COSEWIC
Assessment and Status Report

on the

Buffalograss
Bouteloua dactyloides

in Canada

SPECIAL CONCERN
2011

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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Other names previously used by COSEWIC or synonyms: Other names (scientific name): *Buchloë dactyloides*

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COSEWIC
Assessment Summary

Assessment Summary – November 2011

Common name
Buffalograss

Scientific name
Bouteloua dactyloides

Status
Special Concern

Reason for designation
This grass occurs in limited areas of remnant short-grass prairie in southern Saskatchewan and Manitoba. Threats to this species include coal strip mining, invasive alien plants and overgrowth by woody vegetation and high grass that were once controlled by bison grazing and fire. However, recent survey efforts have increased the known number of populations and it no longer qualifies as a threatened species.

Occurrence
Saskatchewan, Manitoba

Status history
Designated Special Concern in April 1998. Status re-examined and designated Threatened in November 2001. Status re-examined and designated Special Concern in November 2011.

COSEWIC
Executive Summary

Buffalograss
Bouteloua dactyloides

Wildlife species description and significance

Buffalograss is a low-growing, stoloniferous (bearing runners), curly-leaved, perennial grass forming dense, clonal mats. The species is primarily dioecious: male (staminate) and female (pistillate) flowers are found on different plants. Male plants have slender, erect stems, mostly 6-12 cm high, bearing 1-3, 1-sided spikes that are about 1 cm long. The pistillate plants have short, often prostrate stems beneath the leaves, and bear flower clusters that remain together to form hard, globular “burs” that become the seed dispersal units. Buffalograss is an important drought-tolerant forage and turf grass in the United States.

Distribution

Buffalograss is widespread in North America, ranging northward from Central Mexico, over the Chihuahuan and Great Plains grasslands of the United States, just reaching into the southernmost Canadian prairie provinces. In Canada, it is a peripheral species found in southeastern Saskatchewan and southwestern Manitoba. Less than 1% of the global population is in Canada.

Habitat

In Canada, Buffalograss occurs on remnant patches of shortgrass prairie, in clay to clay-loam soils, often below shale outcrops, on dry, shallow valley bottoms and lower slopes, or on south- or west-facing mid-slope benches of the Souris and Blind river valleys. The species requires an environment with little competition from taller, more competitive grasses and herbs. Grazing and moderate trampling may help maintain suitable habitat.

Biology

Buffalograss reproduces both vegetatively, forming solid clonal mats, and sexually reproducing by seeds produced from outcrossing via wind-pollination. In Canada, Buffalograss flowers in midsummer and produces seeds from late July to August. The seed-containing burs are dispersed by herbivores and water. The life expectancy at one year is approximately 2.16 years with a maximum life span of 35 years. The seeds have relatively long viability estimated between 25-35 years.

Population sizes and trends

There are two populations of Buffalograss in Canada. The population in Manitoba is south of Melita along the Blind and Souris river valleys. The population in Saskatchewan is west of Estevan along both sides of the Souris River Valley. The number of mature individuals is unknown and difficult to estimate as Buffalograss occurs in clonal patches that are too interconnected to be distinguished from each other. However, due to detailed surveys and mapping since the species was last assessed in 2001, the size of the populations in Canada is much larger than originally estimated. This discrepancy is likely not due to growth of the populations but rather insufficient initial surveying.

Threats and limiting factors

The potential threats to Buffalograss arise, not so much from low numbers of plants present, but from its occurrence over a small area of unusual habitat, together with the possibility of altered land-use in the future. Potential threats to the Buffalograss populations in Canada in order of importance include: coal strip mining, invasive alien species, disruption of natural disturbance regimes including grazing and/or fire, flooding by reservoirs and dams, cultivation, and road construction or upgrades.

Protection, status, and ranks

Buffalograss is listed as Threatened under the federal *Species at Risk Act*. In Manitoba, Buffalograss is considered Threatened and is protected under *The Endangered Species Act*. Buffalograss is not protected in Saskatchewan, except one small population in the Buffalograss Ecological Reserve. The Canadian national NatureServe rank is N1 (critically imperilled), and in Manitoba and Saskatchewan it is S1 (critically imperilled).

TECHNICAL SUMMARY

Bouteloua dactyloides
Buffalograss Buchloé faux-dactyle
Range of occurrence in Canada (province/territory/ocean): Manitoba, Saskatchewan

Demographic Information

Generation time (usually average age of parents in the population) *3.16 years (2.16 year life expectancy at year 1) with a maximum life span of 35 years. The seeds have relatively long viability estimated to be between 25-35 years*.	3+ years (>10 years if seed bank is considered)
Is there an observed, continuing decline in number of mature individuals? *Long-term trends are unknown, but no decline documented in surveys over the last few years*.	Unknown
Estimated percent of continuing decline in total number of mature individuals within 5 years. *Estimated stable but no current population monitoring*.	Unknown
Observed percent reduction in total number of mature individuals over the last 10 years.	Unknown
Projected percent reduction in total number of mature individuals over the next 10 years.	Unknown
Suspected percent reduction in total number of mature individuals over any 10 years period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	N/A
Are there extreme fluctuations in number of mature individuals? *Though population sizes fluctuate due to available moisture and nutrients, the fluctuations are not believed to be of an order of magnitude*.	No

Extent and Occupancy Information

Estimated extent of occurrence (*however, 95% of intervening habitat is cultivated and therefore unsuitable, leaving an EO of only 138 km^2*)	2,383 km^2
Index of area of occupancy (IAO) *SK: 13 grids = 52 km²* *MB: 30 grids = 120 km²*	172 km^2
Is the total population severely fragmented?	No
Number of "locations∗" *There are likely multiple locations and land tenures. The number of locations is therefore not defined but is greater than 10 (a threshold number for COSEWIC's B criterion)*.	>10
Is there an observed, continuing decline in extent of occurrence?	No
Is there an observed continuing decline in index of area of occupancy?	No
Is there an observed continuing decline in number of populations?	No
Is there an observed, continuing decline in number of locations?	No
Is there an observed, continuing decline in quality of habitat? *As the result of encroachment of invasive species and through disruption of natural processes such and wild fires and bison grazing*.	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No

∗ See definition of location.

Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Saskatchewan	Unknown
Manitoba	Unknown
Total Considering the clonal nature of the species, it is highly likely that the number of asexually produced ramets (both male and female) surpasses the maximum criteria limits of 10,000.	Likely >>10,000

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

Coal strip mining, invasive alien species, disruption of natural disturbance regimes including grazing and/or fire, and road construction or upgrades are the major threats. Minor threats include flooding by reservoirs and dams, cultivation, and oil & gas development.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? USA: Arkansas SNR, Arizona S1S2, Colorado SNR, Georgia SNR, Illinois S2, Iowa S1, Kansas SNR, Louisiana SNR, Minnesota S3, Missouri SH, Montana S4?, Nebraska SNR, Nevada SNR, New Mexico SNR, North Dakota SNR, Oklahoma SNR, South Dakota SNR, Texas SNR, Utah S1, Virginia – exotic, Wisconsin SNR, Wyoming S3	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely? *Though propagules are expected to possibly be transported into Canada, likely of sufficient habitat make rescue unlikely*.	No

Current Status

COSEWIC: Special Concern (November 2011)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not applicable

Reasons for designation:

This grass occurs in limited areas of remnant short-grass prairie in southern Saskatchewan and Manitoba. Threats to this species include coal strip mining, invasive alien plants and overgrowth by woody vegetation and high grass that were once controlled by bison grazing and fire. However, results of recent survey efforts have increased the known number of populations and it no longer qualifies as a threatened species.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable; a decline in the number of mature individuals has not been demonstrated.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Though meeting the criteria for Endangered in having an EO <5000 km^2 and an IAO <500 km^2 and there is a continuing decline in the quality of habitat, it is known to occur at >10 locations, the populations are not considered severely fragmented nor is the population considered to undergo extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable; exceeds thresholds for population size.
Criterion D (Very Small Population or Restricted Distribution): Not applicable; exceeds thresholds for population size, area of occupancy and number of locations.
Criterion E (Quantitative Analysis): None conducted.

PREFACE

Since Buffalograss was assessed as Threatened by COSEWIC in 2001 and subsequently listed on Schedule 1 of the federal *Species at Risk Act*, it was also listed in Manitoba where Buffalograss is considered as Threatened and is protected under *The Endangered Species Act*. A recovery strategy for the species was prepared by Environment Canada in 2007 and is in the process of being implemented.

When the last status report for Buffalograss was completed in 1998, the extent of occurrence (EO) was estimated to be <10 km^2 with slightly more than 5,000 individuals. A substantial amount of survey and inventory work has been conducted for this species since the last status report. Today the EO is estimated to be 2,383 km^2 with considerably more than 10,000 individuals.

Knowledge of the size of the two populations has also been greatly expanded. In 1998, it was estimated that the area of occupancy (AO) in Saskatchewan was approximately 0.000232 km^2. However, surveys conducted since revealed that Buffalograss occurs in at least 25 quarter sections in Saskatchewan, and occupies an area >0.032 km^2. In 1998, the AO in Manitoba was estimated to be approximately 0.010142 km^2. Recent surveys discovered it in 67 quarter sections and now it is known to occupy a 4.07 km^2 area.

