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Adopt-a-Plant Alberta: Implementing Recovery Actions for Western Spiderwort (*Tradescantia occidentalis*)

2007-2008

Alberta Species at Risk Report No. 128

Government of Alberta

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Adopt-a-Plant Alberta: Implementing Recovery Actions for Western Spiderwort (*Tradescantia occidentalis*)

2007-2008

Sue Peters, Darren Bender, and Lisa Matthias

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EXECUTIVE SUMMARY

Western spiderwort (*Tradescantia occidentalis* (Britt.) Smyth) is an *Endangered* plant found in the southeastern corner of Alberta, within the Grassland Natural Region. It is associated with sandy soils, including active and partially stabilized sand dunes, as well as stabilized sand hills. This plant was listed as *Endangered* in Alberta because of its very small number of populations (one confirmed, at the sand hills northeast of Pakowki Lake), small number of individuals, and isolation from populations in Saskatchewan and the United States. The goal of the *Maintenance and Recovery Plan for Western Spiderwort in Alberta (2005-2010)* is to maintain western spiderwort's existing habitat and distribution, and to maintain a naturally, self-sustaining population in Alberta.

In 2007 and 2008, the Adopt-a-Plant Alberta (APA) program implemented some of the recovery strategies outlined in the Recovery Plan for western spiderwort by collecting standardized population data and conducting invasive species management in western spiderwort habitat. In this way, the APA program provided much-needed data for use in conservation and planning, and carried out direct conservation actions for the species and its habitat.

APA volunteers visited and confirmed 19 western spiderwort patches (of 26 known) at Pakowki Lake North and delineated their edges; the number of plants was counted in 9 (total area of 1.28 ha) of those 19 patches. Since only a portion of the total population could be counted, the remainder was extrapolated using the mean plant density (0.280 plants/m^2) obtained within the counted patches. The spiderwort inventory conducted in 2007/08 recorded the largest known population estimate for this species in Alberta: 37 200 plants. The area of occupancy of western spiderwort in Alberta in 2008 is estimated at 13.3 ha, and the extent of occurrence is estimated at 2.2 km^2. Both figures are smaller than the minimum mapping unit of 4 km^2 (i.e., 2 km x 2 km) recommended in the IUCN Red List Guidelines (IUCN 2008).

Invasive species, namely crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), baby's breath (*Gypsophila paniculata* L.), and yellow goat's-beard (*Tragopogon dubius* Scop.) were detected in and among the patches of western spiderwort. Further inventory is needed to determine the presence and extent of other invasive species in the area. APA volunteers focused 2008 efforts on mechanical removal of 18 baby's breath plants at Pakowki Lake North, from within and between spiderwort patches.

APA is well equipped to implement many of the recovery actions for western spiderwort, and is committed to long-term partnership with the Alberta Western Spiderwort Recovery Team in the conservation of this unique species and its habitat.

We make the following recommendations for future population monitoring, habitat management and research of western spiderwort in Alberta:

- Conduct a comprehensive population survey every three or four years, during peak flowering period, using the same methods as outlined in this report to facilitate comparisons

- Survey for new patches of western spiderwort at Pakowki Lake North and in other locations with suitable habitat, making sure to record not only locations where spiderwort is found, but also where it is searched for and not found
- Conduct a comprehensive, multi-species inventory of rare plants and species at risk in the Pakowki Lake area
- Closely monitor (for plant density, browsing, and phenology) each western spiderwort plant within sampling plots in a small subsample of patches, on an annual or biannual basis
- Monitor annual changes in patch location and size by recording (using high-precision GPS) the perimeter of at least two closely monitored patches
- Annually monitor and control the progression of invasive species at Pakowki Lake North, particularly crested wheatgrass and baby's breath, during less sensitive periods of western spiderwort growth
- Conduct comprehensive surveys for the presence of other invasive species known from southern Alberta (for example, leafy spurge, smooth brome [*Bromus inermis*], Canada thistle [*Cirsium arvense*])
- Control/remove invasive plants in spring/early summer to prevent seed development and dispersal
- Record invasive plant locations and monitor the encroachment of crested wheatgrass and other infestations using permanent markers or high-precision GPS
- Develop an integrative and adaptive monitoring and control program for invasive plants at Pakowki Lake North, incorporating only the control measures endorsed by provincial and national recovery teams for plant species at risk
- Closely monitor the longer-term effectiveness of invasive plant control and re-evaluate on a regular basis
- Research optimum levels of grazing (by cattle and native herbivores) to maintain western spiderwort and its habitat; document the current cattle grazing regime (i.e., stocking rate, timing and duration of grazing) at Pakowki Lake North, and how that influences plant life history (e.g., seed set) and habitat (e.g., stabilization/de-stabilization of dunes)

ACKNOWLEDGEMENTS

Funding for this report was provided by the Adopt-a-Plant Alberta (APA) program. Funding for the APA program in 2007 was provided by the Government of Canada Habitat Stewardship Program; Alberta Sustainable Resource Development, Fish and Wildlife Division; Alberta Sport, Recreation, Parks and Wildlife Foundation; and Shell Environmental Fund. Funding in 2008 was provided by the Alberta Lottery Fund; the Government of Canada Habitat Stewardship Program; Alberta Sustainable Resource Development, Fish and Wildlife Division; and Alberta Ecotrust.

