Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Small-flowered Sand-verbena (*Tripterocalyx micranthus*) in Canada

Small-flowered Sand-verbena

2012

Canada

About the *Species at Risk Act* Recovery Strategy Series

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

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

What is recovery?

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

What is a recovery strategy?

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

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

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. 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).

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Additional copies can be downloaded from the SAR Public Registry (www.sararegistry.gc.ca).

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DECLARATION

This recovery strategy has been prepared in cooperation with the jurisdictions responsible for the Small-flowered Sand-verbena. Environment Canada has reviewed and accepts this document as its recovery strategy for Small-flowered Sand-verbena, as required under the *Species at Risk Act* (SARA). 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, as required under SARA.

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 Small-flowered Sand-verbena 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 (Environment Canada, Canadian Wildlife Service).

ACKNOWLEDGMENTS

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The Saskatchewan Conservation Data Centre and Alberta Natural Heritage Information Centre provided updated element occurrences for this species, and Brent Smith provided occurrence records from Canadian Force Base Suffield. Thanks are also extended to all the landowners, lessees and land managers who granted access to their land for surveys and research. The cover illustration was graciously provided by Hope Johnson, LLD.

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

This recovery strategy will clearly benefit the environment by promoting the recovery of Small-flowered Sand-verbena. 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 Small-flowered Sand-verbena; 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. Small-flowered Sand-verbena was listed as endangered under SARA in January 2005. Environment Canada, Canadian Wildlife Service – Prairie and Northern Region 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 Small-flowered Sand-verbena posted on the Species at Risk Public Registry.

EXECUTIVE SUMMARY

- Small-flowered Sand-verbena is an annual species, with branched, trailing stems and opposite leaves. It produces small, greenish-white flowers in umbel-like clusters and large peach-coloured winged fruits. It requires some looser sand in active or semi-stabilized sand dunes, and is well adapted to growing in arid environments. In Canada, as of 2009 there were 18 populations believed to be extant in Alberta, and 6 extant populations in Saskatchewan, with an estimated provincial population size of 8438 plants and 3243 plants, respectively.

- Currently identified threats to Small-flowered Sand-verbena include changes in ecological dynamics or natural processes due to a lack of grazing and/or alteration to fire regimes, ultimately contributing to dune stabilization and woody vegetation encroachment; invasive alien species; incidental mortality from overgrazing by ungulates; and habitat loss and degradation as a result of sand extraction, oil and gas activities, road maintenance and construction, recreational activities, military activities, and urban development.

- Recovery of Small-flowered Sand-verbena is deemed biologically and technically feasible. The population and distribution objectives for the Small-flowered Sand-verbena 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 the recovery of this species:
  - (1) Determine area of occupancy and extent of occurrence of additional Small-flowered Sand-verbena populations, to the extent possible, by 2013.
  - (2) Develop beneficial management practices to reduce threats to Small-flowered Sand-verbena 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 Small-flowered Sand-verbena.
  - (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 for the known naturally occurring Small-flowered Sand-verbena populations in Canada.

- One or more action plans for Small-flowered Sand-verbena will be completed by 2013.

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1. BACKGROUND

1.1 Species Assessment Information from COSEWIC*

Date of Assessment: November 2002

Common Name (population): Small-flowered Sand-verbena

Scientific Name: *Tripterocalyx micranthus*

COSEWIC Status: Endangered

Reason for Designation: An annual of a few widely dispersed sand hill habitats where populations occupy very small sites and consist of low numbers that fluctuate greatly with precipitation levels.

Canadian Occurrence: Alberta and Saskatchewan

COSEWIC Status History: Designated Threatened in April 1992. Re-examined and designated to Endangered in November 2002.

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

1.2 Description

Small-flowered Sand-verbena (*Tripterocalyx micranthus* Torr.) is an annual species with tiny greenish-white flowers arranged in clusters (Figs. 1 and 2). It has many trailing, decumbent branches which measure 10-30 cm long (Looman and Best 1979). Its leaves are opposite each other on the stem and have prominent veins. The peach-coloured fruits are up to 2 cm in length and width, with usually 3 thin wings (Great Plains Flora Association 1986; Fig. 2). It is a member of the four o'clock family (Nyctaginaceae), named because the flowers generally open up in the late afternoon. Flowering in Canada generally occurs in the middle of June (Smith 2002b).

Figure 1. Small-flowered Sand-verbena plant.

Small-flowered Sand-verbena is well adapted to growing in arid environments. Its rigid stems and thick leaves reduce the potential for water loss. It grows very quickly, germinating in the spring, setting seeds, and dying before mid-summer. With adequate moisture they can continue to grow, flower, and produce seed through to late summer or early fall (Smith 2002b, D. Nernberg, pers. comm.). Otherwise, this species can survive the heat and drought conditions of summer as dormant seeds (Smith and Bradley 1992, Smith 2002b). The seeds are extremely hardy and can survive in this dormant state for at least 2 to 3 years until conditions are favourable for germination (Danin 1996).

Figure 2. Seeds and flowers of Small-flowered Sand-verbena.

1.3 Populations and Distribution

1.3.1 Global

Small-flowered Sand-verbena is native to western North America, occurring in both Canada and the United States (Fig. 3). In Canada, it is restricted to southeastern Alberta and southwestern Saskatchewan where it is ranked as critically imperiled to imperiled (S1S2) in Alberta and imperiled (S1) in Saskatchewan (NatureServe 2009). Nationally in Canada it has a rank of imperiled (N2; NatureServe 2009). Small-flowered Sand-verbena was assessed in 2002 as Endangered by COSEWIC (the species was formerly known as *Abronia micrantha* (COSEWIC 2002)). It is listed as Endangered under the *Species at Risk Act* (SARA). In the United States, the conservation status has not been assessed nationally, or in many of the states in which it occurs (i.e., Arizona, Colorado, Montana, New Mexico, Nevada, North Dakota, and Utah; NatureServe 2009). However, it has received a ranking of critically imperiled (S1) in California, Kansas, and Nebraska, and vulnerable (S3) in Wyoming (NatureServe 2009). It possibly has been extirpated (SH) from South Dakota (NatureServe 2009). Globally, Small-flowered Sand-verbena has been assessed as secure (G5; NatureServe 2009).

Figure 3. Known range of Small-flowered Sand-verbena in North America (modified from NatureServe 2009, USDA 2007).

No information is available on the abundance of Small-flowered Sand-verbena 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 3). There is insufficient historical and long-term data collected for this species to determine a rate of population decline.

1.3.2 Canada

In Canada, Small-flowered Sand-verbena is restricted to localized sand dune complexes within Aeolian (wind-blown) and glaciofluvial landscapes in Alberta and Saskatchewan (Figure 4). These sand dunes complexes are comprised mainly of the Dominion, Grassy Lake, Bowmanton, and Middle sand hills in Alberta (Wolfe 2001). In Saskatchewan, the sand dune complexes include the Empress Meander and Cramersburg sand hills as well as unnamed sand hills along the South Saskatchewan River bank at Saskatchewan Landing and south of Outlook (Wolfe 2001).