The use of Buffalograss cultivars as lawn in the United States has increased considerably due to the breeding of new hybrids that are disease-resistant.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2011)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Scientific name:	*Bouteloua dactyloides* (Nuttall) J.T. Columbus
Synonym:	*Buchloë dactyloides* (Nuttall) Engelmann, *Sesleria dactyloides* Nuttall, *Bulbilis dactyloides* (Nuttall) Rafinesque, *Anthephora axilliflora* Steudel, *Calanthera dactyloides* (Nuttall) C.S. Kunth, *Castiostega dactyloides* (Nuttall) Fournier
Common name:	Buffalograss, Buchloë faux-dactyle
Family:	Poaceae (grass family)
Major plant group:	Angiosperm (monocot flowering plant)

Bouteloua dactyloides was first described and named by Thomas Nuttall (1818) as *Sesleria dactyloides*, based only on male (staminate) plants from the “plains of the Missouri”. In 1999, Columbus recommended including *Buchloë* in the genus *Bouteloua* based on results from molecular phylogenetic analysis. However, the Flora of North America editorial committee (2003) recommended maintaining this species in a separate genus pending corroboration from other studies.

Morphological description

Buffalograss plants bear a superficial resemblance to Blue Grama (*Bouteloua gracilis*), a common dominant in upland mixed-grasslands at Buffalograss sites in Canada. Vegetatively they are similar because of their abundant, curly basal leaves that closely cover the ground. However, Blue Grama is a bisexual, monoecious bunch grass with short, scaly rhizomes while Buffalograss is a unisexual, dioecious (male and female flowers occur on different plants) plant with numerous stolons (Figure 1).

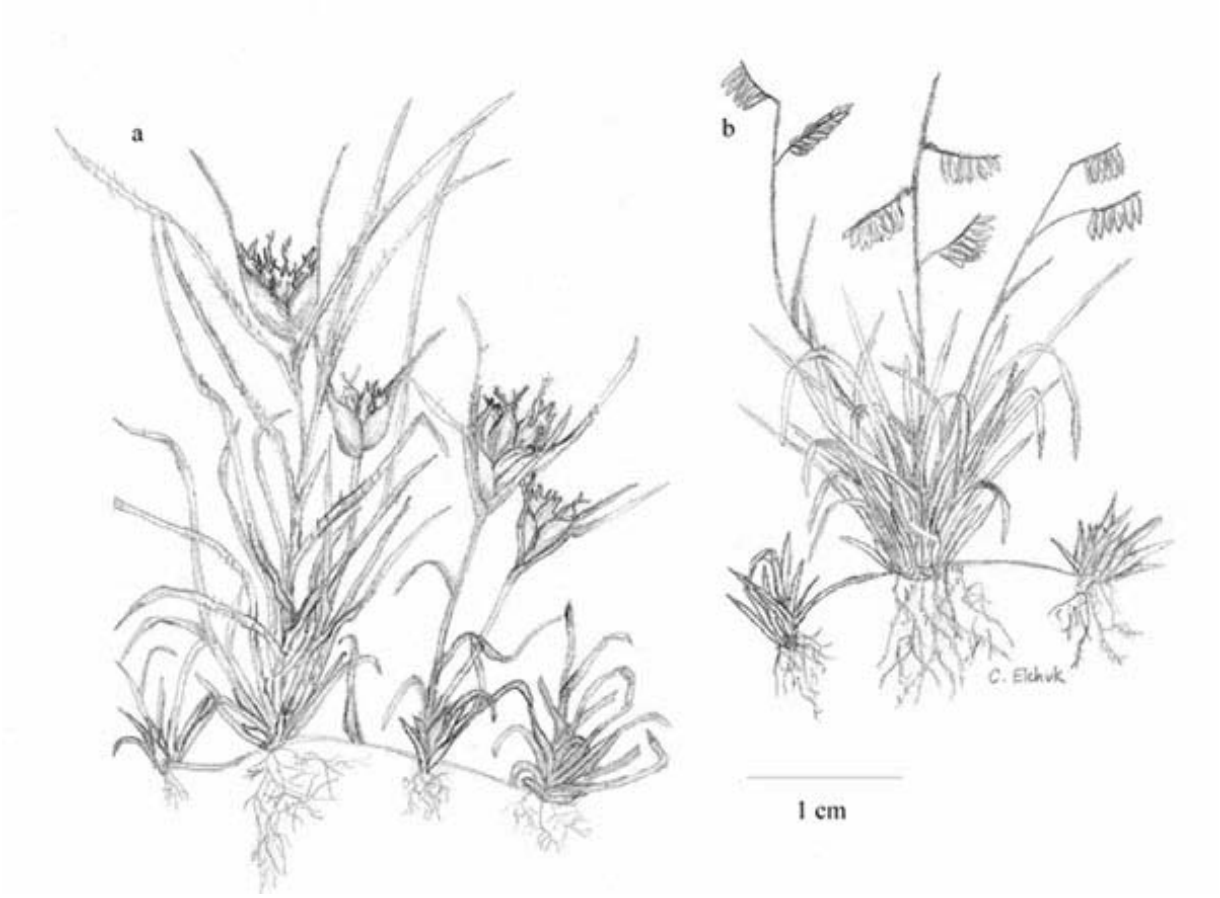

Figure 1. Illustration of (a) female and (b) male *Bouteloua dactyloides* (Line drawing from Environment Canada 2007, by permission).

Bouteloua dactyloides is a creeping perennial with stolons rooting at the nodes to form dense, matted sods. The culms are slender and essentially glabrous. Leaves are grayish-green, tufted, with curly, flattish blades that are 2-10(-15) cm long and 1-2 mm wide. The female inflorescences are terminal and consist of 2(-3) bur-like clusters that are 4-5 mm wide, 6 mm long, with (1-) 2-5, 1-flowered spikelets per cluster. The hard, thick rachis and broad outer glumes form a rigid, white, globular structure crowned by 3-toothed glume-tips. At maturity each cluster contains 1-5 fruits that are permanently retained within the outer glumes and rachis, forming a hard, toothed, globular bur that becomes the dispersal unit. The fruit is a grain or caryopsis (Figure 2). Male inflorescences are made of 10 spikelets that are closely imbricated in two rows on one side of the spike-rachis (Figure 3). (For more morphological descriptions see Hitchcock 1950; Boivin 1981; Stubbendieck *et al.* 1990; Flora of North America vol. 25, 2003).

Figure 2. Female *Bouteloua dactyloides* plant in flower south of Melita, Manitoba. Photo by D.B. Robson 2009.

Figure 3. Male *Bouteloua dactyloides* plant in flower south of Melita, Manitoba. Photo by D.B. Robson 2009.

Population spatial structure and variability

Buffalograss, as in some other chloridoid grasses, has a base chromosome number of x=10. Three chromosomal races are known: diploid (2n=20), tetraploid (2n=40), and hexaploid (2n=60). The diploid and tetraploid races occur mostly in Mexico; most individuals in the U.S.A. and Canada are hexaploid (Reeder 1967, 1968, 1971; Reeder and Reeder 1972). These chromosomal races could be interpreted as representing different biological species because they are unable to produce fertile offspring despite being morphologically inseparable. However, current taxonomic treatments consider Buffalograss to be a single species, and separation would require detailed mapping of ploidy variation and studies to determine whether gene flow is possible among races.

The Saskatchewan and Manitoba populations are approximately 160 km apart. The nearest documented populations in the United States are 50 to 100 km away from the Canadian populations in Ward, Pierce and Walsh counties, North Dakota (Duttenhefner pers. comm. 2009). However, as Buffalograss grows right up to the U.S. border in Manitoba, the population likely continues into the J. Clark Salyer National Wildlife Refuge in Bottineau County as appropriate habitat was observed by D.B. Robson in 2009 from the Canadian side of the border.

Designatable units

A single designatable unit (DU) is recognized. There are no described subspecies or varieties of Buffalograss and, though separated by 160 km, the populations in Manitoba and Saskatchewan occur within the same National Ecological Region (Prairie). There is no evidence as of yet that the Canadian populations are genetically or ecologically distinct from each other or the nearest populations in the United States.

Special significance

Buffalograss has long been recognized in the American west-central Great Plains states as a valuable natural livestock forage grass that thrives under semi-arid conditions, and even increases under grazing pressure (Dittberner and Olson 1983; Howard 1995). It is excellent winter forage, due to its natural curing, and retention of high protein and nutrient content after frost. Its forage potential seems mainly limited to drier grasslands and heavier soil regions of the western Great Plains, as the species does not compete well, either ecologically or in livestock preference, in higher rainfall regions (Beetle 1950).

Because of its drought-tolerance, low nutritional requirements, pronounced sod-formation, and short stature, Buffalograss has become an important, low-maintenance turf-grass for xeriscaped lawns and golf courses (Quinn 1998; Mintenko *et al.* 2002), and for revegetation projects such as erosion-control, reclamation and natural prairie restoration (Vogel 1981; Thornburg 1982; Sieg *et al.* 1983; McFarland *et al.* 1994). Quite a number of cultivar strains are sold in the southern and central Great Plains states, despite difficulties in seed-harvesting due to light seed crops, seeds produced near ground level, early detachment of seed-burs, and seed dormancy (Beetle 1950; Ahring and Todd 1977).