In-kind support in 2007 and 2008 was provided by various agencies and individuals, including Alberta Native Plant Council; Alberta Sustainable Resource Development, Fish and Wildlife Division; Alberta Tourism, Parks, and Recreation, Alberta Natural Heritage Information Centre; Devonian Botanic Gardens; and Federation of Alberta Naturalists. Alberta Tourism, Parks, and Recreation, Parks Canada, and Nature Conservancy Canada, provided APA volunteers with access to these lands for program activities. Numerous professional botanists generously provided their time and expertise in training workshops for the program.

Conservation activities at the western spiderwort site in 2007 and 2008 were coordinated by Kelley Kissner (APA), Lisa Matthias (Alberta Sustainable Resource Development, Fish and Wildlife Division; ASRD), and Joel Nicholson (ASRD). Field work was completed by APA volunteers Craig Marshall, Elizabeth Podgurny, Kathryn Podgurny, and Richard Caners; Corlaine Gardner and Rob Gardner from the Medicine Hat Interpretive Centre; Kelley Kissner, and Lisa Matthias. Joel Nicholson and Kelley Kissner provided some of the background materials and data needed to produce this report; they also edited earlier versions of this report. Office support for writing this report was provided to Sue Peters by the Alberta Conservation Association.

Thanks go to the Alberta Western Spiderwort Recovery Team for its guidance and support of monitoring and habitat stewardship activities carried out by APA.

Finally, thank you to the over 40 APA volunteers in both 2007 and 2008, whose interest and energy continue to make this a successful volunteer-based conservation program in Alberta.

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1.0 INTRODUCTION

Western spiderwort (*Tradescantia occidentalis* (Britt.) Smyth) is a unique and rare species of Alberta's native flora (Kershaw et al. 2001). It is a perennial monocot with slender stems (20 cm – 60 cm high), linear leaves, and dark blue to purple flowers (Budd et al. 1994). Western spiderwort is found in the southeastern corner of Alberta, within the Grassland Natural Region (Alberta Natural Heritage Information Centre [ANHIC] 2005). It is associated with sandy soils, including active and partially stabilized sand dunes, as well as stabilized sand hills (Goulet and Kenkel 1997, Peters 2003a, Remarchuk 2005; see Photograph 1). This plant is rare in Alberta and only found in a habitat that is under pressure from agriculture and the petroleum industry; therefore, Alberta's population of western spiderwort has been monitored periodically since it was found in 1986.

In 2001, Alberta's Endangered Species Conservation Committee (ESCC) recommended that western spiderwort be listed as *Endangered* because of its very small number of populations (one confirmed, at the sand hills northeast of Pakowki Lake), small number of individuals, and isolation from populations in Saskatchewan and the United States (ESCC 2001, Fish and Wildlife Division 2008a). Western spiderwort has been designated as *Endangered* in Alberta since 2001, and *Threatened* in Canada since 1992 (COSEWIC 2008). At the direction of the Minister of Alberta Sustainable Resource Development, the Alberta Western Spiderwort Recovery Team was formed in 2003, and the *Maintenance and Recovery Plan for Western Spiderwort in Alberta (2005-2010)* was produced (Alberta Western Spiderwort Recovery Team 2005). The goal of the recovery plan is to maintain western spiderwort's existing habitat and distribution, and to maintain a naturally, self-sustaining population in Alberta. To achieve this, the recovery plan outlines several strategies: population conservation and management, habitat conservation and management, information and education outreach, research, resourcing, legislation and plan management, and administration.

The Adopt-a-Plant Alberta (APA) program is well equipped to implement some of the recovery strategies for western spiderwort, specifically, the conservation and management of the population and habitat in Alberta, as well as informing and educating the public. APA is a not-for-profit program that trains and engages volunteer plant enthusiasts to search for new locations and monitor known sites of select rare plant (and lichen) species in Alberta, to provide much-needed data for detailed assessment of whether or not they should be designated as *Endangered* or *Threatened* in Alberta (Adopt-a-Plant Alberta 2008, Fish and Wildlife Division 2008b). APA also offers support to provincial resource management agencies, private land stewardship organizations and provincial and federal plant species at risk recovery programs by providing dedicated and trained volunteers to assist in monitoring rare plant populations and implementing habitat stewardship activities. APA volunteers play an important role in conservation and stewardship efforts for plant species at risk such as western spiderwort.

By engaging, training and supporting "citizen scientists", APA facilitated the collection of standardized data on western spiderwort in 2007 and 2008, as well as the removal of non-native invasive plant species in western spiderwort habitat. These activities are outlined in the Action Plan of the Recovery Plan (see section 6.1 in Alberta Western Spiderwort Recovery Team 2005).