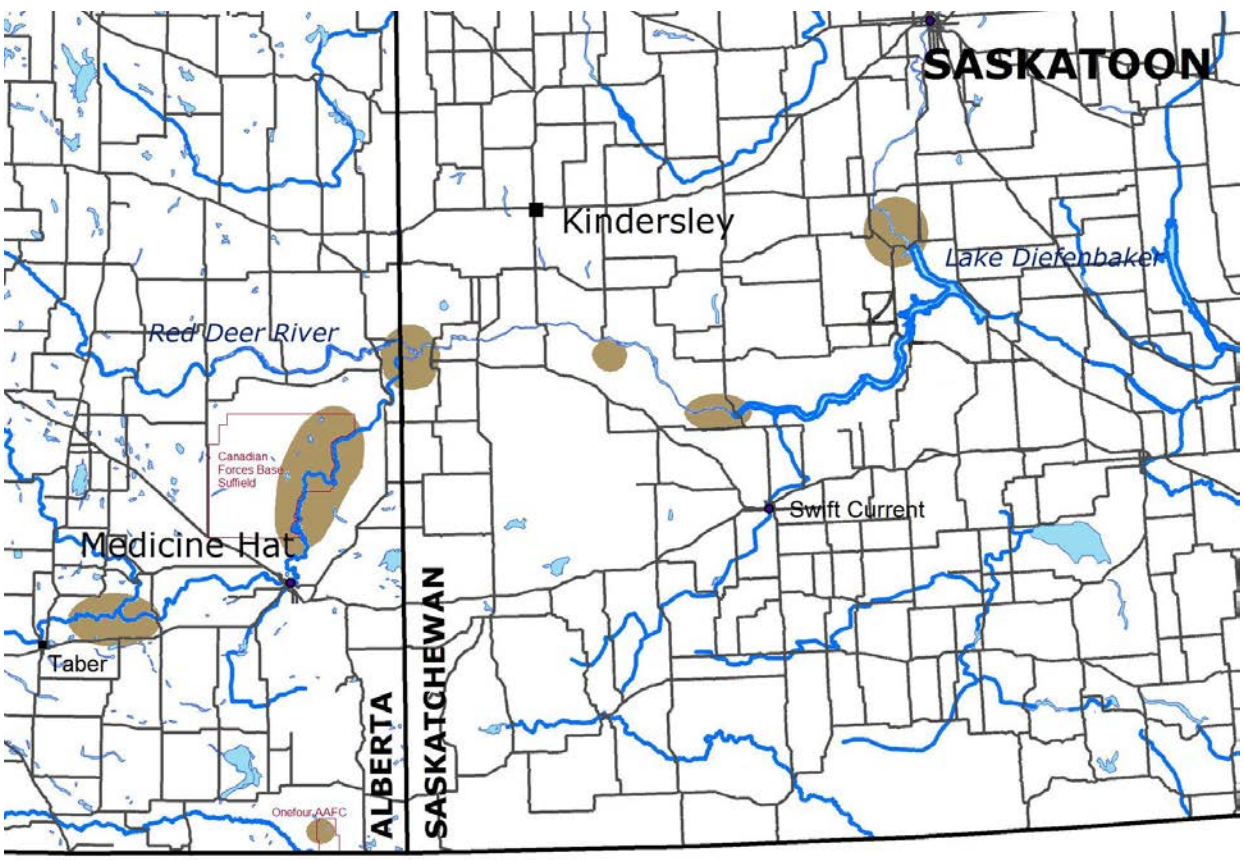

Figure 4. Known range of Small-flowered Sand-verbena in Canada.

In Alberta, there are 18 populations[1] believed to be extant, although one of those has inaccurate location information and has not been relocated recently (Table 1). Four additional populations are historic (>25 years old) and have not been relocated, and one population has been extirpated (Table 1). Six populations of Small-flowered Sand-verbena have been confirmed recently in Saskatchewan; prior to the last 5 years there was only one known population just east of the Alberta border (Table 1).

In 2001, a drought year, only one plant was found in a survey of all known Alberta populations, but in 2003 the estimate for Alberta was 3,600 plants (Smith 2002b, Alberta Sustainable Resource Development 2003). A resurvey of the majority of known populations, and the discovery of a few new populations, yielded a total of approximately 5,902 plants in 2004 and 8,438 plants in 2009 (Alberta Natural Heritage Information Centre 2009a, C. Neufeld, unpubl. data). In Saskatchewan in 2009, the population estimate for 5 out of 6 populations was 3,243 plants. It is likely that more Canadian occurrences[2] of Small-flowered Sand-verbena will be found with increased survey effort, because this plant can exist as viable seed in the soil in areas surrounding known occurrences, and not all potentially suitable habitats have been surveyed in years with rainfall sufficient to stimulate seed germination.

Numerous factors complicate interpretation of trend information for this species. In the case of annual plants like Small-flowered Sand-verbena, the location and density of plants is not consistent among years. The distribution of annual plants in one year reflects the patterns of seed dispersal in previous years, but because the seed is hidden under the soil and not all of it germinates every year, it is difficult to predict that distribution in advance (Chambers and McMahon 1994). Also, Small-flowered Sand-verbena seed produced one year can disperse downwind or downslope to a new area in a subsequent year, particularly in a shifting sand dune environment (Smith 2002b; C. Neufeld, pers. obs.). This presents a problem for establishing population and distribution trends, because known locations must be revisited and enumerated

[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 occurrences that are greater than 1 km apart 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 occurrences 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.

for at least three or more years (Brigham and Thomson 2003). Although some Small-flowered Sand-verbena occurrences have been revisited and enumerated on three or more occasions, the subsequent counts include new occurrences discovered in the surrounding area, which may just be an extension of the same seed bank, and exclude occurrences where plants are not present that year. Overall, the counts show increases, decreases and large fluctuations in both population size and area of occupancy; regular monitoring of the majority of populations has not occurred. All of these factors complicate interpretation of trend information.

Another complicating factor is a detection bias (Pollock et al. 2004) caused by the interaction of precipitation stimulating germination and the search efficiency of people looking for these plants. In years with abundant precipitation, many plants germinate and these conspicuous patches of robust plants are more easily detected and discovered. Revisiting these sites in subsequent years often leads to reports of declining trends that may be correlated with declining precipitation or natural succession of the vegetation, and do not necessarily represent threats to survival of the species throughout its range. It is less likely that new occurrences will be discovered in drought years, when plants are expected to occur as more widely separated and inconspicuous clusters or isolated individuals. Resurveys of such occurrences in subsequent years with more precipitation could lead to reports of increasing trends. The degree to which these sources of bias may have affected the data available is difficult to evaluate.

No overall trend in population size or area of occupancy[3] can be established throughout the Canadian range of this species at this time. More data is required to establish long-term trends.

[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 occupied by each occurrence.

Table 1. Summary of Small-flowered Sand-verbena populations in Canada [a,b].

