Slender Mouse-ear-cress (e.g., Henderson 2010).

2) Alteration to hydrological regimes - Examples include temporary or permanent inundation resulting from construction of impoundments downslope or downstream, and accidental or intentional releases of water upslope or upstream. As the seed bank and plants of Slender Mouse-ear-cress are adapted to semi-arid conditions, flooding or inundation by substances like water or hydrocarbons, even for a short period of time, can be sufficient to alter habitat enough to be unsuitable for survival and re-establishment. Even construction of a road can interrupt or alter overland water flow, altering the conditions of the habitat required for the long-term survival of the species at this occurrence enough to render it unsuitable for growth.

3) Indiscriminate application of fertilizers or pesticides – Examples of both herbicide and fertilizer effects that change the habitat include increasing soil water and nutrient availability such that species composition of the surrounding community changes. These changes in addition to the altered interspecific competition that results from them could render the habitat unsuitable for the species at risk. Additional examples are the single or repeated use of broad-spectrum insecticides that may negatively affect pollination and reduce reproductive output, such that the functioning of critical habitat may be negatively impacted.

4) Spreading of wastes – Examples include spreading of materials such as manure, drilling mud, and septic fluids. These have the potential to negatively alter soil resource availability, species composition, and increase surrounding competitor plants, such that population declines occurs. Unlike covering the soil, these liquid or semi-liquid materials can infiltrate the surface in the short-term, but leave little long-term evidence at the surface that could point to the cause of negative changes observed thereafter.

5) Deliberate introduction or promotion of invasive alien species – Examples of deliberate introduction include intentional dumping or spreading of feed bales containing viable seed of invasive alien species, or seeding invasive alien species onto a disturbed area

within critical habitat where the invasive alien species did not already occur. Examples of deliberate promotion include use of uncleaned motorized recreational vehicles on existing race courses, where many of the vehicles arrive contaminated from off-site use and represent significant dispersal vectors for invasive alien species. Once established, these invasive alien species can alter soil resource availability and directly compete with species at risk, such that population declines occur. The following invasive alien species are not restricted by any other legislation due to their economic value, yet invasion by these species could destroy critical habitat for Slender Mouse-ear-cress: Smooth or Awnless Brome (*Bromus inermis*), Crested Wheatgrass, Yellow Sweet Clover (*Melilotus officinalis*), White Sweet Clover (*Melilotus alba*), and Baby's Breath (*Gypsophila elegans*). This form of destruction is often a cumulative effect resulting from the first four examples of critical habitat destruction.

While the human activities listed above can destroy critical habitat, there are a number of activities that can be beneficial to the Slender Mouse-ear-cress and its habitat. These activities are described in Appendix E.

2.6 Effects on Other Species

A number of other federally listed species at risk that occur in the vicinity of Slender Mouse-ear-cress rely on sandy environments in the Canadian prairies for their survival. These species include Tiny Cryptanthe (endangered), Small-flowered Sand-verbena (endangered), Burrowing Owl (*Speotyto cunicularia*, endangered), Sprague's Pipit (*Anthus spragueii*, threatened), Loggerhead Shrike (*Lanius ludovicianus excubitorides*, threatened), Great Plains Toad (*Bufo cognatus*, special concern), Gold-edged Gem (*Shinia avemensis*, endangered), Dusky Dune Moth (*Copablepharon longipenne*, endangered), Pale Yellow Dune Moth (*Copablepharon grandis*, special concern), and Ord's Kangaroo Rat (*Dipodomys ordii*, endangered).

All of these species may benefit from research on dunes, mitigating threats to dunes, and the identification of management activities necessary to maintain dune ecosystems. Sand hill and sand plain communities are very diverse and management actions will need to maintain a variety of stages of dune stabilization (i.e., stabilized to active) to ensure ecological diversity is maintained. Management practices, including disturbances such as fire and grazing, are natural components of prairie ecosystems and should not negatively impact other native species particularly if the timing, intensity and frequency mimic natural processes (Samson and Knopf 1994). Fire and grazing practices tend to reduce invasive alien species and some competitively dominant native species, which is usually beneficial to an ecosystem (Higgins *et al.* 1989, Milchunas *et al.* 1989, Milchunas *et al.* 1992). However, management or recovery decisions should be made that benefit all target species and minimize negative effects to non-target native species. Efforts should be coordinated with other recovery teams working in the dune ecosystem to help ensure the most efficient use of resources, and to prevent duplication of effort and conflicts with research. The creation of a multiple-species action plan may be beneficial for species inhabiting this ecosystem and should be considered (e.g., Multiple Species at Risk, or MultiSAR in Alberta, Downey *et al*. 2005).