APA's involvement with the recovery and stewardship actions for western spiderwort and other plant species at risk, including tiny cryptanthe (*Cryptantha minima*), western blue flag (*Iris missouriensis*), and small-flowered sand verbena (*Tripterocalyx micranthus*) represents an evolution

Photograph 1: Western spiderwort habitat, including active sand dunes and stabilized sand hills, in southeastern Alberta (Pakowki Lake North).

of the scope and capacity of the program since its inception in 2005. With support from the Habitat Stewardship Program for Species at Risk (Government of Canada), APA contributes directly to habitat management for plant species at risk, education and awareness initiatives, survey and monitoring efforts, and any additional support requested by recovery teams (Adopt-a-Plant Alberta 2008). The work of APA fits well within the overall goal of the Habitat Stewardship Program, which is to "contribute to the recovery of Endangered, Threatened, and other species at risk, and to prevent other species from becoming a conservation concern, by engaging Canadians from all walks of life in conservation actions to benefit wildlife" (Habitat Stewardship Program 2007).

Data collected by APA volunteers are provided to the Alberta Natural Heritage Information Centre (ANHIC), which tracks information on Alberta's plant and animal biodiversity. The information is available to be used in detailed status assessments and is also available to industry and other land users to flag occurrences of rare species to help mitigate effects of development and other land uses on these species.

2.0 STUDY AREA

Western spiderwort is found in the Dry Mixedgrass Subregion of the Grassland Natural Region, the warmest and driest subregion of Alberta (ANHIC 2005). The Alberta population is found northeast of Pakowki Lake, west of the hamlet of Manyberries (subsequently referred to as Pakowki Lake North; Figure 1). The legal land location is T5-R7-W4 on topographic map 72 E/7. Alberta's Dry Mixedgrass Subregion contains other potential habitat for western spiderwort that was searched in 1987 (Wallis and Wershler 1988), as well as in 2003 (Peters 2003b), without finding an occurrence.

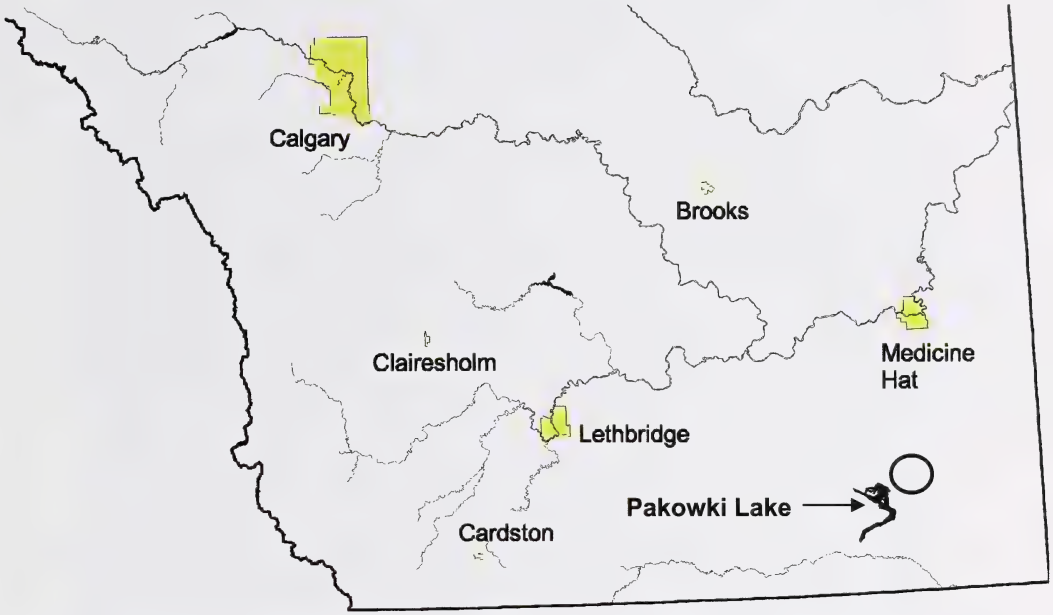

Figure 1: The location of the one known western spiderwort population in Alberta, northeast of Pakowki Lake (referred to as Pakowki Lake North [O]).

3.0 METHODS

3.1 Population inventory

As a perennial, western spiderwort plants live for several or more years, flowering and dispersing seeds each year. Therefore, the population surveys aim to monitor the species' well-being (i.e., abundance, distribution, phenology) through time rather than looking for major annual fluctuations, and to look for new and/or previously undiscovered patches of western spiderwort. A western spiderwort plant is defined as a clump of multi-stemmed shoots, with each stem originating from the same point in the soil (as in Remarchuk 2005). The term "patch" refers to a discrete collection of several or more closely located western spiderwort plants; patch boundaries are likely limited either by unsuitable habitat or the low dispersal capability of western spiderwort seeds. The term "population" is used in reference to the entire collection of western spiderwort patches at Pakowki Lake North.

Before searches were conducted, all of the landholders with western spiderwort occurring on their lands/leases were contacted to obtain land access permission. All landholders granted land access to Alberta Sustainable Resource Development staff and APA members to conduct an inventory of western spiderwort. In both years, searches were conducted in July (7^{th}-8^{th}, 2007; 12^{th}-13^{th}, 2008), when western spiderwort is known to flower in Alberta.