Population	Recent Pop. Estimate (year) [c]	Max. Recorded Pop. (Year) [c]	First Observation Date	Land Tenure	Threats
ALBERTA					
Lost River/Onefour 1	47 (2009)	60 (2004)	1985	Federal Government (AAFC)	Invasive aliens, dune stabilization, oil and gas activity
Lost River/Onefour 2	2932 (2009)	2932 (2009)	1985	Federal Government (AAFC)	Invasive aliens, dune stabilization, oil and gas activity
Drowning Ford 1	314 (2009)	314 (2009)	2007	Leased Provincial Crown	Oil and gas activity, invasive aliens
Drowning Ford 2	225 (2009)	225 (2009)	2007	Leased Provincial Crown	Oil and gas activity, invasive aliens
Hays	125 (2009)	125 (2009)	2007	Leased Provincial Crown	Oil and gas activity
Bow Island (Lower Bow) 1	917 (2009)	917 (2009)	1987	Leased Provincial Crown	Invasive aliens, oil and gas activity, dune stabilization, road maintenance
Bow Island (Lower Bow) 2	8 (2009)	253 (1987)[d]	1987		
Purple Springs	1429 (2009)	1429 (2009)	2002	Leased Municipal	Invasive aliens, dune stabilization, ATV activity
East Purple Springs	62 (2009)	62 (2009)	1987	Leased Provincial Crown	Invasive aliens, dune stabilization
Grassy Lake	463 (2009)	3024 (2002)	2002	Private	Sand extraction
Wolf Island	628 (2009)	628 (2009)	1987	Leased Provincial Crown	Invasive aliens, oil and gas activity, dune stabilization
CFB Suffield NWA, Fish Creek	79 (2009)[e]	120 (2002)	1973	Federal Government (CFB Suffield)	Dune stabilization, oil and gas activity, invasive aliens, road maintenance
CFB Suffield NWA, Whitco Trail	0 (2002)	1 (1994)	1994		
CFB Suffield NWA, Mule Deer Springs	0 (2007)	5 (2004)	2004		
CFB Suffield, Koomati 1	0 (2009)	1 (2002)	2002		
CFB Suffield, Koomati 2	120 (2009)	157 (2004)	2004		
CFB Suffield, Koomati 3	1089 (2009)	4400 (2004)	2004		
CFB Suffield NWA, Bull Pen[f]	0 (2009)	<100 (1973)	1973		
Medicine Hat [g]	0 (2004)	10+ (2004)	2004	City of Medicine Hat	Urban development
North of Medicine Hat[d]	169 (2002)	169 (2002)	2002	Leased Provincial Crown	Oil and gas activity, invasive aliens, road maintenance
North Lost River [f]	>0 (1979)	>0 (1979)	1979	Leased Provincial Crown	Unknown
South Lost River [f]	>0 (1972)	>0 (1972)	1972	Federal Government (AAFC)	Unknown
Manyberries[f]	>0	1 (1895)	1895	Unknown	Unknown

Table 1 (Continued). Summary of Small-flowered Sand-verbena populations in Canada [a,b].

Population	Recent Pop. Estimate (year) [c]	Max. Recorded Pop. (Year) [c]	First Observation Date	Land Tenure	Threats
SASKATCHEWAN					
South of Empress	3 (2004)	<10 (1981)	1981	Leased Provincial Crown	Invasive aliens
Saskatchewan Landing	>87 (2009)[e]	161 (2004)[e]	2004	Provincial Park	Recreation, invasive aliens
Lancer	20 (2009)	20 (2009)	2009	Leased Provincial Crown	Sand and gravel extraction, dune stabilization, oil and gas activity
South of Outlook 1	2242 (2009)	2242 (2009)	2008	Leased Provincial Crown	Oil and gas activity, sand and gravel extraction potential
South of Outlook 2	874 (2009)	874 (2009)	2009	Leased Provincial Crown, Private	Sand and gravel extraction, invasive aliens
South of Outlook 3	20 (2009)	20 (2009)	2009	Leased Provincial Crown	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: ANHIC (2009a,b), ASRD (2003), ASRD (2008), Bradley et al. 2006, SCDC (2009), Smith (2002a), Smith (2002b), Smith and Bradley 1992, D. Bush (unpubl. data), T. Freeman (pers. comm.), C. Neufeld (unpubl. data), S. Vinge (pers. comm.).
[c] If no estimate of population size was given with the reported location, it is recorded here as >0.
[d] The exact locations for occurrences in the 1987 Bow Island 2 population have not been relocated despite recent search effort but a new occurrence was found within 500 m; therefore, either the original reports for the occurrences were inaccurate or imprecise or the original population has just not been relocated. As a result, only the recently found 2009 occurrence is being included as critical habitat at this time. There was erroneous location information provided with the North of Medicine Hat population so it is not being included as critical habitat at this time.
[e] This only includes a partial inventory of all patches within the population.
[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 them. They are $\geq$ 25 years old and for the purposes of this strategy are considered historic and will not be considered as part of the population and distribution objectives or critical habitat until they are relocated.
.[g] This population was extirpated due to an urban development.

1.4 Needs of Small-flowered Sand-verbena

1.4.1 Habitat and biological needs

Small-flowered Sand-verbena occurs in the Mixed Grassland Ecoregion of Alberta and Saskatchewan (Wiken 1986, Ecological Stratification Working Group 1995). Small-flowered Sand-verbena grows in a steppe climate, which is characterized as being dry year-round as a result of low annual precipitation levels, high rates of evaporation, and fast surface runoff (Fung et al. 1999). In Medicine Hat, Alberta, at the centre of the Canadian distribution for the species, annual precipitation is about 334 mm, with the highest precipitation occurring in June (Environment Canada 2009). These areas experience warm summers (mean summer temperatures of 18.5°C at Medicine Hat) and cold winters (mean winter temperatures of −8.1°C at Medicine Hat) (Environment Canada 2009).

Soils in the areas where Small-flowered Sand-verbena is growing are Brown Orthic or Rego Chernozems and sometimes Orthic Regosols, with coarser soil textures of sand, sandy loam or loamy sand, typically formed in sandy fluvial or aeolian materials (Wyatt et al. 1937, Wyatt et al. 1941, Kjearsgaard and Pettapiece 1986, Saskatchewan Soil Survey 1990, Fung et al. 1999, Alberta Sustainable Resource Development 2003).

Small-flowered Sand-verbena is found on active to sparsely vegetated dunes or blowouts typically on south, west, and east-facing slopes, as well as hard-packed finer sand on level terrain (Smith 2002b, Alberta Sustainable Resource Development 2003). Some element of active sand is usually present in the habitat, and is likely important for seed establishment (Smith 2002b). Current populations are found in small, discrete areas, while seemingly similar suitable habitat is uninhabited by Small-flowered Sand-verbena for unknown reasons (Alberta Sustainable Resource Development 2003). For a list of plant species that have been found growing near Small-flowered Sand-verbena, refer to Alberta Sustainable Resource Development (2003) and Smith (2002).

1.4.2 Ecological role

There is no evidence of Small-flowered Sand-verbena having a key ecological role.

1.4.3 Limiting factors

Habitat availability

Small-flowered Sand-verbena is restricted to landscapes experiencing active erosion and deposition of sand, like sand dunes and valley slopes (Smith 2002b, Alberta Sustainable Resource Development 2003). These habitats are not evenly distributed across the Canadian range of the species, which results in multiple isolated population clusters separated by unsuitable habitat. These isolated clusters of populations may appear or disappear through competitive exclusion by native and alien plant species, low rates of immigration from distant populations, and potential reproductive problems due to inbreeding and genetic drift or the absence of co-evolved and preferred pollinators. The Canadian range of Small-flowered Sand-verbena represents the northern extreme limit, and isolated populations may represent colonizing satellites of an expanding range, or fragmented remnants of a retracting and formerly more extensive range. Genetic analysis of populations in Canada and adjacent parts of the United States could help resolve this latter question, and would assist defining whether we are dealing with a rare species during the phase of expansion or contraction. Recent and widespread dune stabilization in the prairies (Geological Survey of Canada 2001) may be slowing the rate of expansion or accelerating the rate of contraction.