Buffalograss turf was primarily used for the building of sod-houses by early settlers in the American west-central Great Plains, although not in the Canadian prairie provinces. Members of the Acoma, Laguna and Blackfoot tribes used Buffalograss (Swank 1932; Johnston 1987).

DISTRIBUTION

Global range

Buffalograss is a common and dominant short grassland species on the western Great Plains uplands in the U.S.A., and occurs in the eastern Great Plains in favourable sites (Figure 4). The overall natural range of Buffalograss extends from SE Saskatchewan and SW Manitoba west to Montana, E Wyoming, E Colorado, and Arizona, east to SW Minnesota, W Iowa, Missouri, Oklahoma and Texas, and south through North and South Dakota, Nebraska, Kansas, New Mexico and S central Mexico (NatureServe 2010). Apparently native, disjunct outliers occur in Arkansas, Louisiana, Georgia, Illinois, Nevada, Utah and Wisconsin (NatureServe 2010). The Virginia population is introduced (NatureServe 2010). Thus, less than 1% of the historical and current range of Buffalograss is in Canada.

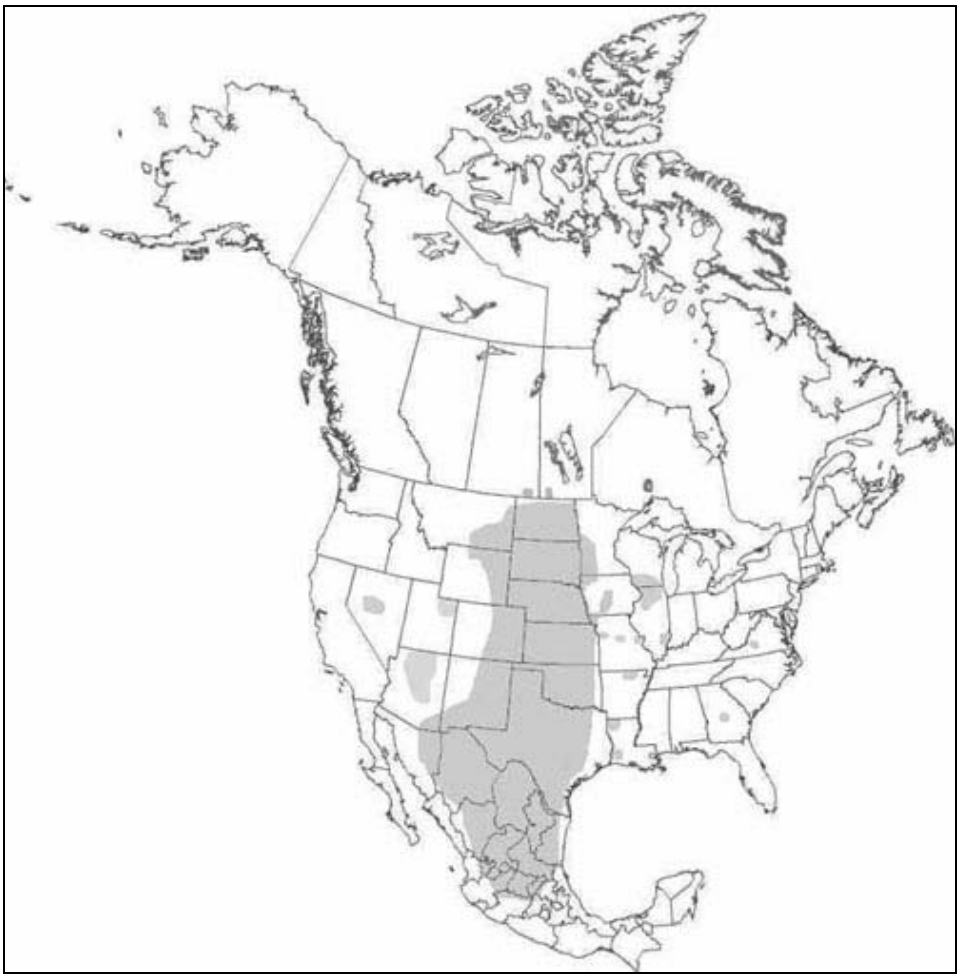

Figure 4. North American distribution of *Bouteloua dactyloides*. (Map from Environment Canada 2007, by permission.)

Canadian range

In Canada, Buffalograss is a peripheral species, reaching its northernmost range limit in southeastern Saskatchewan and southwestern Manitoba (Figure 5). It occurs in the Aspen Parkland Ecoregion of Manitoba and the Moist Mixed-grass Prairie Ecoregion of Saskatchewan, both of which are in the Prairie Ecozone (Marshall and Schut 1999). The population in Manitoba is south of Melita along the Blind and Souris rivers. The population in Saskatchewan is west of Estevan along both sides of the Souris River Valley. Buffalograss was first discovered and collected from east of Coulter, Manitoba, by H.J. Scoggan in 1953, and from Estevan, Saskatchewan by John H. Hudson in 1957 (Hudson 1958).

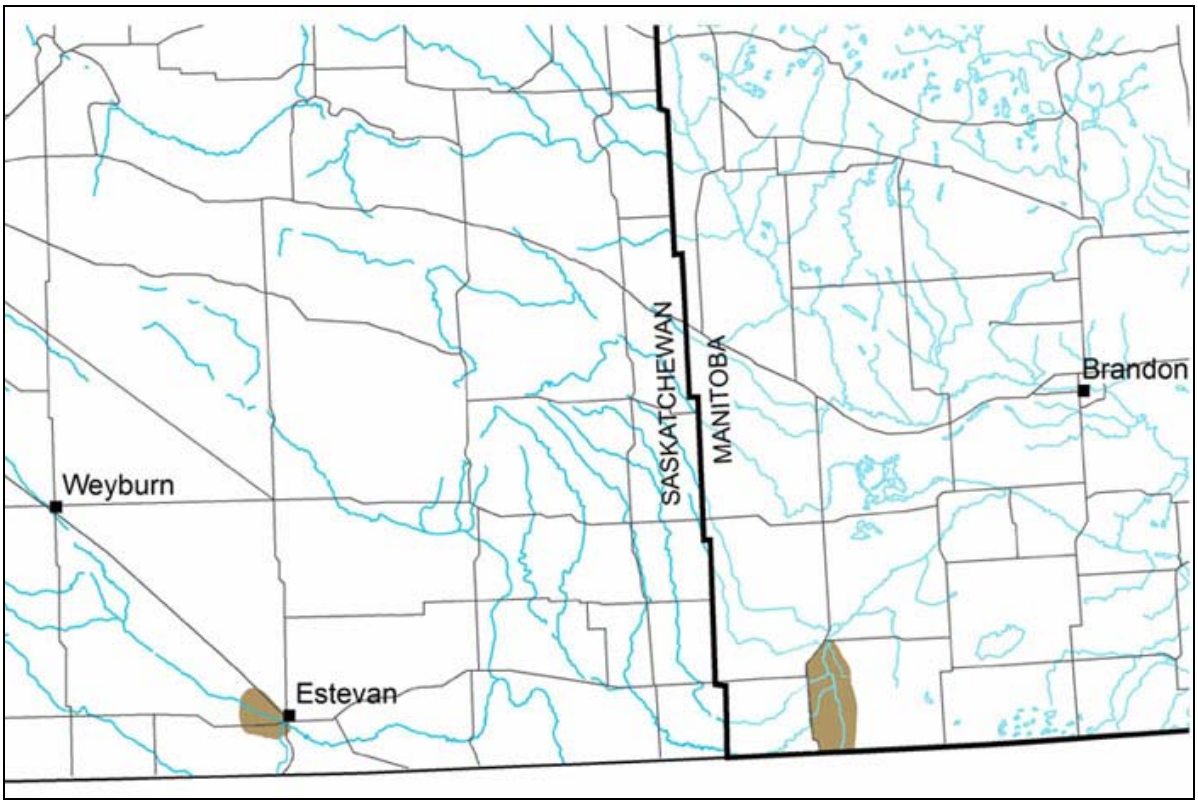

Figure 5. Ranges of the two populations of *Bouteloua dactyloides* in Canada. (Map from Environment Canada 2007, by permission.)

Saskatchewan population

The Saskatchewan population, just west of Estevan, occurs within a 46 km^2 area along the Souris River Valley. The Saskatchewan population was initially described as containing five “subsites” at least 500-m apart from each other (Harms 1998). However, many more Buffalograss patches have been discovered since the initial status report (Harms 1998). The most recent survey work by Environment Canada, Nature Saskatchewan and The Manitoba Museum estimates that Buffalograss occupies at a minimum a 0.032-km^2 to 0.068-km^2 area in Saskatchewan and possibly even more as additional quarter sections within the EO still need to be surveyed.