Surveys focused on known patches of western spiderwort in order to compare plant counts, phenology, and browsing intensity with data from previous years. In 2007, 18 of the 26 known

western spiderwort patches at Pakowki Lake North were visited and had their boundaries delineated (see subsection 3.3 below). The number of plants was counted in 8 of those 18 patches (see polygons 7-9, 12, 13, 15, 16, 20, 21 in Figure 2). One additional patch was inventoried and delineated in 2008 (see polygon 9 in Figure 2). All of the other previously documented patches were present in 2007/2008, but not inventoried. Meandering searches for additional spiderwort plants were conducted between patches, but not outside the limits of the known population.

A large number of spiderwort plants were found at Pakowki Lake North, so only a portion of the total population could be counted. The numbers of plants in patches that were not counted were extrapolated from the average density of plants in sampled patches. To prevent plants from being missed or counted twice, a small flag was placed beside each plant and then removed after it was counted (Photographs 2a and b). For each patch, the approximate vegetative and reproductive phenology, presence of herbivory, habitat description, and threats to the population and habitat were recorded.

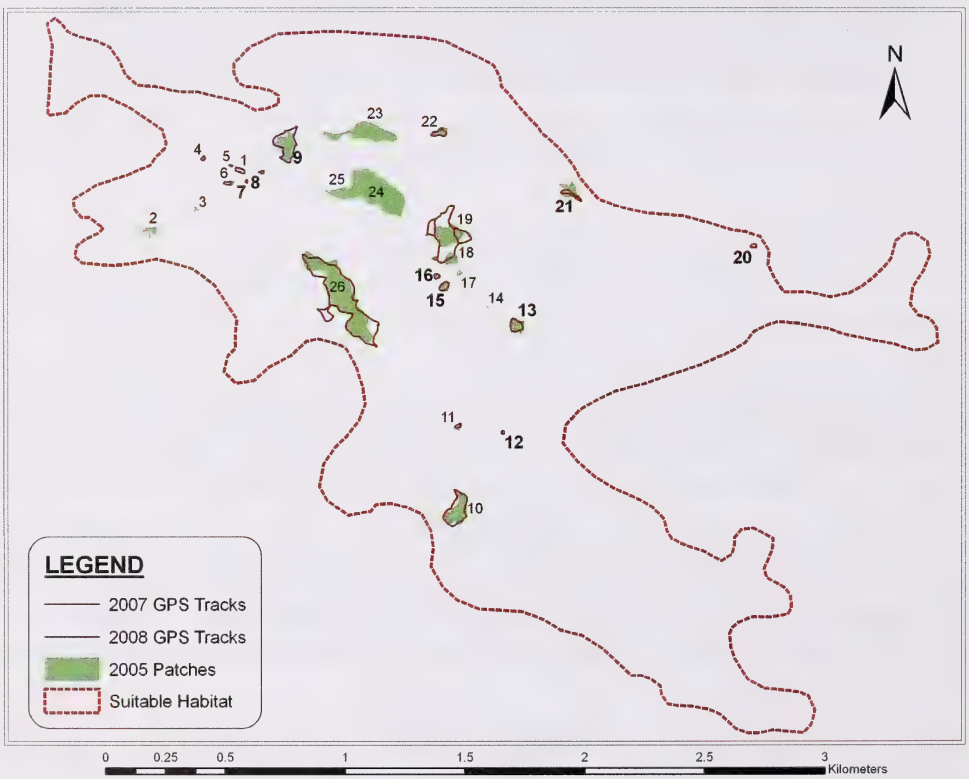

Figure 2: Map of western spiderwort patches (polygons) at Pakowki Lake North, as surveyed in 2005, 2007, and 2008. Numbers on the map correspond with patch numbers used in the 2005 inventory (Remarchuk 2005). Bold-face numbers indicate patches that were counted in 2007/2008. The patch boundaries illustrated for 2005 may not be complete and were not used for computing patch areas.

Photograph 2a: APA volunteers counting western spiderwort plants at Pakowki Lake North. To prevent plants from being missed or counted twice, a flag was temporarily placed beside each plant.

Photograph 2b.

3.2 Invasive plant control

In 2008, APA volunteers focused their efforts on site management by searching for and removing baby's breath (*Gypsophila paniculata* L.), an invasive ornamental plant (Alberta Invasive Plants Council 2009) (Photographs 3, 4a and b). This was done by digging up plants, making sure that the root system was removed to approximately one to two feet below the root collar (where the root joins the stem, around ground level). Baby's breath plants were collected in garbage bags and hauled from the site (to completely remove flowers, seeds and other plant parts) (Photographs 5a, b, and c). Bags of baby's breath plants were disposed of at a municipal garbage dump. APA volunteers recorded the location of baby's breath plants using a handheld global positioning system (GPS), for future reference to assess the effectiveness of the mechanical control techniques used. All baby's breath plants encountered in meandering searches within and between the western spiderwort patches were removed.