Climatic factors

Small-flowered Sand-verbena is also limited by climatic factors which affect seed germination, a key transition in the life history of this species. As Small-flowered Sand-verbena is an annual plant, a large portion of its life cycle is spent dormant as a seed. Most aspects of the Small-flowered Sand-verbena ecology including seed bank dynamics and germination are unknown. However, future survival of populations is dependent on having a viable seed bank present, and having conditions favourable for germination to occasionally replenish that seed bank. Annual plants adapted for arid conditions tend to germinate in the spring, taking advantage of brief periods of excess soil moisture and warm temperatures. During these periods, it is typical to see a flush of annual plants quickly growing, producing flowers, and dispersing large numbers of seed, most of which will then sit dormant in the soil until conditions needed for germination reoccur (Evans and Thames 1981). In general, annual seeds are hardy and can remain viable in the seed bank for many years to buffer against environmental unpredictability (Harper 1977, Templeton and Levin 1979, Danin 1996). Small-flowered Sand-verbena seed is enclosed by a persistent, papery, winged structure which is thought to protect the seed from premature germination (Fig. 2). It is thought that there is a biochemical inhibitor within these wings that needs to be leached away by sufficient soil moisture (e.g., heavy rains or snowmelt) to prevent seeds from germinating when there is insufficient moisture for growth. A sustained drought in which there is insufficient moisture for seed germination could reduce the number of viable seeds remaining in the seedbank. However, exact effects of temperature and precipitation on Small-flowered Sand-verbena requires further study.

1.5 Threats

1.5.1 Threat classification

Table 2. Threat Classification Table.

1	**Lack of grazing and/or alteration to 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	Lack of grazing and/or alteration to fire regimes	**Occurrence**[b]	Historic and Current	
		Frequency [c]	Continuous	
Specific Threat	Dune stabilization, vegetation encroachment, plant competition	**Causal Certainty** [d]	Medium	
		Severity [e]	Medium	
Stress[a]	Reduced reproductive output, recruitment and population size, increased mortality, loss of habitat	**Level of Concern** [f]	High	

2	**Cultivation**	**Threat Information**		
Threat Category	Habitat loss or degradation	**Extent**	Widespread	
			Local	**Range-wide**
General Threat	Crop production, cultivation, conversion to tame forages	**Occurrence**	Historic and Current	
		Frequency	One-time/Recurrent	
Specific Threat	Population and habitat permanently reduced, fragmention and isolation, introduction of invasive alien species	**Causal Certainty**	High	
		Severity	Medium	
Stress	Plant and seed mortality, reduced population size, loss of habitat	**Level of Concern**	High	
		Extent	Widespread	

3	**Invasive alien species**	**Threat Information**		
Threat Category	Exotic, invasive, or introduced species	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Invasive alien species (Crested Wheatgrass, Downy Brome, Russian Thistle)	**Occurrence**	Current	Anticipated
		Frequency	Continuous	
Specific Threat	Dune stabilization, resource and plant competition, alteration of habitat characteristics (e.g., litter, bare sand, vegetation height), changes in species community	**Causal Certainty**	Medium	
		Severity	Medium	
Stress	Reduced population size, reduced reproductive output and recruitment, increased plant mortality	**Level of Concern**	High	

4	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**	Medium	

5	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/Current	Anticipated/Unknown
		Frequency	Recurrent	One-time
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	Medium	Unknown (could start small and expand)
Stress	Mortality of plants and seeds, reduced population size, loss of habitat	**Level of Concern**	Low-Medium	

6	Road Maintenance or Construction	Threat Information		
Threat Category	Habitat loss or degradation	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Road maintenance or construction (e.g., grading, mowing, herbicides, road repair)	**Occurrence**	Current/Anticipated	
		Frequency	Recurrent/Seasonal	
Specific Threat	Alteration of habitat characteristics; destruction of plants or plant parts, introduction of invasive alien species	**Causal Certainty**	Medium-High	
		Severity	Low	
Stress	Mortality of plants and seeds, reduced population size, reduced reproductive output, reduced dispersal	**Level of Concern**	Low	

Table 2. Threat Classification Table continued.

7	**Recreational Activities**	**Threat Information**		
Threat Category	Disturbance or harm	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Recreational activities (i.e. all-terrain vehicle or motor vehicle use, hiking)	**Occurrence**	Current	Unknown
		Frequency	Intermittent	
Specific Threat	Alteration of habitat characteristics; trampling or destruction of plants or plant parts	**Causal Certainty**	High	
		Severity	Low	
Stress	Mortality of plants and seeds, reduced reproductive output, reduced population size	**Level of Concern**	Low	
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/ Recurrent	
Specific Threat	Disturbance of substrate, disturbance to plants, alteration of habitat characteristics from military operations and heavy machinery	**Causal Certainty**	Low-Medium	
		Severity	Low	
Stress	Mortality of plants and seeds, reduced population size	**Level of Concern**	Low	
9	**Overgrazing** by domestic livestock and wildlife	**Threat Information**		
Threat Category	Natural Process/ Accidental Mortality	**Extent**	Localized	
			Local	**Range-wide**
General Threat	Overgrazing by ungulates (e.g., deer or cattle)	**Occurrence**	Current	Unknown
		Frequency	Seasonal (summer)	
Specific Threat	Loss of flowers and seeds, consumption of entire plants	**Causal Certainty**	Medium	
		Severity	Low-Medium	
Stress	Reduced reproductive output, recruitment and population size, increased mortality of plants	**Level of Concern**	Low	

Table 2. Threat Classification Table continued.

10	**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	

[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

Lack of grazing and/or alteration to fire regimes

Dunes in the southern Canadian prairies have been stabilizing over the last century (Epp and Townley-Smith 1980, Wallis 1988, Wallis and Wershler 1988, Geological Survey of Canada 2001). This is possibly due to climate change (Vance and Wolfe 1996), but also due to changes in land-use and management decisions since European settlement (Geological Survey of Canada 2001). 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). Very few active dunes currently exist and those that do have been stabilized at a rate of 10-20% per decade (Wolfe et al. 2001), although the rate may be as high as 30-90% since the 1940's (Wallis 1988). In the absence of natural disturbances like grazing and fire, which interact with cycles of drought, natural succession can stabilize and cover sand dunes with vegetation (Potvin and Harrison 1984, Hulett et al. 1966). Shrubs and trees with long roots able to reach the water table, and woody roots that withstand sand abrasion tend to be successful early colonizers in the absence of fire and browsing. More shallow-rooted grasses and forbs can become established at dune edges, and gradually spread up the edge of dunes, unless grazing and trampling by large herbivores slows this process. Small-flowered Sand-verbena appears to decline without disturbance that creates partially active to active sand (Smith 2002b, Alberta Sustainable Resource Development 2003, C. Neufeld, pers. obs.).

It is not known how Small-flowered Sand-verbena responds to fire and grazing, but prairie plants evolved with the ecological processes of fire and grazing which are important for maintaining ecosystem function. A combination of grazing and fire are important disturbances in keeping dunes and blowouts active. Fire followed by heavy grazing likely destabilizes sand hills more than either disturbance independently (Lesica and Cooper 1999). Dunes have been stabilizing in some areas where there have been repeated fires but little grazing, while in other areas dunes have stabilized where there has been grazing but few fires (Wallis and Wershler 1988). It is possible that, historically, fires in the summer or fall created lush vegetation the following spring which attracted large herds of grazing animals like bison (*Bison bison*) and resulted in reactivation of sand dunes (Smith 2000). It is only recently that people have realized the benefits of having active dunes for wildlife species. Historically, the stabilization of active dunes was thought to be good conservation practice and land managers attempted to stabilize dunes by extinguishing fires, altering grazing patterns, and placing objects, such as tires or bales, on blowouts (Wallis and Wershler 1988).