2.7 Recommended Approach for Recovery Implementation

An ecosystem or multi-species approach is recommended to implement approaches identified in this recovery strategy (see Section 2.4), in cooperation with jurisdictions responsible for the species.

2.8 Statement on Action Plan

An Action Plan for Slender Mouse-ear-cress will be completed by 2013.

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APPENDIX A. Decision Tree for Determining the Type of Critical Habitat Identification Based on Biological Criteria

This decision tree was developed by the Recovery Team for Plants at Risk in the Prairie Provinces, to guide the approach for identifying critical habitat for all terrestrial and aquatic prairie plants species at risk.

The first decision is regarding the quality of available information on the species occurrences in Canada, with the choice of accepting or rejecting any given occurrence for consideration as critical habitat based on three criteria.

The second decision is based on how well the habitat is defined. If habitat is not well defined, critical habitat consists of the area encompassing the occurrence and all natural landform, soil, and vegetation features within a 300 m distance of the occurrence.

For species that occupy well-defined and easily-delineated habitat patches, a third decision relates to the ease of detection of the species and the spatial and temporal variability of their habitat.

Decision Tree:

1a. Occurrences have not been revisited for >25 years, **or** use imprecise and/or inaccurate geographic referencing systems, **or** the habitat no longer exists at that location to support the species (no critical habitat will be defined until more is known about the population and location)
1b. Occurrences have been relocated and revisited in past 25 years, **and** habitat has been revisited in past 5 years to confirm it has the potential to support an occurrence, **and** geographic reference is accurate and precise (go to 2)

2a. Species is a generalist associated with widespread habitats, **or** a specialist that occupies dynamic disturbance regimes difficult to delineate as patches in space, **or** occupies habitat that is otherwise poorly defined (***critical habitat area = occurrences +*** all natural landform, soil, and vegetation features within a 300 m distance of each occurrence.
2b. Species occupies well-defined and easily delineated habitat patches in space (go to 3)

3a. Habitat patches are spatially static in the medium to long term, **or** species is easy to reliably detect (***critical habitat area = occupied habitat patches +*** all natural landform, soil, and vegetation features within a 300 m distance of the habitat patches.
3b. Habitat patches are spatially dynamic in the medium to long term, **or** species is difficult to reliably detect (***critical habitat area = occupied and potentially occupied habitat patches +*** all natural landform, soil, and vegetation features within a 300 m distance of the habitat patches).

Notes

Criterion 1a is consistent with NatureServe guidelines for data quality, in that records >25 years old with no subsequent revisit record are least accurate.

Criterion 1b is consistent with SARA Sections 46 and 55 which require reporting on progress towards meeting recovery objectives at five-year intervals.

Criteria 2a, 3a and 3b are consistent with recommendations in Appendix B. In some cases a large barrier exceeding 150 m in width creates a discontinuity in the natural habitat within the 300 m, like a major river channel or cultivated field. These barriers effectively overwhelm other edge effects at the distal end of the 300 m, or prevent effective dispersal of the plant at the proximal end closest to the occurrence. In these particular cases, some patches of natural vegetation on natural landforms within a distance of 300 m, but discontinuous from the habitat occupied by the plants, may be exempt from consideration as critical habitat.

Criterion 3 will be applied only after the results of appropriate studies indicate something beyond Criterion 2 can be defended biologically.