3.3 Geospatial analysis

Western spiderwort plants in Alberta tend to occur in aggregations or patches. The locations of patches in 2007/2008 were recorded using a handheld GPS (Garmin eTrex Legend, Garmin GPSMAP 60CSx and GPSMAP 76S) to delineate patch boundaries (Photograph 6). Isolated individual plants well beyond the recorded boundaries were uncommon (or not found).

Photograph 3: Baby's breath (*Gypsophila paniculata*) is an invasive ornamental plant that is threatening western spiderwort habitat in Alberta.

Photograph 4a: APA volunteers searched for and removed 18 baby's breath plants from within and around western spiderwort patches.

Photograph 4b: Western spiderwort growing beside a baby's breath plant.

Photograph 5a: APA volunteers dug up baby's breath plants, including at least one to two feet of the root system, then bagged and removed them.

Photograph 5b.

Photograph 5c.

Photograph 6: The distribution of western spiderwort plants in 2007/2008 was recorded using a handheld GPS to delineate patch boundaries.

GPS tracklogs representing patch boundaries were imported into a geographic information system (GIS) for analysis (ESRI ArcGIS 9.2). Each GPS tracklog was converted to a polygon feature in the GIS to obtain the area of each patch. Occasionally, the GPS tracklogs contained spurious locations that did not appear to have been collected at the patch boundary, thereby distorting the shape of the patch boundary. At the discretion of the GIS analyst (DB), such points were removed to improve the representation of the patch boundary and improve the accuracy of the computed patch area.

Plant density was calculated for each of the nine patches that were counted in 2007/2008 by dividing the number of plants within each patch by the corresponding patch area. These values were then averaged using an area-weighted mean to estimate overall plant density for the entire population. The estimated number of plants in each surveyed, but uncounted, patch was estimated by multiplying each patch area by the average plant density, following Remarchuk (2005). Seven patches did not have their boundaries recorded with a GPS in 2007/08, so for these patches we estimated their area by multiplying their 2005 area by the ratio of change in patch areas between 2005 and 2007/08.

The amount of change for each western spiderwort patch between 2005 and 2007/08 was calculated for three parameters: patch area, plant density, and plant abundance. The 2005 and 2007/08 inventories each counted plants using a subset of patches (10 and 9 patches, respectively). Five counted patches were common to both inventories allowing direct comparison of the parameters above. For these five patches, we compared the observed area/density/abundance from the 2007/08 inventory with the same values published in Appendix 1 of the 2005 inventory report (Remarchuk 2005). Differences between 2007/08 and 2005 were calculated as a percentage change relative to 2005 values.

To estimate the total population size of western spiderwort in Alberta, we summed the plant counts for the nine patches that were counted by APA volunteers with estimates of abundance for the remaining patches.

4.0 RESULTS

4.1 APA volunteer effort

In 2007 and 2008, APA members spent the equivalent of 19 person days (where a person day amounts to the work completed by one person in one day) in the field inventorying the population of western spiderwort and carrying out habitat stewardship at the site. Data collected by APA volunteers will be provided to the chair of the Alberta Western Spiderwort Recovery Team and ANHIC, so that it is available in future years to assist survey efforts.

The western spiderwort inventory and habitat stewardship has become a regular and well-attended annual APA event, with several volunteers returning again in 2009 to help with the species' conservation (L. Matthias pers. obs.). The APA program acknowledged the efforts of these volunteers with a recognition event in the fall of 2008.

4.2 Population inventory

The spiderwort inventory conducted in 2007 and 2008 recorded the largest known population estimate for this species in Alberta. APA volunteers counted a total of 3569 plants, and the total

Alberta population was estimated to be 37 200 plants, based on the sum of the 2007/08 count data (from 9 patches covering 1.28 ha) plus the extrapolated plant abundances in uncounted patches (Table 1). The population of western spiderwort was estimated to be 31% larger in 2007/08 compared to 2005 (when the population was estimated to be 28 400 individuals; Remarchuk 2005). However, there are several possible sources of discrepancy between 2005 and 2007/08 estimates that could account for at least some of the difference in population estimate, including detectability of plants (e.g., number of surveyors, timing of survey/flowering period), and GPS accuracy.

Based on the counts performed at the five patches that were common between the 2005 and 2007/08 inventories (Table 1), there was an increase from 395 to 419 plants, indicating a 6% increase over the period. This may represent an actual increase in plant abundance, but more likely this small change reflects differences in conditions across surveys (e.g., multiple surveyors). Furthermore, it is difficult to judge whether these five patches are representative of the overall population, particularly because all were relatively small patches (all were well below the mean patch size for the population). Regardless, both these direct counts and the extrapolated ones demonstrate a modest increase in estimated population size between 2005 and 2007/08.

Average plant density for all counted patches was 0.280 plants/m^2 in 2007/08, which represents a 42% increase in density from 2005 (0.161 plants/m^2). Comparing only the five patches common between both inventories, an even greater increase was observed: 0.225 plants/m^2 in 2007/08 vs. 0.135 plants/m^2 in 2005, representing an increase of 67%.