Climate has historically played an important role in the stability of dunes. Higher moisture levels allow vegetation encroachment on the sandy dunes, which causes dunes to stabilize. Periods of drought are associated with the reactivation of dunes (Wolfe 1997). The shift towards a warmer drier climate, as predicted by climate change models, suggests that in the future there may be a shift towards increased levels of dune activity (Wolfe 1997, Wolfe et al. 2001), which in turn may benefit species such as Small-flowered Sand-verbena.

Cultivation

In general, sand hill areas that support Small-flowered Sand-verbena are not considered suitable habitat for agriculture due to low soil moisture, low soil fertility, and high risk of wind erosion (Geological Survey of Canada 2001). Nevertheless, these areas are surrounded by Mixed Prairie grasslands which are commonly converted for cultivation resulting in sand hills becoming islands in a landscape dominated by crops. In addition, within sand dune complexes where there are level sandy plains between dunes, it is possible to grow certain types of crops which need irrigation, such as potatoes, corn and sugar beets. This is a common practice in Alberta around Taber where sandy soils already have been converted to irrigated cropland; it is possible that nearby dunes inhabited by Small-flowered Sand-verbena also may be impacted in the future. Cultivation can result in permanent habitat loss.

Invasive alien species

Some alien plant species may be relatively unpalatable to livestock and wildlife, or provide poor fuels to support fires. As a result, an influx of these aliens could stabilize sand dunes and represent an indirect threat to Small-flowered Sand-verbena, which requires partially active to active dunes. Direct threats through competition may be posed by some invasive aliens; some invasive alien species can displace native species, and decrease species diversity or richness through their superior competitive ability and 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). Invasive species, such as Russian Thistle (*Salsola kali*), Downy Brome (*Bromus tectorum*), and Crested Wheat-grass (*Agropyron cristatum*) have been found growing in sites with Small-flowered Sand-verbena

(C. Neufeld, pers. obs.). Long-term impacts of these invasive aliens on Small-flowered Sand-verbena presence are not known. There is also the potential for Small-flowered Sand-verbena to be killed, or its habitat negatively altered, by indiscriminate use of herbicides intended to control invasive species.

Oil and Gas Activities

Oil and gas activities include a number of processes including exploration, drilling, completion, production and transportation, abandonment and reclamation. In the Prairie Ecozone, the two most common petroleum resources extracted are crude oil and natural gas, each of which may pose different threats to Small-flowered Sand-verbena[4]. 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 kilometers of pipeline in total and a greater probability of natural gas wells occurring within or adjacent to Small-flowered Sand-verbena 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 large volumes of both oil or gas, larger trenches are excavated using many 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.

[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*.

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 common 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* become 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 potential threats 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.

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. A few sites containing Small-flowered Sand-verbena are currently being threatened, or may be threatened in the future, by this land use in Alberta and Saskatchewan as the need increases for this resource (Smith 2002b, Alberta Sustainable Resource Development 2003). Removal of the soil substrate can not only kill living plants, but permanently removes all of or portions of the seed bank; this can prevent resurgence of the population during good germination years and can have substantial implications for the future survival of the populations at those sites (Alberta Sustainable Resource Development 2003). This disturbance to the habitat can also lead to introduction and/or invasion by alien species.

Road Maintenance or Construction

Small-flowered Sand-verbena has been found in sandy ditches along roadsides and road allowances where disturbance has provided loose sand for the plants to establish themselves. Road maintenance activities, such as road repair, mowing and herbicide applications intended to control weeds and woody vegetation are a threat to these populations (C. Neufeld, pers. obs.). It is estimated that hundreds of Small-flowered Sand-verbena plants were killed or defoliated in July 2006 at Canadian Force Base (CFB) Suffield (Koomati) when a grader operator unknowingly graded a road with hundreds of plants along it (D. Boyd, pers. comm.). Although defoliation of plants may not kill them, it can prevent seeds from being set that year and threaten the demographic stability of roadside populations. Although roadside areas are not ideal habitat for Small-flowered Sand-verbena, they may be important for dispersal of pollen and propagules (seeds, rhizomes, or stolons) between populations or within a population.

Recreational activities

Recreational activities have caused habitat disturbances and physical plant damage at some locations with Small-flowered Sand-verbena. All-terrain vehicles (ATV) and other off-road vehicles, like motorbikes, can either damage or kill plants. Although this is not currently considered a major threat to the species or its habitat, ATV tracks and motorbikes have been observed on the dunes at the Purple Springs sites (Alberta Sustainable Resource Development 2003, C. Neufeld, pers. obs). Vehicle tires and foot traffic can physically damage plants, ultimately leading to their mortality or reduced reproductive output. It is possible that a small amount of disturbance to the sand hills by this type of activity may benefit some populations by preventing dunes from stabilizing, thereby favouring the growth of early successional species like Small-flowered Sand-verbena. However, repeated disturbance can lead to shifting and eroding dunes, which does not support any vegetation growth. Therefore, this type of activity is not encouraged as it is difficult to control and enforce, may result in plant mortality, and natural methods are likely more effective.

Military activities

It is not clear how military activities may affect Small-flowered Sand-verbena growing in CFB Suffield. Activities such as road creation and maintenance, and use of heavy tracked or wheeled tactical vehicles can negatively alter native prairie, particularly in sand habitats, by reducing vegetation cover and altering species composition (McKernan 1984, Wilson 1988, Severinghaus 1990). These activities have the potential to directly damage plants and the seed bed. Some minor disturbances, however, may initially stimulate germination of seeds by opening habitat, reactivating dunes, 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). If these disturbances occur repeatedly the areas can become “population sinks” where plants and/or seedbeds are destroyed by vehicles or machinery, and invasive alien species are introduced via seed transport off equipment.

Overgrazing by domestic livestock and wildlife

These plants evolved with fire and ungulate grazing as natural disturbances, but it is possible that the current timing, duration, location and diet selection of cattle and White-tailed Deer is unlike what occurred naturally with bison, Elk, Mule Deer, and Pronghorn prior to 1850. The effects of grazing on Small-flowered Sand-verbena, and the degree to which it is being grazed, has not been researched. At a few sites in Alberta, Small-flowered Sand-verbena plants were trampled by cattle with the majority of plants grazed to ground level at one site (Smith 2002b, C. Neufeld, pers. obs.). This could affect fitness and productivity if repeated frequently, particularly if heavy grazing occurs during the reproductive period, prohibiting plants from setting and distributing seed. It is possible that wildlife graze this plant as well, although no direct observations of this have been reported. It needs to be reiterated, however, that grazing is necessary in maintaining active dune sites and healthy ecosystems and should not be eliminated from sites with Small-flowered Sand-verbena.

Urban development

Urban development results in direct, irreversible damage to habitat and plants and indirect damage to adjacent undeveloped habitat. For example, a population of Small-flowered Sand-verbena located on adjacent undeveloped land could suffer from the loss of a large portion of the seed bank, invasion by alien species from disturbed construction or residential areas, and changes to species composition or surrounding vegetation height from increased urban water runoff and fertilizer. Although this is not a widespread threat, a population of Small-flowered Sand-verbena was reported within the city of Medicine Hat in 2004 shortly before the area was cleared for a housing development (D. Nernberg, pers. comm.). This population was not enumerated before the development occurred. This population has been extirpated, although further surveys may find suitable habitat in other areas within this municipality. Urban developments are effectively permanent, and there is little or no opportunity to mitigate this type of disturbance.

1.6 Actions Already Completed or Underway

Small-flowered Sand-verbena status reports for Canada (Smith and Bradley 1992, Smith 2002b) and Alberta (Alberta Sustainable Resource Development 2003) have been written. The Recovery Team for Plants at Risk in the Prairie Provinces was formed in 2003; recovery of the Small-flowered Sand-verbena 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 (e.g., Bradley et al. 2006).