APPENDIX B. Rationale for Including a Distance of 300m from Plant Occurrences in the Critical Habitat Identification

Critical habitat will always be spatially linked to confirmed locations of individual plant species at risk. Terrestrial plants are sessile and their propagules (seeds, rhizomes, or stolons) are more dispersal-limited than the offspring of mobile organisms like vertebrates and invertebrates. Terrestrial plants also compete for the same primary resources of space aboveground for sunlight and gas exchange, and space belowground for water and nutrients. To protect habitat critical for survival of a plant, it is also necessary to protect the current distribution of these resources where the plants are known to occur. Any human activity that could disrupt this otherwise natural distribution of resources could effectively destroy critical habitat for a plant species at risk. Often human activity may occur at one site but the effects of that activity occur at another site. Alternatively, the effect of human activity may decline with distance from the site where the activity took place, or the effects of human activity could be cumulative over time (Ries *et al.* 2004). The question then becomes, what is a reasonable minimum distance from the occurrence of a plant species at risk that may encompass habitat required for its survival or recovery? The answer will define the area requiring protection as critical habitat under the *Species at Risk Act* (SARA).

Protection of Habitat Subject to Edge-Effects of Human Activities

An area including a distance of 300 m from detectable plants will be critical to ensure long-term survival of plant populations.

Edge Effects of Soil Disturbance
The only research to actually describe edge effects on short-term survival of plant species at risk indicated that 40 m was the minimum distance needed to avoid negative impacts of road dust on plant health and population growth (Gleason *et al.* 2007); however, that was also the maximum distance at which measurements were made. In detailed reviews by Forman and Alexander (1998) and Forman *et al.* (2003), most roadside edge effects on plants resulting from construction and repeated traffic have their greatest impact within the first 30 to 50 m. However, salinity, nitrogen and hydrological effects could extend 100 to 200 m from a road, and invasive alien species may spread up to 1 km. Invasive alien species have the potential to competitively exclude plant species at risk, and alter the ecosystem such that the plant species at risk can no longer use the habitat. This particular threat may then destroy critical habitat, without some active restoration.

Hansen and Clevenger (2005) observed no decline in the frequency of invasive alien species up to 150 m away from roads and railways in a grassland environment, although sampling did not extend further than 150 m. Gelbard and Harrison (2005) concluded that edge effects of roads on the plant and soil habitat was such that invasive alien species could more readily establish and survive within 10 m of roads compared with plants up to 1000 m from roads. Of course, not all roads are the same and Gelbard and Belnap (2003) found that paved or graded roads tend to have a higher cover and richness of invasive alien species compared with 4 x 4 vehicle tracks. All classes of road created habitat for the dispersal and establishment of these species in roadside verges and 50 m beyond. The difference was that greater frequency of traffic and intensity of disturbance on improved roads increased the process of invasion.

The road density typical of the Canadian prairies is one road every 1.6 to 3.2 km through road allowances in the Dominion Land Survey grid system. As such, it is unlikely that source populations for invasive alien species can be accurately identified beyond 800 m from roadside or cultivated field edges (the center of a 1.6 x 1.6 km section assuming it is surrounded by roads or cultivated lands). Considering that significant effects of invasive alien species can currently be detected up to 150 m from roads and other developed sites, but can occur >800 m from a source population, some compromise distance between 150 and 800 meters seems reasonable for protection of critical habitat.

Edge Effects of Atmospheric Industrial Emissions
Atmospheric emissions from industrial activity, including intensive agriculture, can lead to a cumulative deposition of nitrogen on surrounding soils. Elevated concentrations become analytically detectable in plants and soils up to 1 to 2 km away (Meshalkina *et al.* 1996, Hao *et al.* 2006). It is not clear if these detectable increases in macronutrients are biologically meaningful, but since most plant species at risk occupy nutrient-poor, early to mid-successional grassland habitats, any increase in soil nutrient availability is likely to intensify competition, speed succession, and eliminate habitat critical for the species survival.

Reich *et al.* (2001) observed an increase in the productivity of Hairy Prairie Clover (*Dalea villosa*) in response to nitrogen fertilizer, but in a mixed community any positive effect would be offset by the greater productivity response of other competing species. Kochy and Wilson (2001) observed nitrogen deposition in Elk Island National Park several kilometers downwind of petroleum refineries and an urban center to be 22 kg ha^{-1} $year^{-1}$, while background rates in the wilderness of Jasper National Park were only 8 kg ha^{-1} $year^{-1}$. These increased deposition rates appeared to promote forest encroachment at the expense of native grasslands at Elk Island, moreso than rates at Jasper. Experiments by Plassmann *et al.* (2008) found that low additions of nitrogen (15 kg ha^{-1} $year^{-1}$) to sand dunes increased germination rates of annual plants from the seedbank, which risks depleting the seedbank and eliminating a species from a low-nitrogen site to which it is adapted.