Manitoba population

Initially Harms (1998) described the Manitoba population as consisting of a single population with five “subsites” over 1.01 hectares. The plants at these “subsites” were all recently relocated and a similar or greater number of clones discovered. The recovery strategy for this species (Environment Canada 2007) describes five populations in Manitoba: three in the Blind River Valley, one at Sourisford Park and one very large one along the Souris River. Additional survey work since the recovery strategy was prepared supports an alternative interpretation of a single large population scattered along the Blind and Souris river valleys (Friesen pers. comm. 2010) as currently disjunct populations may be amalgamated into fewer and larger populations (Environment Canada 2007).

Buffalograss plants in the Souris River Valley begin at Sourisford Park, north of Coulter, and likely continue into northern North Dakota. Thus it covers a length of at least 17.6 km of the Souris River Valley. The plants in the Blind River Valley begin about 4.8 km south of the town of Melita and join up with the Souris River Valley plants via the Waskada Creek tributary.

To determine the extent of occurrence (EO) in Canada, the centroid of all quarter sections where Buffalograss had been documented was calculated using a Geographic Information System. The minimum convex polygon encompassing the centroid of these quarter sections was then determined. Using this technique, the Canadian EO is approximately 2,383 km^2 (Wu pers. comm. 2010). However, this area includes a considerable amount of cultivated land (about 95%) that is unlikely to contain any Buffalograss, except potentially along the Antler River valley in southeast Saskatchewan. If these large areas of unsuitable habitat are excluded the EO decreases to 138 km^2, a value lower than the index of area of occupancy (IAO).

Harms (1998) estimated that the area of occupancy (AO) in Saskatchewan was approximately 232 m^2 (2.32 $x10^{-4}$ km^2). However, surveys conducted in 2005, 2006, 2008 and 2009 revealed that Buffalograss occurs in at least 25 quarter sections[1] (a quarter section is about 0.647 km^2) in Saskatchewan and possibly more (Table 1) (Neufeld pers. comm. 2010; Vinge pers. comm. 2010). Plants have been found both north and south of the Souris River. Because the area occupied by Buffalograss within each quarter section is not known, a new AO has not been calculated for Saskatchewan.

Table 1. The sites, geographical areas, survey years and total number of quarter sections where Buffalograss was found in Canada.

Population	Geographical Area	Year	Presence (cumulative total number of quarter sections)
Saskatchewan	North Souris River	1969[1]	1
		1993[1]	2
		1994[1]	2
		2005[2]	2
		2006[2]	3[8]
		2008[2]	6
		2009[3]	7
	South Souris River	1957[1]	2
		1987[1]	4
		1994[1]	8
		2005[2]	9
		2006[2]	13
		2009[3]	18
Subtotal			**25**
Manitoba	Souris River Valley	1953[1]	1
		1993[1]	2
		1994[1]	3
		1997[6]	3
		1999[5]	3
		2000[4]	3
		2001[4]	4
		2002[7]	34
		2004[5]	35
		2005[4]	40
		2006[4]	42
		2007[4]	53
		2008[4]	57
		2009	57
	Blind River Valley	2001[7]	1

[1] A quarter section is a legal land parcel approximately 800 x 800 m in size, nested within the Dominion Land Survey System used widely throughout the agricultural areas of Western Canada. Quarter sections are identified with prefixes related to their cardinal direction within a 1600 x 1600 m section (i.e. NW, NE, SW, SE).

Population	Geographical Area	Year	Presence (cumulative total number of quarter sections)
		2005[4]	2
		2006[4]	4
		2007[5]	8
		2009	10
Subtotal			**67**
TOTAL			**92**

[1] Harms, 1998
[2] Neufeld pers. comm. 2010
[3] Vinge pers. comm. 2010
[4] Firlotte pers. comm. 2009
[5] Friesen pers. comm. 2010
[6] Johnson pers. comm. 2009
[7] Reimer *et al.* 2003
[8] The plants found on one quarter section in 1993 and 1994 could not be relocated in 2005 and this section was removed from the cumulative total.

The AO in Manitoba was estimated to be approximately 0.01 km^2 in 1994 (Harms 1998). Manitoba Conservation staff have conducted Buffalograss surveys almost every year since 2000 (Reimer *et al.* 2003; Firlotte pers. comm. 2009; Friesen pers. comm. 2010), discovering it in 67 quarter sections (Firlotte pers. comm. 2009). The total area that Buffalograss occupies within those 67 quarter sections was estimated to be 2.7 km^2 in 2003 (Reimer *et al.* 2003); this was later updated to 4.07 km^2 (407 ha) in 2007 (Environment Canada 2007).

To calculate the IAO, the surface area of 2 km by 2 km grid cells that intersect the actual area occupied by Buffalograss (i.e. the biological area of occupancy) was calculated using a GIS (Wu pers. comm. 2010). The IAO for Canada is estimated as 172 km^2: 52 km^2 in Saskatchewan and 120 km^2 in Manitoba (Wu pers. comm. 2010). As part of the recovery strategy for this species (Environment Canada 2007), there are plans to map population boundaries of Buffalograss using Global Positioning Systems (GPS) to delineate the actual area of occupancy within each quarter section.

The number of locations is difficult to define for Buffalograss, but with occurrences in at least 92 quarter sections, many with different ownership and management regimes, the number is certainly greater than 10 (the threshold for COSEWIC's B criterion). Large populations of Buffalograss cannot constitute a single location because it is highly unlikely that a single threatening event could impact the entire area of the population, as required by the IUCN definition (IUCN 2010). The number of locations within a single large population would depend on the type of potential threat being considered, and the resulting number of locations at that population may be different for different threats. Finally, the main threats are general or broad-acting and may act too slowly to be useful for the definition of location. The application of location for purposes of assessment is therefore not applied to Buffalograss. As both populations are in habitat patches that are large enough to support viable populations Buffalograss is not considered to be severely fragmented.

Search Effort

The size of the Buffalograss population in Canada is now known to be considerably larger than was estimated in the initial status report (Harms 1998). This change is not likely due to massive expansion of Buffalograss in the last decade, but more likely reflects increased survey effort. However, whether Buffalograss in Canada has been spreading or declining is unknown. The efforts by various searchers are summarized in Table 2.

Table 2. Summary of Buffalograss search efforts.

Pop.	Searcher Name	Method[1]	Survey Year	Total time[2] (hrs)	Presence[3] (# ¼ sections)	Absence[4] (# ¼ sections)
SK	J. Hudson[5]	General?	1957	?	1	?
		General?	1969	?	1	?
		General?	1993	?	2	?
	V.L. Harms[5]	General	1987	?	1	?
		Targeted	1993	?	2	?
		Targeted	1994	~16	6	?
	EC/NSK[6]	Targeted	2005	90	5	0
		Targeted	2006	352[7]	11	9
	NSK[8]	Targeted	2008	55[7]	3	0
			2009	65[7]	6	1
	D.B. Robson	Targeted	2009	13	10	3
MB	H.J. Scoggan[5]	General?	1953	?	1	?
	V.L. Harms[5]	General	1993	?	2	?
		Targeted	1994	~16	3	?
	K.L. Johnson[9]	Targeted	1997	4	1	?
	MCDC[10]	Targeted	1999	~2-3	2	0
		Targeted	2000	~1-2	1	0
		Targeted	2001	~4-6	4	0
		Targeted	2002	~12-18	8	4

Pop.	Searcher Name	Method[1]	Survey Year	Total time[2] (hrs)	Presence[3] (# ¼ sections)	Absence[4] (# ¼ sections)
		Targeted	2004	~1-2	1	0
		Targeted	2005	~7-11	7	0
		Targeted	2006	~13-16	5	7
		Targeted	2007	~24-32	16	5
		Targeted	2008	~6-9	6	0
		Targeted	2009	~7-11	6	3
	D.B. Robson	Targeted	2009	15	10	14

[1] General surveys involved documenting the local flora while targeted surveys involved looking specifically for Buffalograss.
[2] Where the exact number of hours spent searching was not recorded, an estimated time (~) is indicated.
[3] Indicates the number of surveyed quarter sections where Buffalograss was found that year.
[4] Indicates the number of surveyed quarter sections where Buffalograss was not found that year.
[5] Harms, 1998.
[6] In 2005, surveys were conducted by 2 searchers from Environment Canada and 1 from Nature Saskatchewan (Neufeld pers. comm. 2010).
[7] Henderson pers. comm. 2010.
[8] Nature Saskatchewan – Rare Plant Rescue surveys in 2008 were conducted by four searchers and in 2009 by 7 searchers (3 searchers x 23.5 hrs, 2 searchers x 19.5 hrs x and 2 searchers x 8 hrs) (Vinge pers. comm. 2010).
[9] Johnson pers. comm. 2009.
[10]Surveys were conducted by 1-3 searchers each year from the Manitoba Conservation Data Centre (Reimer *et al.* 2003, Firlotte pers. comm. 2009, Friesen pers. comm. 2010). In 2006, surveys were conducted by 2 staff from Nature Saskatchewan and 4 staff from Environment Canada (Neufeld pers. comm. 2011).

The 1987 survey by V.L. Harms was part of a general rare plant survey of the Souris River Valley. The survey work in 1993 and 1994 by V.L. Harms consisted of targeted Buffalograss searches to collect data for the initial COSEWIC report (Harms pers. comm. 2010).