In 2008, Environment Canada began an intensive monitoring project at CFB Suffield to monitor a population of Small-flowered Sand-verbena growing in the ditch along a well used gravel road which is graded in the dormant season. The objective of the monitoring project is to determine whether traffic and road maintenance are affecting population viability and habitat quality. The project is comparing data collected on seed bank and plant density, survival at different demographic stages, and reproductive output among three different habitat strata situated different distances from the roadside edge. This project continued in 2009, expanding to include comparison of roadside habitats with naturally occurring habitats. An ex-situ experiment was conducted in 2009 comparing seed survival at different burial depths, simulating effects of road grading. These activities align with recommended recovery approaches to meet the recovery objectives (see Section 2.3 and 2.4).

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 research will be an essential component of the overall strategy to recover the species.

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. Potential habitat and habitat associations.
5. Effect and extent of factors influencing Small-flowered Sand-verbena habitat, and its survival and reproductive success (e.g., pollinators, timing and intensity of grazing, fire suppression, invasive alien species encroachment, woody vegetation encroachment, dune stabilization, anthropogenic features).
6. Population dynamics and life-history including seed production, seed germination rates and 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.

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 the Government of Canada (2009), the recovery of the Small-flowered Sand-verbena is considered biologically and technically feasible:

[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).

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 populations in recent years, and is it likely that a viable soil seed bank also occurs at these locations. Further surveys of suitable habitat may result in the discovery of additional populations. Recent efforts to locate the species have resolved uncertainty regarding the best timing to detect the species, and the range of 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. Soils of sand to loamy sand texture, and microsites with bare sand exposures exists in much greater supply than the area currently known to be occupied by Small-flowered Sand-verbena. For that reason alone, sufficient suitable habitat appears to be available. Management efforts to maintain active sand dunes could also restore additional habitat.

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

Yes. The main threats to Small-flowered Sand-verbena recovery are changes in ecological dynamics or natural processes due to an alteration of grazing and/or fire regimes, ultimately contributing to vegetation encroachment on barren sand. Other major threats include habitat loss and degradation as a result of cultivation or industrial activities. 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. Small-flowered Sand-verbena, like other annual 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 Small-flowered Sand-verbena.

2.2 Population and Distribution Objectives

The population and distribution objectives for the Small-flowered Sand-verbena are to maintain the persistence of known naturally[6] occurring populations within the current range of the species in Canada.

Small-flowered Sand-verbena is restricted to sand dunes that are currently geographically isolated from other similar such habitats. It is unknown whether the species previously occupied these similar isolated habitats where currently it is not found, or if it has declined within occupied habitats in the time since European colonization. Other than the site in Medicine Hat, there is no evidence of any known populations of Small-flowered Sand-verbena being extirpated, and because it is at the northern edge of its distribution, it is unlikely that a supplemental increase in Small-flowered Sand-verbena populations or its distribution is feasible or warranted. 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 naturally occurring populations of this endangered species is the most appropriate population objective.

For annual plants, the largest and most genetically diverse component of the plant exists as seed in the seedbank (Harper 1977, Silvertown and Charlesworth 2001). Therefore, an enumeration of mature individuals is usually an unreliable indicator of actual population size in the short-term (Brigham and Thomson 2003). Although COSEWIC's criteria for assessing population size is based on number of mature individuals (COSEWIC 2009), past experience with this species indicates severe droughts may result in a population size of zero mature plants in one year, followed by several thousand mature plants in subsequent wet years; these fluctuations are not necessarily indicators of threats to survival. Fluctuations by one or more orders of magnitude complicate setting any achievable or reliable quantitative population objectives based on current information.

Previously-unknown occurrences are located nearly every year with increased search effort, and much of the available habitat has not been searched. Therefore, any quantitative distribution objective provided in this recovery strategy would be an underestimate and likely out of date within a year. Due to uncertainties regarding the actual area of occupancy, feasibility of monitoring and reporting on a fluctuating annual plant species, and the increasing number of newly-discovered occurrences for this species, only a general statement can be provided on a distribution 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.

2.3 Recovery Objectives

Objective 1: Determine area of occupancy and extent of occurrence of additional Small-flowered Sand-verbena populations, to the extent possible, by 2013 (Priority - Urgent).

The objective to locate new populations by 2013 is considered a reasonable time frame considering the challenges associated with surveys for Small-flowered Sand-verbena. This species can be difficult to detect, can fluctuate an order of magnitude among years, and has a wide extent of occurrence across Saskatchewan and Alberta 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 Small-flowered Sand-verbena has already been found, it is not possible to predict how many additional populations might be found.

Objective 2: Develop beneficial management practices to reduce threats to Small-flowered Sand-verbena 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 Small-flowered Sand-verbena (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 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

2.4.1 Recovery planning

The intent of this recovery strategy is to provide a general description of the studies and management activities recommended to meet the recovery objectives and address threats. Performance measures that can be used to evaluate progress in meeting the recovery objectives are 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 Small-flowered Sand-verbena populations, to the extent possible, by 2013.				
Habitat loss and degradation, changes in ecological dynamics and natural processes, invasive alien species	Urgent	Population Inventory and Monitoring	• 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 Small-flowered Sand-verbena by 2013.				
All threats	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 prepared and submitted to funding agencies by qualified researchers (2010-2013). • Proposals to apply research findings for developing BMPs will be prepared and 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 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, alien species, Disturbance and persecution	Necessary	Research, Habitat Protection	• In addition to identifying or refining area of occupancy above, determine area of potential habitat for Small-flowered Sand-verbena. • Describe habitat associations. • Determine effects of anthropogenic features on aspects of Small-flowered Sand-verbena or invasive alien species occurrences. • Determine size and longevity of Small-flowered Sand-verbena soil seed banks.	• Proposals to conduct field investigations, in-situ or ex-situ manipulated experiments will be prepared and 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 Small-flowered Sand-verbena.				
All threats	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); requires review and input by communications experts. • Conservation or stewardship agreements meeting SARA criteria of effective protection are in place with affected land owners, land 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 stakeholders by 2013; 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. • Survey and map known occurrences 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 occurrences 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".

Critical habitat has been identified using the best available information (up to 2009), and is believed to be sufficient to meet the population and distribution objectives. The identification of critical habitat will be updated periodically to include any new populations or occurrences that meet the specified criteria.

2.5.1 Approaches to Identifying Critical Habitat

The approach used for identifying critical habitat for the Small-flowered Sand-verbena is based on a decision tree developed by the Recovery Team for Plants at Risk in the Prairie Provinces, as 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 Small-flowered Sand-verbena 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 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. Of the 29 recorded populations in Canada, six populations were excluded based on this first decision due to being historic (not relocated in more than 25 years; four populations) and due to imprecise location information (one population). The potential for the habitat to support occurrences was confirmed between 2004 and 2009 at 23 of the remaining 24 populations (one population is extirpated with no habitat remaining).

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 (area of occupancy of the population) and all natural landform, soil, and vegetation features within a 300 meter distance of the occurrence.