Similar to the effects of industrial emissions, some invasive alien species like the legume sweet clover (*Melilotus* spp.) can elevate soil nitrogen through biological fixation and facilitate invasions by other invasive alien species (Jordan *et al.* 2008; Van Riper and Larson 2009). This particular plant has become one of the most widespread invasive alien species in the northern Great Plains, due initially to deliberate planting in roadside edges, forage crops, and other reclaimed areas (Lesica and DeLuca 2000). These findings reinforce the idea that an area greater than 150 m to avoid invasive alien legumes, and possibly greater to avoid negative effects of industrial nitrogen and sulphur emissions, is necessary to protect habitat critical for prairie plant species at risk.

Edge Effects of Fluid Spills
Water, hydrocarbons or other fluids leaking from pipeline ruptures will have edge effects that vary greatly depending upon topography of the site. For example, an Alberta Energy Resources Conservation Board (ERCB) investigation during 2008 at CFB Suffield found a surface leak of crude oil spread 165 m along ungulate trails and ultimately covered 1200 m^2 of native grassland, killing more than 200 migratory birds (ERCB Investigation Report 2009-06-18). A second incident investigated by ERCB involved a natural gas blowout that released “lower explosive levels” of gas at 100% within 50 m of a wellhead decreasing to 0% at 500 m. This incident also involved a spill of fluids up to 25 m from the wellhead that resulted in excavation and removal of 540 tonnes of soil for remediation (ERCB Investigation Report 2009-06-01). ERCB investigations elsewhere have found oil spills that spread 1.6 km across the surface from rupture points before clean-up could begin (ERCB Investigation Report 2007-05-09).

As plants are not mobile, flooding and inundation for any period of time may be sufficient to destroy critical habitat for several months, years, or decades. The probability of such a rupture is unknown, particularly in proportion to the density of all existing and planned pipelines, and in proportion to habitat availability and species at risk occupancy in the area. The risk of an irreversible change to the habitat is high, so critical habitat should not permit the addition of more pipelines within several hundred meters of plant occurrences.

Summary
All of the factors discussed above are potentially cumulative, particularly in the more industrialized parts of southern Alberta and south-western Saskatchewan. Industrial emissions, road construction, and fluid spills are logically co-located land use activities, and land spreading of agricultural wastes can add to the effects. Given the uncertainty regarding the outer distance for possible edge effects exceeding 150 meters, and the difficulty of identifying a point source for effects beyond 800 m, a precautionary approach is to include a distance of 300 m from plant species at risk occurrences as habitat critical to survival of the species. This value of 300 m is simply twice the 150 m value for which published evidence indicates that significant negative effects can occur to the habitat of plant species at risk. A doubling of the 150 m value is intended to be precautionary to avoid the risk of irreversible destruction of critical habitat.

Research is needed to more specifically address the edge-effects of major land use activities on habitat critical to survival of prairie plant species at risk. A smaller or larger distance may be suggested based on the results of that research, and changes to the definition of habitat critical to survival of prairie plant species at risk could result from that work.