Since Buffalograss was listed as a Threatened species in 2001, Environment Canada, Nature Saskatchewan – Rare Plant Rescue, and Manitoba Conservation Data Centre staff have conducted extensive surveys for it. Nature Saskatchewan staff found Buffalograss on five new quarter sections when they conducted surveys as recently as August 2009. The sampling method in Saskatchewan has been “adaptive cluster sampling” whereby quarter sections supporting native grassland, and adjacent to previously known occurrences of Buffalograss, were searched systematically until no habitat remained, or until a ring of absent quarter sections was created (Henderson pers. comm. 2009). Four quarter sections along the Souris River west of Roche Percee and two along Boundary Dam Reservoir were also surveyed without finding any Buffalograss. The search method was a census-search, whereby entire quarter sections were searched with parallel adjacent transects until Buffalograss was detected, excluding only water and forest cover (Henderson pers. comm. 2009). This took as many as 40 person-hours per quarter section when Buffalograss was absent. If Buffalograss was present, it was usually detected in the first hour or two of the survey (Henderson pers. comm. 2009). Between 2006 and 2009, approximately 385 person-

hours of search effort were invested in Saskatchewan by Environment Canada and Nature Saskatchewan's Rare Plant Rescue staff using this single consistent method (Neufeld pers. comm. 2010). The resulting dataset for Buffalograss is presence or absence at the scale of individual quarter sections. The estimated patch-scale area of occupancy of Buffalograss was recorded using GPS devices for a few of the quarter sections where it was found in 2005 (Neufeld pers. comm. 2010).

During the 2006 surveys performed by Environment Canada and Nature Saskatchewan, Buffalograss was not found in nine quarter sections in Saskatchewan. In 2009, four additional quarter sections, and four partial quarter sections, were searched without finding Buffalograss. Approximately 31 quarter sections adjacent to those with some Buffalograss have not been surveyed but some of them have been heavily disturbed by coal mining activities and dam construction. The Estevan-Cambria Prairie Farm Rehabilitation Administration Community Pasture, west of Estevan, was also searched for Buffalograss in 2007 using random transects but no plants were found (Henderson pers. comm. 2009). No searches along the Antler River have been conducted.

In Manitoba, forest resource inventory maps, Landsat TM satellite imagery and digital aerial photographs were used to identify potential native prairie along the Souris and Blind river valleys (Reimer *et al.* 2003). On each quarter section field surveyors from the Manitoba Conservation Data Centre (MCDC) walked roughly parallel transects, recording the extent of each patch of Buffalograss encountered on aerial photographs; these data were later digitized based on ortho photos and entered into a GIS system (Reimer *et al.* 2003; Friesen pers. comm. 2010). The number of hours spent surveying each quarter section was recorded and is generally between 15 minutes and three hours depending on the topography and amount of native prairie present. From 1999 to 2009, MCDC staff spent an estimated 77-110 person hours searching for Buffalograss.

During the 2002, 2006 and 2007 surveys conducted by the Manitoba Conservation Data Centre, Buffalograss was not found in five quarter sections along the Souris River Valley. Eight quarter sections in the Blind River Valley were searched in 2006 and 2007 without finding Buffalograss. In 2009, two additional quarter sections in the Blind River Valley and three along the Souris River Valley were searched without finding Buffalograss.

The Manitoba population can be divided roughly into two geographical areas: one along the Blind River and one along the Souris River valleys. Buffalograss plants in the Souris River Valley begin at Sourisford Park, north of Coulter, and likely continue into northern North Dakota. Thus the species is dispersed along at least 17.6 km of the Souris River Valley. The plants in the Blind River Valley begin about 4.8 km south of the town of Melita and join up with the Souris River Valley plants via the Waskada Creek tributary.

From July 20 to 24, 2009, D.B. Robson visited 13 quarter sections in Saskatchewan for 13 hours and 24 quarter sections in Manitoba for 15 hours. The purpose of these surveys was to revisit the populations identified by Harms (1998), and to visit additional quarter sections that had not been surveyed. One new, fairly large discontinuous patch of Buffalograss was found on one quarter section in Saskatchewan that had not been searched before. This was achieved by following the entire length of the coulees where Buffalograss was found into the upland until no plants were detected. GPS data were used to delineate the boundaries of the coulees where Buffalograss populations occurred.

HABITAT

Habitat requirements

Buffalograss is abundant and often co-dominant with Blue Grama on the dry, short-grass steppes of the western Great Plains of the United States. The species apparently tolerates a fairly wide range of edaphic conditions, although it grows more abundantly on clay rather than sandy soils (Wenger 1943; Beetle 1950). It reportedly exhibits a high alkali-tolerance and is capable of good growth even on hard clay-pan substrates. Beetle (1950) indicated that the optimal annual precipitation range for Buffalograss on the central Great Plains is 15 inches (=384 mm) to 25 inches (=640 mm). Having evolved under the unique grazing and intermittent disturbance regime of migrating American Bison (*Bison bison*) herds, it reportedly withstands moderate to heavy grazing and trampling extremely well (Wenger 1943; USDA 1948; Beetle 1950).

Buffalograss abundance increases with reduction of tall grass cover, whether by experimental clipping or by increased grazing pressure (Weaver and Clements 1938; Barker and Whitman 1988). Buffalograss appears intolerant of shade, including the shade of other grasses. Competition for water and nutrients may also be involved, although its importance was discounted by Turner (1987).

The Canadian populations of Buffalograss occur on shale-outcrops, open, eroded benches or gentle west- or south-facing slopes of the immediate Souris and Blind river valley slopes (Harms 1998). The plants in Saskatchewan also occur on dry, near-level bottoms and gentle, outwashing lower slopes of shallow, open coulees[2] that head tributary streamlets of the Souris River. Less commonly it has been found on upland prairies and dugout edges. Cattle grazing, of unknown intensity, occurs on some of the sites. The Buffalograss Ecological Reserve area, 5 km west of Estevan, has been fenced since 1981 and has not experienced any cattle grazing, which has resulted in an increase in Kentucky Blue Grass (*Poa pratensis*) cover (Environment Canada 2007). The largest Buffalograss population in Saskatchewan along the south side of the Souris River occurs along branch coulees and the edges of cow-paths on dry coulee bottoms. Local cattle disturbance (e.g. trampling and grazing) may be just as instrumental in defining the Buffalograss habitat as the plants' topographic position along the base of shallow coulees.

Canadian Buffalograss sites can be described as a semi-arid continental type, characterized by cold winters, warm summers and extreme variations in temperature and precipitation. From climatic records available from Estevan, SK, and Pierson, MB, the mean annual temperature ranges from 3.2ºC to 3.7ºC, and the mean annual precipitation from 433 mm-478 mm (Environment Canada 2010). Annual potential evapo-transpiration usually exceeds precipitation, resulting in soil moisture deficits (Baschak and Vandall 1994).

Buffalograss habitat is characterized by upland mixed-grasslands dominated primarily by needle grasses (*Nassella viridula* and *Hesperostipa* spp.) and Blue Grama, plus wheatgrasses (*Pascopyrum* spp. and *Elytrigia* spp.) and June Grass (*Koeleria macrantha)*. Besides the upland mixed-grasslands, regional vegetation types include aspen (*Populus* spp.) groves and riparian deciduous woodlands (but none locally near the Buffalograss sites), shrublands, moist sedge/grass meadows on floodplains and riparian valley lower slopes, and Western Snowberry (*Symphoricarpos occidentalis*) shrub patches scattered on moister slopes and in upland prairie depressions (Baschak and Vandall 1994). A list of 115 vascular plants found at the Buffalograss Ecological Reserve was prepared by Baschak and Vandall (1994).

[2] Dry, treeless valleys on the Northern Great Plains with or without an under-fit ephemeral stream, most often the result of glacial melt-water channels formed 8-12 thousand years before present (Kehew 1982).

Habitat trends

Both the quantity and quality of habitat for Buffalograss in Canada has declined significantly since European settlement of the prairies (Anderson *et al.* 1996). In Manitoba and Saskatchewan, 99.9% and 81.3% respectively of mixed grass prairie has been lost due to cultivation and other human developments (Samson and Knopf 1994). Specifically, the vast majority of land within the EO of Buffalograss has been cultivated. Because Buffalograss was not collected in Canada until 1953, despite the fact that vegetation surveys had been occurring since the 1870s (Macoun 1979), it was likely not particularly common or widespread. Nonetheless, areas within the EO that are now under cultivation may have contained Buffalograss that was overlooked during earlier vegetation surveys. Although most of the arable land within the EO has already been cultivated there are some remaining areas in the river valleys that could be cultivated if there is increasing pressure to do so.

Coal continues to be mined in Saskatchewan at the rate of approximately 70 million tonnes per year; this rate of production could be sustained for at least a hundred years (Stone 2008). Although much of the land that is being mined is agricultural, some of the land that is destroyed is native mixed-grass prairie, and in the vicinity of known populations.