Small-flowered Sand-verbena 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 Small-flowered Sand-verbena is identified as the area encompassing the occurrence (area of occupancy) and all natural landform, soil, and vegetation features within a 300 meter distance of each occurrence[7]. 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 is 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 the Small-flowered Sand-verbena in this strategy. Maps showing the location of areas containing critical habitat are provided in Appendix C. The total size of the areas containing critical habitat is 1500 hectares (15 km^2), with 1195 hectares identified in Alberta and 305 hectares identified in Saskatchewan. This occupies or overlaps into 92 quarter sections of land in the Dominion Land Survey System (21 in Saskatchewan, 71 in Alberta). In Saskatchewan, all 21 quarter sections that contain portions of critical habitat are provincially owned. In Alberta, 2 quarter sections are privately owned, 4 are municipally owned, 33 are provincially owned, 7 are provincially owned but leased to the federal government (Agriculture and Agri-Food Canada), and the remainder is federally owned by the Department of National Defence (see Appendix D for land ownership). Out of the total federally owned land, 11 quarter sections are within CFB Suffield National Wildlife Area. Only the natural landform, soil, and vegetation features within the boundaries displayed in Appendix C are critical habitat (Section 2.5.1).

In accordance with Section 124 of the *Species at Risk Act*, the precise geographic locations of Small-flowered Sand-verbena occurrences are not included in this document to protect the plants 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 displayed 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 at 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).

[7] Rivers, wetlands, and forested areas are exempt from the definition of natural landforms and vegetation. In addition, large barriers like river channels or cultivated fields (e.g., greater than 150 m wide) can create a discontinuity in the natural habitat. These barriers effectively overwhelm other edge effects at the distal end of critical habitat, 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 (see Appendix A).

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 new 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, such that critical habitat is destroyed. Examples of covering the soil include the new creation or expansion of permanent/temporary structures, spreading of solid waste materials, or roadbed construction. Covering the soil prevents solar radiation and water infiltration needed for germination and survival of plants, such that critical habitat is destroyed. Examples of soil inversion and excavation or extraction include new or expanded cultivation, sand and gravel extraction pits, dugouts, road construction, pipeline installation, and stripping of soil for 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, and the critical habitat is therefore destroyed. 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 Small-flowered Sand-verbena (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 and upstream. As the seed bank and plants of Small-flowered Sand-verbena 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 or 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 compositions, and increase surrounding competitor plants, such that population declines occur. This effectively destroys the critical habitat. 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. This effectively destroys the critical habitat. 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 Small-flowered Sand-verbena: 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 Small-flowered Sand-verbena 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 Small-flowered Sand-verbena rely on sand dunes and sandy habitat for their survival. These species include Tiny Cryptanthe (*Cryptantha minima,* endangered), Smooth Goosefoot (*Chenopodium subglabrum,* threatened), Slender Mouse-ear-cress *(Halimolobos virgata,* threatened), Ord's Kangaroo Rat (*Dipodomys ordii,* endangered*)*, Great Plains Toad (*Bufo cognatus*, special concern), Gold-edged Gem (*Schinia avemensis,* endangered), Dusky Dune Moth (*Copablepharon logipenne*, endangered), and Pale Yellow Dune Moth (*Copablepharon grandis*, special concern).

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.

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 Plans

One or more action plans for Small-flowered Sand-verbena 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 distance of 300 m** 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 distance of 300 m** of the habitat patches)**.**

<u>Notes</u>

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 if information is sufficient to classify the habitat as spatially static or dynamic and to classify the species' detectibility as easy or difficult. If information is not sufficient, critical habitat will be identified as per 2a until studies are completed to obtain the necessary information.

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

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 required for survival or recovery 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 meter from detectable occurrences is 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 meters. 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 to ensure the maintenance of critical habitat attributes.

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 prairie 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 at 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 seed bank, which risks depleting the seed bank 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 ensure the maintenance of habitat critical attributes 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 the addition of pipelines within several hundred meters of plant occurrences should not be permitted.

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 ensure critical habitat attributes are maintained.

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 the survival of prairie plant species at risk could result from that work.

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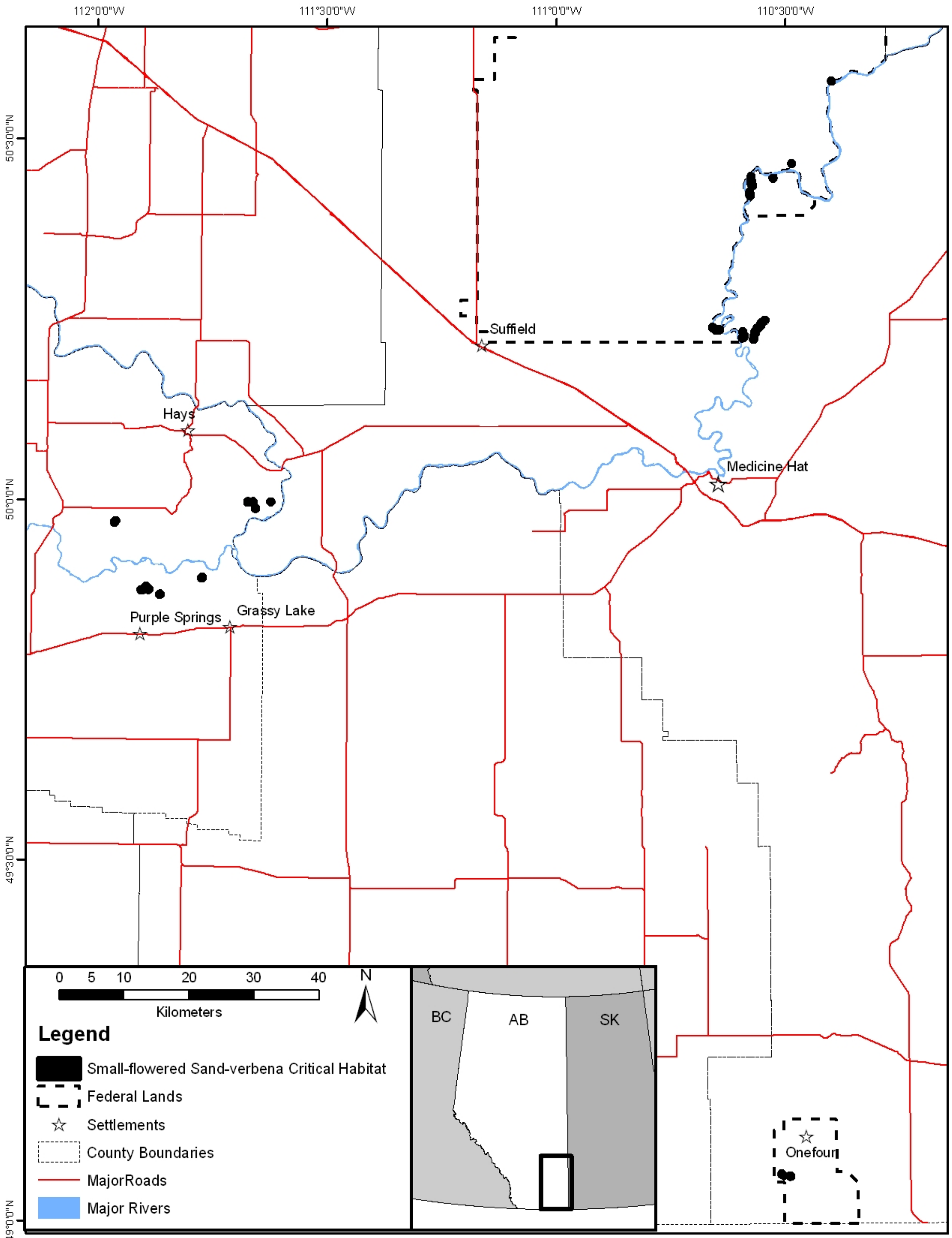
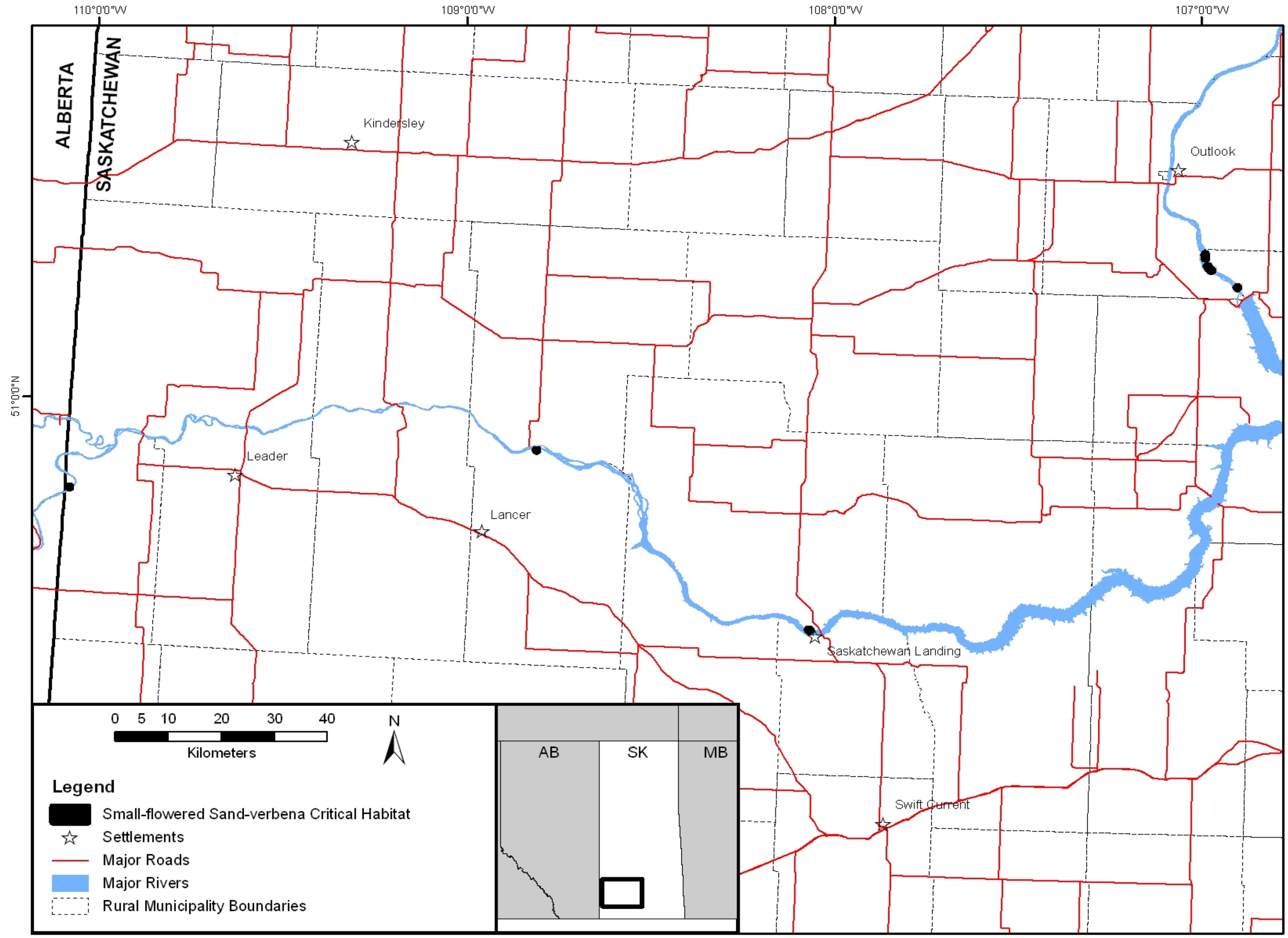
APPENDIX C. Maps of Small-flowered Sand-verbena Critical Habitat