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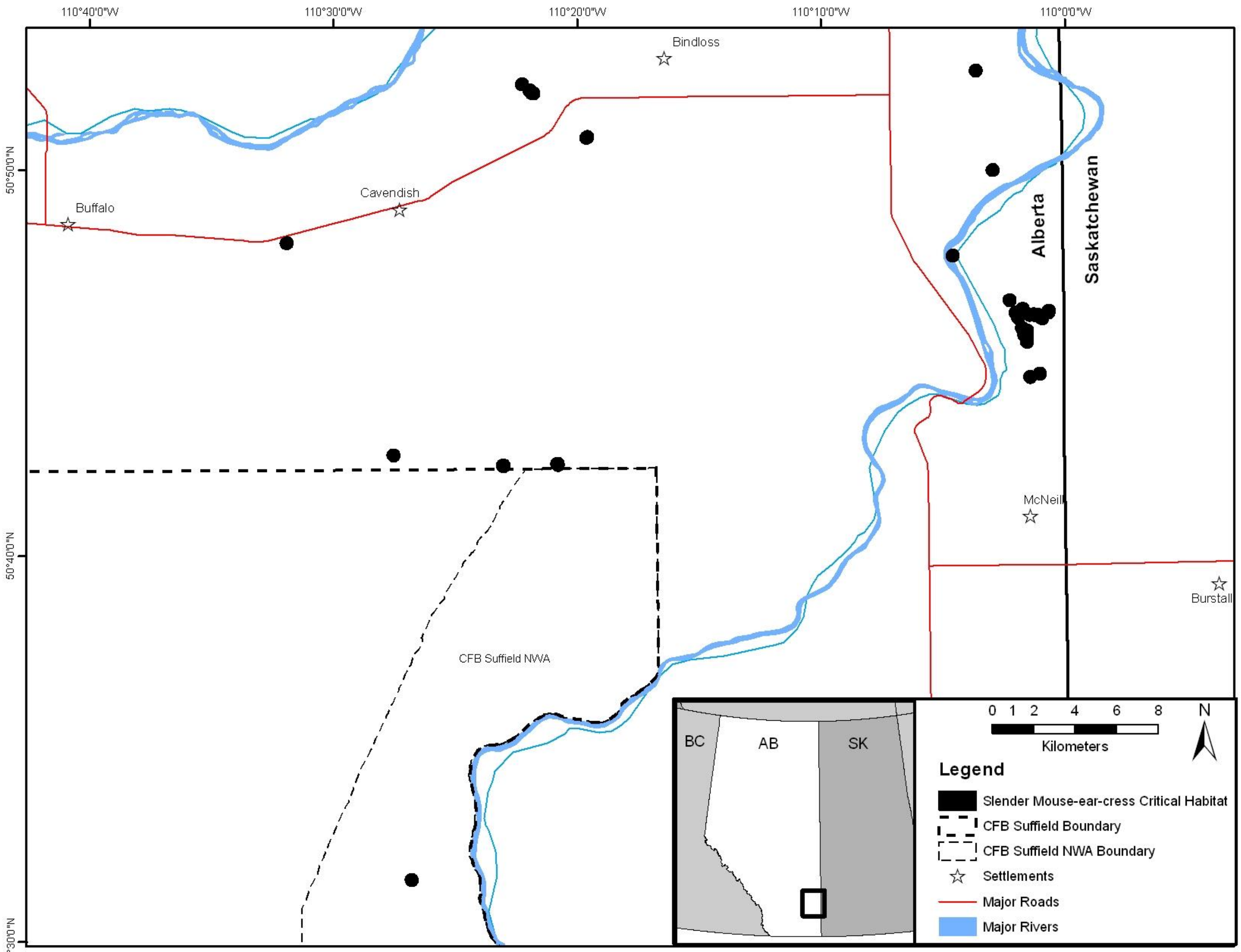
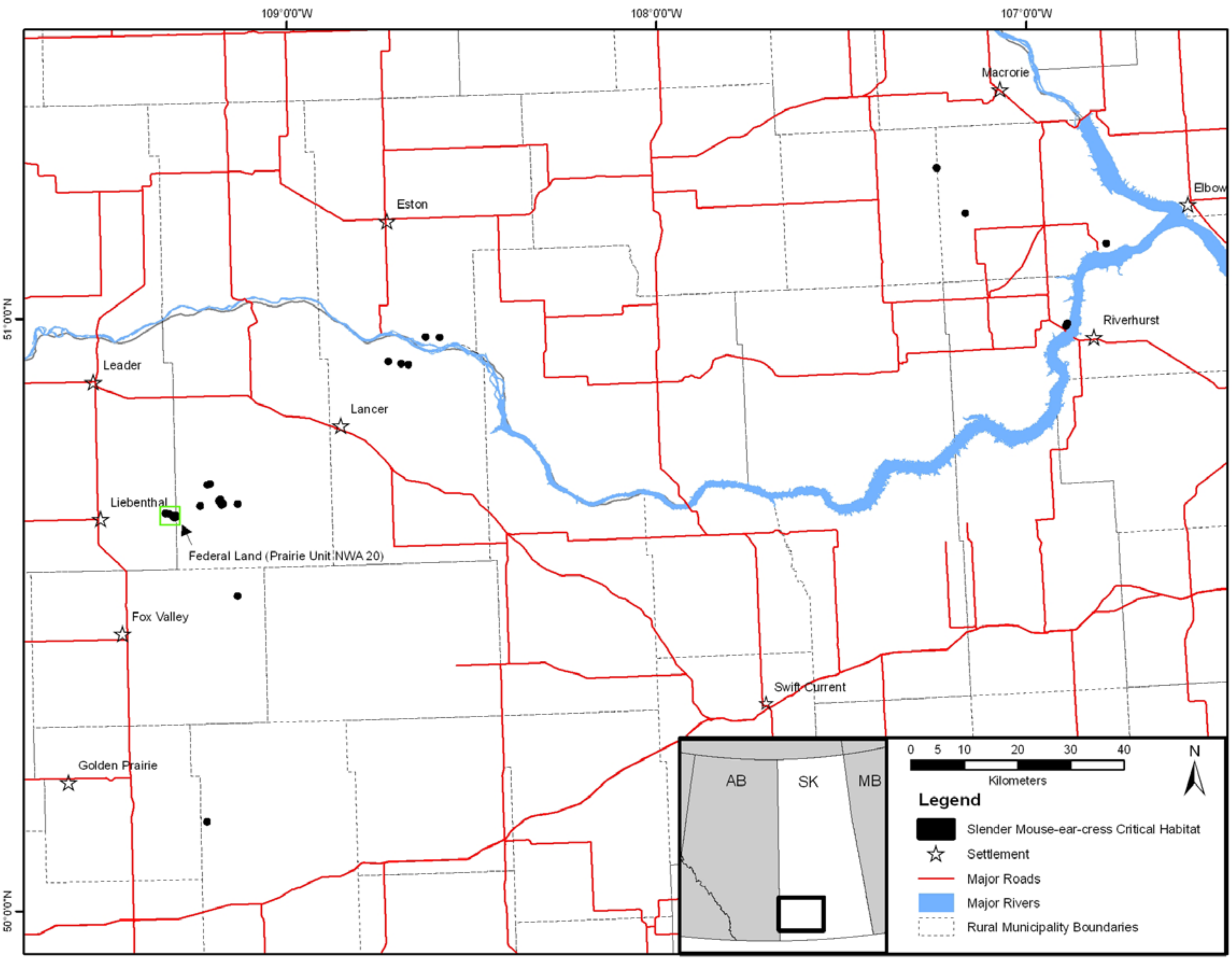
APPENDIX C. Maps of Critical Habitat for Slender Mouse-ear-cress in Canada