The quality of mixed-grass prairie habitat has been declining due to the loss of "ecological drivers" such as grazing and fire at both the landscape and local levels (Samson *et al.* 2004). The loss of migratory Bison in the mixed-grass prairie and subsequent habitat changes since the 1880s have likely negatively impacted seed dispersal (and thus genetic exchange) and habitat quality for Buffalograss (Knapp *et al.* 1999; Keeler 2000). Samson *et al.* (2004) hypothesize that the movements of Bison would have resulted in a "natural habitat mosaic of short, mid and tall seral stages" that would have altered the abundance of plant species. Although cattle may create similar disturbances as Bison via their grazing and wallowing (Knapp *et al.* 1999), they do not provide long-distance seed dispersal as they are confined. Fire in the mixed-grass prairie was estimated to occur every three to five years in pre-European contact times, resulting in a heterogeneous landscape (Samson *et al.* 2004). The lack of fire in the prairies is contributing to an increase in woody plant cover and altering population sizes of some species adapted to high grass cover (Grant *et al.* 2006).

The quality of prairie habitat is also declining due to the encroachment of invasive plant species (Mansell and Moore 1999). In 1999, Leafy Spurge (*Euphorbia esula*) alone was estimated to cover at least 340,000 acres in Manitoba (Annis 2009). Both natural soil disturbances such as rodent activity, and anthropogenic ones, such as cultivation, mining and road construction, facilitate the invasion of alien species into native mixed grass prairie (Belcher and Wilson 1989; Larson 2003). Once established, invasive plants such as Leafy Spurge, Smooth Brome (*Bromus inermis*), Kentucky Bluegrass, and Crested Wheatgrass (*Agropyron cristatum*), tend to modify the soil and facilitate further invasion of native habitats (Jordan *et al.* 2008). Despite some effective initiatives to control invasive plants (Larson *et al.* 2008; Government of Saskatchewan 2010), they will likely never be eradicated entirely on native prairie, especially if they are agriculturally useful plants that are still being grown as forage crops (e.g. Smooth Brome and Crested Wheatgrass).

BIOLOGY

Due to its importance as a forage species and as a turf grass, several studies on the reproductive biology of Buffalograss have been conducted (Lowe 1940; Beetle 1950; Quinn and Engel 1986; Quinn 1987, 1991; Lauenroth and Adler 2008).

Life cycle and reproduction

Buffalograss is a perennial, wind-pollinated, outcrossing herb, reproducing sexually by seeds and vegetatively by stolons. Its breeding system has been the subject of some controversy with regard to the presence and frequency of the three recorded sex forms (dioecious, monoecious and hermaphroditic), and possible inconstant sex expression in the monoecious forms. Careful research during the last 60 years, however, has reaffirmed that under natural conditions, the species is largely dioecious. Monoecious forms occur infrequently in the south, and hermaphroditic plants are found very rarely and mostly in Mexico (Quinn and Engel 1986; Quinn 1987, 1991). None of the Canadian clones observed showed anything but apparent dioecy (Harms 1998).

Buffalograss begins growing in mid-spring when temperatures rise above freezing at night, and moisture is available. It flowers in summer, mostly by mid-July in Canada, setting seed soon thereafter, with some apparently mature caryopsis-containing burs becoming detached by late July (Harms 2008).

Although many Buffalograss seeds germinate the first year, others require varying periods of dormancy. While the low germination rate (Beetle 1950 indicated 50%) for seeds the first year after planting is viewed negatively by producers of native seeds for revegetation purposes, this phenomenon of varying dormancies benefits the long-term success of native populations. The differential germinating ability of seeds within one bur not only reduces competition but also gives the bur more than one chance to colonize a microsite (Quinn 1987). The relatively long viability of Buffalograss seeds was illustrated by Lowe (1940) who found a 28% germination success (and in one test 78%) of caryopsis-containing burs preserved in a 25-year-old sod house in Kansas, although after 35 years there was no further germination.

Most Buffalograss plants die young, having a first year survival of 0.454 years (Lauenroth and Adler 2008). Life expectancy at one year is 2.16 years with a maximum life span of 35 years (Lauenroth and Adler 2008). The size of a grass plant or genet is significantly positively correlated with the age of the plant (Lauenroth and Adler 2008). The generation time is therefore >3 years but would be increased if seed dormancy is considered.

Physiology and adaptability

Buffalograss has C4 physiology, which gives it higher water use efficiency than C3 grasses; this makes it tolerant of dry habitats and drought conditions (Ford 1999). Huang (1999) found that the deep root system of Buffalograss relative to Zoysia Grass (*Zoysia japonica*) gave it an advantage under simulated drought conditions in growth chamber experiments. During the 1930s drought in the U.S.A., Buffalograss was less affected than both C3 grasses and taller C4 grasses, actually increasing in density in some areas (Weaver 1968). The stolons of Buffalograss are able to elongate at the rate of 2.5 cm per day; this makes the species valuable for reclamation of grasslands denuded by drought and overgrazing (Weaver 1968).

Buffalograss can tolerate short-term climate variability due to seed dormancy during unsuitable growth conditions (Quinn and Engel 1986). The low stature, and ability to reproduce vegetatively, aids Buffalograss in withstanding heavy grazing, trampling and fire (Ford 1999), and periods of prolonged submersion underwater through flooding (Parks 1993). The hard burs also seem to protect Buffalograss seed from fire damage (Ford 1999). Buffalograss is considered to be moderately salt-sensitive with the degree of sensitivity varying somewhat between clones (Wu and Lin 1994).

Buffalograss has been used successfully as a turf grass in the United States. New cultivars for traits such as freezing tolerance (Qian *et al.* 2001), drought resistance (Kenworthy *et al.* 2008) and pest resistance (Heng-Moss 2002) are being developed.

Dispersal

The seed dispersal units and mechanisms of Buffalograss are quite distinctive. There are 1-5 seeds remaining permanently enclosed in a hard globular bur that serves as the dispersal unit. The bur anchors the seedling in the soil, protects seeds from fire, reduces precocious germination by requiring considerable moisture for saturation, and seems to enhance seed-longevity (Quinn 1987). Most burs contain seeds producing both male and female plants, making sexual reproduction possible and reducing founder effects upon colonization by one or few burs. While wind dispersal of such propagules is reduced from that of most grasses because of their holding teeth and greater weight and size, this is offset by more effective ungulate and water dispersal.

Buffalograss burs catch onto the fur of mammals, such as Bison and deer (*Odocoileus* spp.), and can be transported considerable distances before they are dislodged (Sorenson 1986; Cheplick 1998; Fenner 2000). The distance that seeds travel ranges from metres to kilometres depending on the animal's fur length and behavioural patterns (Fenner 2000; Vander Wall and Longland 2005). Animals that groom frequently, have a small home range and travel in denser brush are expected to transport seeds a shorter distance than animals that groom infrequently, have larger home ranges and travel in more open areas (Fenner 2000; Vander Wall and Longland 2005). The long fur of Bison is particularly prone to capturing seeds (Keeler 2000). Bison may have transported Buffalograss and other seeds hundreds of kilometres from their parents, possibly not even shedding the seeds until they lost their winter coats in the spring (Keeler 2000). Keeler (2000) hypothesizes that the loss of this long-distance dispersal may be negatively affecting genetic exchange between Buffalograss populations.

Buffalograss may also be dispersed by herbivores internally. The passage of Buffalograss diaspores through herbivore digestive systems occurs within 1-5 days in cattle and in 5 hours to 3 days in White-tailed Deer (*Odocoileus virginianus*) (Quinn and Hervey 1970; Quinn *et al.* 1994; Mouissie *et al.* 2005). The passage of Buffalograss seeds through an animal has a positive impact on germination and seedling growth (Quinn *et al.* 1994). The dispersal distance varies with the home range of the animal (Vander Wall and Longland 2005). Seeds ingested by White-tailed Deer were dispersed in the droppings at least several hundred metres from parent plants and occasionally more than 3 km (Vellend *et al.* 2003; Myers *et al.* 2004) and because Buffalograss is consumed by White-tailed Deer (Chamrad and Box 1968), the dispersal range is assumed to be similar.

Buffalograss burs are also lifted and carried by running water during rains (especially thunderstorms) to accumulate in riffles. In addition to dispersal via seeds, a significant part of the reproductive biology of Buffalograss is its vegetative propagation by means of stolons to form the characteristic circular clonal patches.

Interspecific interactions

Cattle and wild ungulates such as Wapati (*Cervus elaphus*), deer and Pronghorn Antelope (*Antilocapra americana*) readily consume the leaves of Buffalograss (Chamrad and Box 1968; Sexson *et al.* 1981; Walter *et al.* 2010). Small mammals such as White-tailed Jackrabbit (*Lepus townsendii*), Black-tailed Prairie Dog (*Cynomys ludovicianus*), upland game birds and small mammals also consume Buffalograss (Howard 1995). As with all grasses, the growing point near the base of the plant means that Buffalograss can regrow leaves if the upper parts are consumed, making it tolerant of grazing.

In experimental studies, biomass production in Buffalograss increased significantly when the plants were grown with arbuscular mycorrhizal (AM) fungi (Wilson and Hartnett 1998). Many other C4 grasses responded positively to AM fungi but C3 grass response was unaffected (Wilson and Hartnett 1998). Thus Buffalograss may be more dependent on AM fungi to survive than many of the C3 grasses with which it competes. The degree to which this may be a limiting factor for Buffalograss populations is unknown.