In 2007/08, the 19 delineated patches of western spiderwort covered an area of 79 450 m^2 (7.95 ha; Table 2). Estimates for the remaining patches were obtained by extrapolating from 2005 polygon areas, and the total area of all spiderwort patches is estimated to be 133 000 m^2 (13.3 ha) (Figure 2). The area occupied by western spiderwort in Alberta in 2005 was 17.6 ha, indicating a recent decline in area of 25%. Using a 2 x 2 km grid resolution (a resolution recommended for use by the IUCN; see IUCN 2008), the area occupied by western spiderwort in Alberta is 4 km^2.

The extent of occurrence (the total area encompassing all patches of plants and the area between them; IUCN 2001) remains approximately 2.2 km^2 (Peters 2003b), because no new locations or population expansion were observed in 2007/08. ANHIC defines plant occurrences as being separated by a distance of at least 1 km (and in certain cases up to 10 km; NatureServe 2004), which is greater than the distances between spiderwort patches at Pakowki Lake North. Therefore, despite the larger number of spiderwort plants estimated in 2007/08 they are still considered to be part of a single population that is separate from the nearest populations in Saskatchewan and Montana.

Detailed information on several earlier (2002, 2003, and 2005) western spiderwort population inventories is available on the Alberta Sustainable Resource Development, Fish and Wildlife Division website (URL: http://www.srd.gov.ab.ca/fishwildlife/; click on Species At Risk, Project Reports). See Species at Risk Program reports #61 and its addendum, as well as #102.

4.3 Invasive plant control

Invasive species, notably, crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), baby's breath, and yellow goat's-beard (*Tragopogon dubius* Scop.) were detected in and among the patches of western spiderwort, in 2007 and 2008.

Table 1: Western spiderwort abundance and density for each known patch at Pakowki Lake North (Alberta). Plant abundances are obtained from count data in the 2005 and 2007/08 inventories*, except for numbers shown in parenthesis, which were values extrapolated from patch area and average population density (see text). Plant density is only shown for patches where counts were performed in an inventory. Highlighted rows indicate the five counted patches that were common to both inventories.

	Plant Abundance		Plant Density (#/m^2)	
Patch	2005	2007-08**	2005	2007-08
1	39	(162)	0.144	
2	622	(81)	1.617	
3	(78)	(102)		
4	38	(57)	0.117	
5	(6)	(11)		
6	38	(85)	0.078	
7	(20)	14		0.201
8	**24**	**46**	**0.140**	**0.291**
9	(1615)	2340		0.301
10	(839)	(2294)		
11	75	(82)	0.155	
12	**53**	**49**	**0.327**	**0.480**
13	(640)	764		0.362
14	52	(30)	0.369	
15	**239**	**204**	**0.130**	**0.200**
16	**59**	**100**	**0.160**	**0.315**
17	(108)	(141)		
18 + 19	(2704)	(5293)		
20	**20**	**20**	**0.053**	**0.076**
21	(883)	32	0.161	0.034
22	(395)	(317)		
23	(3262)	(4266)		
24	(7072)	(9250)		
25	(846)	(1106)		
26	(8235)	(10349)		
TOTAL		**37 195**		

* All inventories were conducted in July: $14^{th} - 18^{th}$, 2005; $7^{th} - 8^{th}$, 2007; $12^{th} - 13^{th}$, 2008.

** Most of the patches were counted in 2007; only patch 9 was counted in 2008.

Table 2: Changes in the size of western spiderwort patches between the 2005 and 2007/08 inventories.

	Area (m^2)			
Patch	2005	2007-08	Difference	% Change
1	271	580	308	+114
4	324	205	-119	-37
5	40	39	-0.4	-1
6	487	303	-185	-38
7	124	70	-55	-44
8	171	158	-13	-7
9	10006	7784	-2222	-22
10	10925	8202	-2723	-25
11	485	292	-193	-40
12	162	102	-60	-37
13	3966	2113	-1853	-47
15	1843	1021	-822	-45
16	369	317	-51	-14
18 + 19	16755	18927	2172	+13
20	381	265	-116	-30
21	5471	932	-4539	-83
22	2450	1134	-1315	-54
26	51028	37005	-14023	-27
Overall	105 258	79 449	-25 809	-24.5

In 2008, APA volunteers removed 18 baby's breath plants from three general locations at Pakowki Lake North (Figure 3). Most of these removals were from within and around the largest patch (#26) of western spiderwort plants, towards the western half of the spiderwort population. All plants were bagged, removed from the site, and disposed of at a municipal garbage dump.

4.4 General observations

Volunteers working in western spiderwort habitat made many informative observations on browsing, plant phenology (vegetative and reproductive processes), pollinators and wildlife species of interest. Browsing of western spiderwort plants was noted at six (of 19) patches in 2007 and 2008, with moderate to heavy browsing noted at four (P9, P10, P15, P26) of the patches.