Location of critical habitat for Slender Mouse-ear-cress in Alberta.



Location of critical habitat for Slender Mouse-ear-cress in Saskatchewan

APPENDIX D. Quarter Sections in Canada Containing Critical Habitat for Slender Mouse-ear-cress[8]

SASKATCHEWAN					
Quarter section	**Section**	**Township**	**Range**	**Meridian**	**Tenure**
NE	6	14	24	3	private
NW	18	18	23	3	provincial
NE	13	18	24	3	provincial
NW	31	19	24	3	private
NE	36	19	25	3	private
NE,SE	7	20	23	3	provincial
NW,SW	8	20	23	3	provincial
SW	6	20	24	3	provincial, private
SE,NE	9	20	24	3	provincial
NE	11	20	24	3	provincial
NE,SE,SW	12	20	24	3	provincial
NW	12	20	24	3	private
SW	13	20	24	3	provincial
SE	14	20	24	3	provincial
NE,NW	22	20	24	3	provincial
NW	23	20	24	3	provincial
SW	26	20	24	3	private
SE	27	20	24	3	provincial
NW, SW	1	20	25	3	federal (EC-NWA), private
SE	1	20	25	3	federal (EC-NWA)
NE,SE	2	20	25	3	federal (EC-NWA)
NW	27	22	20	3	provincial
NE	31	22	20	3	private
SE	31	22	20	3	provincial
NW,SW	32	22	20	3	private
SE,SW	33	22	20	3	private
SW	34	22	20	3	private
SW,NW	4	23	7	3	provincial, private
NE,SE	5	23	7	3	provincial, private
NE	8	23	19	3	private
SW	16	23	19	3	provincial
SE	17	23	19	3	provincial
SW	18	23	19	3	provincial
NE,SE	19	24	6	3	federal (AAFC)