Locations containing critical habitat for Small-flowered Sand-verbena in Alberta.



Locations containing critical habitat for Small-flowered Sand-verbena in Saskatchewan.

APPENDIX D. Quarter sections in Canada Containing Critical Habitat for Small-flowered Sand-verbena[8]

SASKATCHEWAN					
Quarter section	**Section**	**Township**	**Range**	**Meridian**	**Tenure**
NE,NW	34	19	15	3	Provincial
NW	5	22	29	3	Provincial
NW,SW	16	23	20	3	Provincial
NE,SE	17	23	20	3	Provincial
NE,NW,SE,SW	11	27	7	3	Provincial
NE	19	27	7	3	Provincial
NE,NW,SE,SW	20	27	7	3	Provincial
SW	29	27	7	3	Provincial
NE,SE	30	27	7	3	Provincial
NE,SE	31	27	7	3	Provincial

ALBERTA					
Quarter section	**Section**	**Township**	**Range**	**Meridian**	**Tenure**
NE,NW,SE,SW	29	1	4	4	Federal (AAFC)
NE,SE	30	1	4	4	Federal (AAFC)
SE	31	1	4	4	Federal (AAFC)
NE	32	10	14	4	Provincial
NW	33	10	14	4	Provincial
NE,SE	7	11	13	4	Private
SE	4	11	14	4	Provincial
NE	5	11	14	4	Provincial
NW,SE,SW	5	11	14	4	Municipal
SE	6	11	14	4	Municipal
NW	17	12	12	4	Provincial
NE	12	12	13	4	Provincial
NE,NW,SE,SW	13	12	13	4	Provincial
NE,SE	14	12	13	4	Provincial
NE,NW,SE,SW	2	12	15	4	Provincial
NW	7	15	4	4	Provincial
SW	18	15	4	4	Provincial
NE,NW,SW	1	15	5	4	Provincial
NW,SE,SW	2	15	5	4	Provincial
NE,SE	3	15	5	4	Provincial
NE	5	15	5	4	Federal (DND-NWA)

[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 do not contain natural landform, soil, or vegetation features.
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ALBERTA					
Quarter section	**Section**	**Township**	**Range**	**Meridian**	**Tenure**
NW, SE, SW	8	15	5	4	Federal (DND-NWA)
SW	9	15	5	4	Federal (DND-NWA)
SE	10	15	5	4	Provincial
SW	11	15	5	4	Provincial
NE,NW,SE,SW	12	15	5	4	Provincial
SE	13	15	5	4	Provincial
NE,SE	19	17	4	4	Federal (DND)
NW,SW	20	17	4	4	Federal (DND)
NW	27	17	4	4	Federal (DND-NWA)
NE	28	17	4	4	Federal (DND-NWA)
SE	33	17	4	4	Federal (DND-NWA)
SW	34	17	4	4	federal (DND-NWA)
NE	11	17	5	4	Federal (DND)
NW	12	17	5	4	Federal (DND)
NW,SW	13	17	5	4	Federal (DND)
NE,SE	14	17	5	4	Federal (DND)
NE,SE	23	17	5	4	Federal (DND)
NW,SW	24	17	5	4	Federal (DND)
NW	5	19	3	4	Federal (DND-NWA)
NE	6	19	3	4	Federal (DND-NWA)

APPENDIX E. Beneficial or Best Rangeland Management Practices

Small-flowered Sand-verbena 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 Small-flowered Sand-verbena.

Grazing by one or more classes of livestock may help maintain open sandy habitats needed by Small-flowered Sand-verbena, 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 Small-flowered Sand-verbena, or indirectly change ungulate grazing behaviour that would otherwise improve habitat for Small-flowered Sand-verbena. 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 Small-flowered Sand-verbena 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.