Surveys were conducted on July 7th and 8th in 2007, and plants in many of the 18 patches were already senescing (Table 3). The survey of one patch on July 12th in 2008 was better timed with western spiderwort phenology; many plants were still fully developed and many were in full bloom. Plant phenology during the 2005 inventory was comparable to that during 2007 inventory (i.e., many plants beginning to senesce; Remarchuk 2005). The timing of the survey should be coordinated with when western spiderwort plants are fully developed and in full bloom, which varies from year

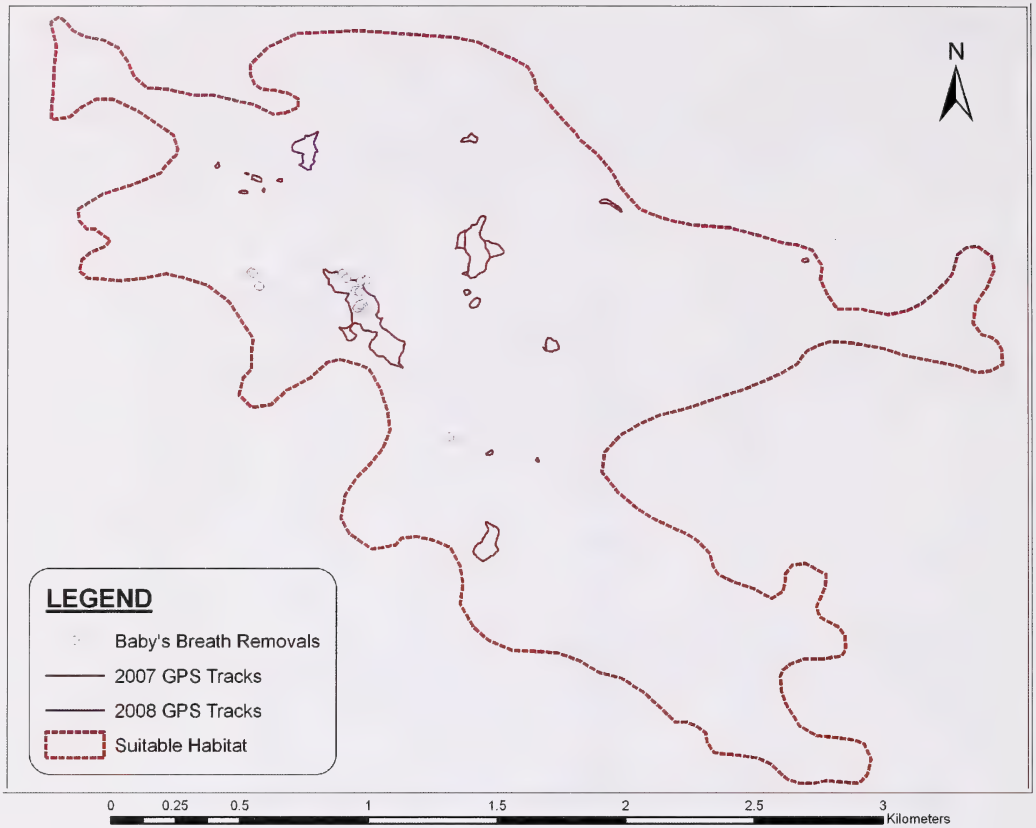

Figure 3: Locations of baby's breath removals in western spiderwort habitat 2008 at Pakowki Lake North.

Table 3: Number of western spiderwort patches in different vegetative and reproductive stages during the 2007 inventory. Eighteen patches were surveyed in 2007.

	Vegetative stage:				
	fully developed	stem &/or 1st leaves fading	yellow ≤50%	yellow >50%	no comment
# of patches	1	1	10	2	4
	Reproductive stage:				
	full bloom	full bloom to fading	fading	completely faded	no comment
# of patches	2	1	8	3	4

to year depending on weather (precipitation and temperature). Plants that have senesced are more difficult to see, and opportunities to document pollinators are reduced. Weather patterns need to be monitored each spring to predict the best time for western spiderwort surveys.

Two different species of bee pollinators were noted in patches 26 and 8 during the 2007 western spiderwort surveys (see photographs 7a and b respectively).

A number of noteworthy incidental wildlife observations were made: long-tailed weasel, ferruginous hawk*, Swainson's hawk, red-tailed hawk, loggerhead shrike*, Sprague's pipit*, horned lark, vesper sparrow, and gray partridge. The species noted with an asterisk are species at risk that are listed under Alberta's *Wildlife Act* or Canada's *Species at Risk Act.*

5.0 DISCUSSION

5.1 Recovery plan implementation

In 2007 and 2008, the APA program implemented three of the population conservation and management actions outlined in the Maintenance and Recovery Plan for Western Spiderwort in Alberta (Alberta Western Spiderwort Recovery Team 2005; see section 6.1): standardized surveys of western spiderwort in currently occupied habitat (to monitor distribution, abundance and population trends); surveys for, and removal of, invasive plants in spiderwort habitat; and surveys for pollinators.