[8] Quarter sections identified in this table include those within which are located the boundaries of critical habitat as described in 2.5.1. The table may include some quarter sections which are, in fact, excluded because they consist of anthropogenic features or other exemptions listed in Appendix A

SASKATCHEWAN					
Quarter section	**Section**	**Township**	**Range**	**Meridian**	**Tenure**
NW,SW	20	24	16	3	federal (AAFC)
NE	9	25	9	3	private, provincial
NW	10	25	9	3	private, provincial
SW	15	25	9	3	private, provincial
SE	16	25	9	3	private, provincial
NW,SW	7	26	9	3	provincial
NE,SE	12	26	10	3	provincial

ALBERTA					
Quarter section	**Section**	**Township**	**Range**	**Meridian**	**Tenure**
NE,NW	14	18	4	4	federal (DND-NWA)
SE,SW	23	18	4	4	federal (DND-NWA)
NE	35	20	1	4	provincial
SE	35	20	1	4	private
NE,SW	36	20	1	4	provincial
NW	36	20	1	4	private
NW	15	20	3	4	federal (DND-NWA)
NE	16	20	3	4	federal (DND-NWA)
NE,NW	17	20	3	4	federal (DND-NWA)
SE,SW	20	20	3	4	provincial
SE	21	20	3	4	provincial
SW	22	20	3	4	provincial
NW,SW	23	20	4	4	provincial
NW,SW	1	21	1	4	provincial
NE,SE	2	21	1	4	provincial
NE,NW,SE,SW	11	21	1	4	provincial
NE,NW,SE,SW	12	21	1	4	provincial
SE,SW	14	21	1	4	provincial
SE	21	21	1	4	provincial
NE	34	21	1	4	provincial
NW	35	21	1	4	provincial
NE	19	21	4	4	provincial
NW	20	21	4	4	provincial
NE,NW,SE	15	22	1	4	provincial
NW	2	22	3	4	provincial
NE	3	22	3	4	provincial
NW,NE	9	22	3	4	provincial
SE	10	22	3	4	provincial
SW	11	22	3	4	provincial
NW,SE,SW	16	22	3	4	provincial
NE,SE	17	22	3	4	provincial

APPENDIX E. Beneficial or Best Rangeland Management Practices

Slender Mouse-ear-cress occupies a variety of locations that vary in ecology, land use history, and land tenure in two provinces. For these reasons, it is not possible to propose a general set of beneficial or best rangeland management practices that would be appropriate for all locations of critical habitat. Instead, specific recommendations will be made in multiple Action Plans at scales appropriate for general recommendations and application. At this time only a few general statements can be made regarding on-going activities that benefit Slender Mouse-ear-cress.

Grazing by one or more classes of livestock may help maintain open sandy habitats needed by Slender Mouse-ear-cress, much the way wild ungulates would have historically. Management of these livestock requires occasional and randomly dispersed overland access on-foot, on-horseback, by all terrain vehicle, or on existing trails by vehicles up to 1 tonne. In light of these facts, no changes are recommended at this time to current stocking rates, grazing seasons, classes of livestock, fence, salt, feed or water distribution, or access methods used by property owners of critical habitat.

Integrated weed management to control Crested Wheatgrass or Downy Brome (*Bromus tectorum*) invasion could directly reduce competition with Slender Mouse-ear-cress, or indirectly change ungulate grazing behaviour that would otherwise improve habitat for Slender Mouse-ear-cress. Approaches used to reduce the occurrence and density of invasive alien species on critical habitat needs to be dealt with on a site-specific basis or in multiple action plans. Until that time, a proponent should apply for a SARA permit or agreement under SARA for activities that may contravene general prohibitions.

Fires resulting from accidental or deliberate ignition by people will not destroy critical habitat nor harm individual plants under most circumstances. In fact, fire is likely to improve habitat by reducing grass litter, insect pests and pathogens from the habitat.

Environment Canada will work with all of its partners to define and improve best practices for conserving the Slender Mouse-ear-cress across its range. In addition, Environment Canada will work with the Department of National Defence to define best practices for managing multiple species at risk at CFB Suffield, that reflect on the unique land use activities posed by military training at that site.