Various fungal diseases have been reported to affect Buffalograss in the more southern Great Plains states, including leaf-rusts, leaf-blotch, smut, and bunt (Beetle 1950), but whether any affect Canadian populations is unknown.

POPULATION SIZES AND TRENDS

Sampling effort and methods

Survey work on Buffalograss has been restricted mainly to delineating the extent of its occurrence in Canada. Estimating the number of individuals (or genets) with any accuracy is in all likelihood impossible due to the clonal nature of Buffalograss. Future survey work will likely focus on documenting the total area covered by Buffalograss. This coverage could be used as an index of the number of individuals and as a basis for assessing trends in population sizes.

Abundance

There are two populations in Canada, one west of Estevan, Saskatchewan, and one in Manitoba south of Melita. The plants in Manitoba are considered a distinct population from the ones in Saskatchewan because they are geographically isolated with no potential for genetic exchange. Rough estimates of the number of clones in Canada based on the density of large clones observed in a few land parcels, multiplied by the total known area of occupancy, suggest the total population is at least orders of magnitude larger than 10,000 individuals. The following is an overview of the populations.

Fluctuations and trends

The size of each Buffalograss clone fluctuates with changes in moisture and nutrients, expanding when availability is high and contracting when it is low (Weaver 1968). Weaver (1968) noted that total Buffalograss cover in western Kansas increased from 16% to 90% over a ten-year period after a severe drought, largely due to declines in the abundance of less drought-tolerant species. Thus the size of Buffalograss colonies can change substantially from year to year. However, Canadian populations are not known to fluctuate by an order of magnitude required to qualify as an “extreme fluctuation” under the COSEWIC B criterion.

The Buffalograss clones at all of the “subsites” described by Harms (1998) except for one have been recently relocated. The number of observed clones at these “subsites” was similar to or greater than what was reported in 1994 with the exception of one (i.e. subsite 1D North Side of Rafferty Reservoir), which was not relocated in either 2006 or 2009. The plants at this subsite may have been flooded when the reservoir filled.

Rescue effect

The likelihood that Buffalograss seeds from the U.S. would arrive and establish here naturally depends on two factors: the distance between the Canadian population and nearest U.S. population, and the migration patterns and home ranges of wildlife (Fryxell and Sinclair 1988) that are potential dispersal vectors for seeds. Although the nearest known U.S. populations of Buffalograss are 50-100 km away from the Canadian populations (Duttenhefner pers. comm. 2009), it is probable that some plants occur just over the U.S. border in North Dakota, given the presence of potential habitat observed by D.B. Robson in 2009. Until Buffalograss surveys are conducted in North Dakota, the potential strength of the rescue effect cannot be stated with any certainty.

Animals that move along the Souris River valley from Canada into the U.S. and vice versa may bring Buffalograss burs with them, spreading seeds naturally (Janzen 1984; Cain *et al.* 2000). Without Bison migration, seed exchange between these populations is much reduced than it likely would have been historically (Keeler 2000). Wapiti, which may transport seeds of Buffalograss (Walter *et al.* 2010), no longer occur in the Souris River Valley. The main herbivores still capable of moving seeds around the landscape both externally on their fur and internally in their digestive systems are Pronghorn Antelope (which are still found in Saskatchewan but not Manitoba) and deer (Sexson *et al.* 1981; Myers *et al.* 2004). Long-haired small mesocarnivores like Coyotes (*Canis latrans*) and Red Foxes (*Vulpes vulpes*) are also potential candidates for external seed dispersal due to their long fur and distribution throughout Canada and the U.S.A. (Jaeger 1950).

THREATS AND LIMITING FACTORS

Buffalograss populations are subject to the cumulative effects of a combination of interacting threats (Table 3). There are six major threats to the Buffalograss populations in Canada: coal strip mining, invasive alien species, disruption of natural disturbance regimes including grazing and/or alteration to the fire regime, flooding by reservoirs and dams, cultivation, and road construction or upgrades (Environment Canada 2007). According to Environment Canada (2007), coal strip mining and invasive alien species are highly threatening, lack of fire and grazing, flooding and cultivation are moderate threats and road construction is a low to moderate threat. These threats are discussed in greater detail below.

Table 3. Threat assessment of Buffalograss in Canada (summary of results of discussions with the Vascular Plant Specialist Subcommittee).

Threat	Impact	Scope	Severity	Timing	Comments
Mining & Quarrying	Medium	Restricted	Extreme	High	Coal mines are expanding in the area. ~27% of all quarter sections are threatened.
Invasive Alien Plants	Medium-Low	Pervasive	Moderate-Slight	High	10-30% of sites are affected by invasive plants
Fire & Fire Suppression	Medium-Low	Pervasive	Moderate-Slight	High	There is a complex interaction between fire, invasive species and grazing
Oil & Gas	Low	Small	Slight	High	Direct impacts <1%, but the cumulative edge effect could extend to 10%
Roads	Low	Small	Extreme	High	Road reconstruction is likely, due to recent flood events. New oil & gas construction is also anticipated
Housing & Urban areas	Low	Small	Extreme	Moderate	Populations near Estevan could be affected
Ecosystem Modifications	Low	Small	Moderate	High	Lack of grazing in the Buffalo Grass ER appears to have decreased the population.
Dams and Water Management		Unknown	Unknown	High	Small impoundments are being built. Ditching is likely to increase due to reaction of recent floods
Storms & Flooding		Unknown	Unknown	High	Extreme flood events seem to be increasing but it is difficult to predict the scope and severity
Cultivation					Very few upland sites are available for agriculture due to soil conditions

Coal strip (open pit) mining

In the Estevan area, lignite coal occurs within the Ravenscrag Formation (Environment Canada 2007). Thus coal deposits underlie most of the area where Buffalograss occurs, although probably of substandard commercial grades. Coal is currently being surface-mined at four different sites in the area, a process that involves the complete removal of the top- and sub-soil covering the coal (Saskatchewan Industry and Resources 2006). Strip-mining is presently actively occurring less than 2 km to the south of the southernmost Buffalograss plants. Expansion of strip mining in the direction of these Buffalograss populations is a potential threat, but one that can be ameliorated by conducting surveys and avoiding Buffalograss habitat. Feasibility and environmental impact studies are required in Saskatchewan for proposed coal mining activities within and adjacent to known Buffalograss occurrences (James pers. comm. 2010). Whether any sites have already been impacted by strip mining is unknown but possible as mining has been occurring in the area since the late 1800s. As coal mining is not a potential threat in Manitoba, only the quarter sections containing Buffalograss in Saskatchewan (~ 27% of all occupied quarter sections in Canada) are at risk from this activity. The rapid effect of coal strip mining could represent two locations.

Invasive alien species

Soil disturbances can encourage the encroachment of invasive plant species (Kiviniemi and Eriksson 1999) and threaten Buffalograss stands by shading and out-competing them (Belcher and Wilson 1989; Wilson 1989; Richard and Redente 1995; Wu and Harivandi 1995). The most common invasive plant species occurring in and around Buffalograss habitat are: Kentucky Blue Grass, sweet-clover (*Melilotus* spp.), Alfalfa (*Medicago sativa*), Leafy Spurge (presently only in the vicinity of Manitoba populations), Crested Wheatgrass, Smooth Brome and Quack Grass (*Elymus repens*) (Harms 1998; Reimer *et al.* 2003). These species potentially threaten the persistence of both populations of Buffalograss in Canada as they appear to be spreading in the Souris and Blind River valleys (Harms 1998; Foster and Hamel 2006). Whether invasive plants have actually displaced any Buffalograss plants yet is unknown. Because invasive species are managed on a site by site level it is not possible to calculate the number of locations based on the threat as dozens of different land owners are known.

Disruption of natural disturbance regimes including grazing and/or alteration to fire regime

Buffalograss is intolerant of shade, occurring mainly in areas with short grass cover (Harms 1998). Grazing by herbivores such as cattle and Bison reduces the height of neighbouring grasses and helps maintain Buffalograss populations (Hart and Ashby 1998; Hayes and Holl 2003). Not allowing grazing in areas with Buffalograss may alter the habitat, rendering it less suitable for Buffalograss. At present, the only areas where grazing does not occur at least periodically is Sourisford Park in Manitoba (although it is mowed) and the Buffalograss Ecological Reserve in Saskatchewan. Mowing in Sourisford Park appears to help maintain suitable conditions for Buffalograss. The lack of grazing in the Buffalograss Ecological Reserve may be contributing to the spread of the invasive Kentucky Blue Grass. It is speculated that an increased litter layer accumulation may suppress germination. High litter accumulation can cause more intense fires that may impact the seed bank.

In the central Great Plains states to the south, prairie fires are important in maintaining Buffalograss over the taller grasses of the mixed grass prairie (Wright and Bailey 1980; Ford 1999), so fire suppression may also be a limiting factor. Overall, Buffalograss has been found to have a positive to neutral response to fire, depending on the amount of precipitation and seasonality of the fire (Ford 2003). Prescribed burning is not typically done on any of the Buffalograss sites in Canada.

Flooding by reservoirs/dams

The creation of the Rafferty and Boundary dams and reservoirs, and several small catchment dams to retain rain water may have historically destroyed some Canadian Buffalograss habitat (Environment Canada 2007). In the future, sites adjacent to the Rafferty Reservoir may flood in years when water levels rise (Harms 1998). As most of the remaining Buffalograss sites occur on valley slopes and coulee walls, prolonged inundation resulting from developments or disturbances that cause unnatural flooding, inhibit channel migration, or divert water could negatively impact Buffalograss habitat (Environment Canada 2007). Buffalograss is known to withstand seasonal flooding for at least five weeks (Parks 1993). No dams currently exist on the Souris or Blind rivers in Manitoba but there is a dam on the Souris River just south of Manitoba in North Dakota (Reimer *et al.* 2003). Thus, this threat could affect both the Saskatchewan and Manitoban populations. Extreme flood events appear to be increasing, but the scope and severity of these events are difficult to determine.

Cultivation

Buffalograss populations are possibly threatened by conversion of the rangelands to crop production. Buffalograss populations may have been more widespread in Canada in the past, but as the composition of the native prairie was not documented prior to initial cultivation of the area, it is impossible to determine how much habitat was lost. Future cultivation of Buffalograss habitat is unlikely for reasons of site topography

and soil fertility (Harms 1998). In Saskatchewan, remaining areas with Buffalograss are only suited for grazing due to their shallow nature, bedrock exposures, and dissected terrain (Environment Canada 2007). In Manitoba, Buffalograss typically grows on soils with poor soil structure, low permeability and a high amount of soluble salts; conditions that are poor for crop growth (Eilers *et al.* 1978). However, in the Blind River Valley, D.B. Robson observed some wheat and canola crops being grown adjacent to quarter sections containing Buffalograss plants, so some conversion from rangeland to cropland is possible in Manitoba.

Road construction or upgrades

In Manitoba, construction of a new road along the existing road allowance that parallels the Souris River Valley south of highway #251 could potentially impact plants on 10 quarter sections (11% of the occupied quarter sections in Canada). The near level bench of the mid-slopes where Buffalograss occurs seems a logical level for such a road. At present there is an unimproved 2-track vehicle trail on a portion of the road allowance; it has only a minor effect on Buffalograss, which in fact, seems even denser along its edges. Road upgrades threaten the plants on a portion of ten quarter sections (11% of the occupied quarter sections in Canada) that are adjacent to the two major highways (# 3 and #251) that cross the Souris River Valley. A major upgraded road could destroy part of the Buffalograss stands nearest to the existing roads, as apparently has already occurred along Hwy. 251 and the now abandoned Canadian Pacific Railroad tracks.

In Saskatchewan, road construction has likely impacted Buffalograss along Highway 18 and the secondary gravel roads south and east of the Rafferty Dam. Habitat for Buffalograss was probably destroyed when these roads were built as Buffalograss can still be found on either side of the roads (Harms 1998). Most of the Buffalograss plants in Saskatchewan are adjacent to either primary or secondary roads. Upgrades to these roads could potentially impact Buffalograss plants and habitat on 21 quarter sections in Saskatchewan (=~22% of the occupied quarter sections in Canada). Recent flooding events require road reconstruction, which could cause more disturbances to Buffalograss populations. The species can recolonize well in the south, but here at the northern edge of range and with competition from invasive species, Buffalograss may be less competitive.

Oil & gas

Though oil and gas drilling and exploration covers much of the land on which Buffalograss grows in Saskatchewan, direct impacts are expected to be less than one percent, but the cumulative effects include roads, the spread of invasive species and an increase of fire suppression.

Other threats

Urban expansion, particularly in Saskatchewan in the vicinity of Estevan is considered a potential threat, which may impact nearby populations. Clay pit mining was a historical threat that if it occurs again would present a threat.

Limiting factors

At its northernmost range limit in southeastern Saskatchewan and southwestern Manitoba, Buffalograss appears to represent a successional or disclimax species, limited to shaley-clayey and often sub-sodic edaphic conditions and unshaded places with an environment with little competition from taller species. Thus geographic and habitat conditions are a limiting factor. Cattle-grazing is not considered a limiting factor, but instead is likely essential for maintaining the habitat of this species. Moderate degrees of soil disturbance by water erosion, cattle trampling or cow-path formation may be seen as positive rather than negative factors. The short length of the growing season in Canada is another natural factor that limits the growth of this C4 grass (Environment Canada 2007).

PROTECTION, STATUS, AND RANKS

Legal protection and status

Buffalograss is currently listed under the federal *Species at Risk Act* (SARA). Initially assessed as Special Concern by COSEWIC in 1998, it was reassessed as Threatened in 2001 and added to Schedule 1 of SARA in 2003. A recovery strategy for the species was prepared by Environment Canada in 2007 and is in the process of being implemented.

In Manitoba, Buffalograss is considered Threatened and is protected under *The Endangered Species Act* (Reimer 2003). Manitoba Conservation staff are part of the recovery team to protect this species. Although Saskatchewan has protected some rare species under *The Wildlife Act*, Buffalograss is not one of them.

The Province of Saskatchewan established the Buffalograss Ecological Reserve under the *Ecological Reserves Act* of Saskatchewan, in part to preserve some native mixed-grass prairie, and in part, as implied by its name, to preserve a population of Buffalograss. Unfortunately, the local population included in that reserve is relatively minor in comparison with the species' IAO in Saskatchewan. Thus, the amount of protection offered by the establishment of the Buffalograss Ecological Reserve falls short of significantly protecting the species' critical range, habitat and mass in Saskatchewan.

Non-legal status and ranks

The NatureServe ranks are Global G4G5 (apparently secure-secure), Canada N1 (critically imperilled), Manitoba S1 (critically imperilled) and Saskatchewan S1 (critically imperilled). The United States ranks are: U.S.A. N4N5 (apparently secure-secure), Arizona S1S2 (critically imperiled), Illinois S2 (imperiled), Iowa S1 (critically imperiled), Minnesota S3 (vulnerable), Missouri SH (possible extirpated), Montana S4? (apparently secure?), Utah S1 (critically imperiled) and Wyoming S3 (vulnerable) (NatureServe 2010). In the remainder of the states where it occurs it has either not been ranked or is currently under review (SNR) including Arkansas, Colorado, Georgia, Kansas, Louisiana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Virginia, Wisconsin (NatureServe 2010).

Buffalograss is one of the species “flagged” by the Saskatchewan Ministry of Environment when reviewing environmental impact assessments and in evaluating potential protected areas.

Habitat protection and ownership

The Buffalograss Ecological Reserve, protected under the *Ecological Reserves Act* of Saskatchewan, contains a small population of Buffalograss. The lack of management that may be beneficial to Buffalograss (e.g. grazing, prescribed burning, and removal of invasive species) on this property is of concern and threatens the persistence of the population. The crown corporations Saskatchewan Watershed Authority and Sask Power own seven and eight, respectively, of the 25 quarter sections containing Buffalograss in Saskatchewan. The remaining nine quarter sections containing Buffalograss in Saskatchewan are privately owned. All the Buffalograss populations in Manitoba occur on privately owned land except for the small population found in Sourisford Park, which is owned by the Rural Municipality of Arthur.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Diana Bizecki Robson received her M.Sc. in Plant Ecology from the University of Saskatchewan in 1997 for studying rare plants in southern Saskatchewan. After doing botanical consulting and sessional lecturing on plant taxonomy and ecology for a few years, she returned to the University of Saskatchewan, obtaining her Ph.D. in Soil Science in 2003. She is currently employed as the Curator of Botany at The Manitoba Museum in Winnipeg, where she curates the second largest herbarium in Manitoba. Her main research interests are rare plant demography and ecology, and pollination ecology. She has authored several papers on rare plant ecology in Canada.

COLLECTIONS EXAMINED

The following institutions were consulted with regard to collections of Buffalograss filed with them, and the specimens from each institution verified by Vernon Harms (acronyms according to Holmgren *et al.* 1990 in Index Herbariorum; those in parentheses indicate an apparent lack of specimens; an asterisk indicates a non-listing by Holmgren *et al.*)

ALTA - Vascular Plant Herbarium, University of Alberta, Edmonton, AB.

CAN - Vascular Plant Herbarium, Botany Division, Canadian Museum of Nature, Ottawa, ON.

DAO - Vascular Plant Herbarium, Centre for Land and Biological Resource Research, Agriculture Canada, Ottawa, ON.

MMMN - Herbarium, Manitoba Museum of Man and Nature, Winnipeg, MB.

MT - Herbier Marie-Victorin, University of Montreal, Montreal, PQ.

SASK - The W.P. Fraser Herbarium, University of Saskatchewan, Saskatoon, SK.

(UAC) - Herbarium, University of Calgary, Calgary, AB.

(USAS) - The G.F. Ledingham Herbarium, University of Regina, Regina, SK.

(UWPG) - Herbarium, University of Winnipeg, Winnipeg, MB.

WIN - Herbarium, University of Manitoba, Winnipeg, MB.