5.2 Population size and trend

In 2007/08, the largest-ever population size was estimated for western spiderwort in Alberta, representing a continuation of the trend of increasing population sizes estimated with each successive inventory. This may be attributed, at least in part, to our improved knowledge of what constitutes potential habitat, higher detectability (improved search image and therefore a higher success rate in finding plants; greater search effort), and the fact that our definition of an "individual" plant has been refined (see Remarchuk 2005 – a single plant's stems originate from the *same* point in the soil). This last factor applies to previous inventories (2003 and earlier), when stems originating quite close to a plant, but not necessarily at the same point, would have been counted as the same plant; now we know that this would have artificially reduced the population estimate to some degree. It remains unknown what proportion of the increase in estimated population size from 2005 to 2007/08 is a result of different conditions across surveys versus actual population growth. Despite the increase in population estimate between the 2005 and 2007/08 inventories, some plant patches shrunk in area. This is possibly a result of human and technological discrepancies across years; for example, if some plants at the outer boundaries of a patch were missed, this would result in the delineated patch area being reduced.

Botanists previously believed that Alberta's western spiderwort population fluctuated widely and consistently with spring moisture levels (Smith 2000, Peters 2003a). Data collected in 2005 by K. Remarchuk seemed to support this correlation between precipitation and spiderwort population size in Alberta, but the correlation did not hold true in other provinces (see Remarchuk 2005, 2006). Logically, both sampling error and environmental variability could result in changes to the population size. However, the possible correlation between precipitation and population fluctuations

Photograph 7a: Two different species of bee pollinators were noted during the 2007/2008 western spiderwort surveys.

Photograph 7b.

needs intentional study before conclusions can be drawn, since different sampling methods among studies and differences in survey effort will affect the accuracy of previous and current population size estimates.

Remarchuk (2006) suggested that consistent sampling methods are required to detect small population fluctuations in western spiderwort. This highlights the importance of consistent sampling; more details on sampling methodology for western spiderwort will be provided in the Management Implications and Future Directions section.

5.3 Habitat management

The threat of invasive plants is well recognized for western spiderwort populations in all Canadian provinces (Smith 2002). In Alberta, baby's breath, crested wheatgrass and yellow goat's-beard are notable at Pakowki Lake North. Leafy spurge (*Euphorbia esula*) has been found in western spiderwort habitat in other jurisdictions (Goulet and Kenkel 1997, Hohn 1994, Saskatchewan Conservation Data Centre 2005, Manitoba Conservation 2009), but has not yet been found in Alberta's spiderwort site. The removal of baby's breath plants by APA volunteers in 2008 was the first targeted invasive species management in western spiderwort habitat in Alberta. Baby's breath, an introduced ornamental perennial from Europe and Asia (Government of Saskatchewan 2008, Government of British Columbia 2007), is well documented at the Pakowki Lake North site (L. Matthias pers. obs.). It is believed to have originated west of the western spiderwort site, from a nearby cemetery, which is infested with baby's breath (J. Nicholson pers. comm., L. Matthias pers. obs.).

Seed is the primary means of reproduction for baby's breath, with an average plant producing 13 700 seeds (Government of Saskatchewan 2008, Government of British Columbia 2007). The majority of seeds drop close to plants; however, some seeds are dispersed to remote locations by wind. In winter, the stems break off and are blown about by the wind like tumbleweeds, spreading the seed to surrounding habitats where new infestations grow (Alberta Invasive Plants Council 2009). Seeds show little or no dormancy (Government of British Columbia 2007). Based on baby's breath biology, mechanical control can be effective since it removes the seed source and much of the root system, which has abundant food reserves for new shoots in spring. The feasibility of other control measures, such as chemical application, is being discussed with the Alberta Western Spiderwort Recovery Team and natural resource managers involved with invasive plant management.

Crested wheatgrass is native to desert steppe regions of southern Siberia and was introduced to the dry Canadian prairies in the 1930s (Saskatchewan Watershed Authority 2009). It is an extremely competitive grass species that can out-compete many of our native grass species by growing very early in spring, producing and storing (in the soil) prolific numbers of seeds, tolerating drought, and producing vigorous seedlings that become long-lived plants (Saskatchewan Watershed Authority 2009). Once crested wheatgrass is established, it threatens the local grassland ecosystem. Crested wheatgrass spreads by seed into native grassland and can gradually form solid stands; it is associated with decreased plant community diversity and potentially the alteration of soil organic matter and carbon sequestration (Henderson and Naeth 2005, Saskatchewan Watershed Authority 2009). Control recommendations for crested wheatgrass need to be site specific and may require the use of two or more management techniques (including grazing, mowing, burning and chemicals; Saskatchewan Watershed Authority 2009). A management plan for crested wheatgrass has not been

developed for Alberta's western spiderwort habitat (J. Nicholson pers. comm.); but as a first step in invasive species management at the site, APA volunteer time was well spent mechanically removing baby's breath plants to limit spread of the infestation.

Invasive species management is not the only habitat stewardship consideration for Alberta's western spiderwort population. Because this plant species is currently known only from a 2.2 km^2 area, local land-use decisions are very important. Most of the Pakowki Lake North site is public land under grazing disposition. Low to moderate cattle grazing likely has limited impact on the western spiderwort population and may even prevent the sand dunes from becoming completely stabilized (Alberta Western Spiderwort Recovery Team 2005). Intensified grazing pressure may be a potential threat; however, not much is known about how spiderwort responds to grazing pressure. Long-term overgrazing may reduce reproductive potential of the population by eliminating or reducing the number of flowers on grazed plants (S. Peters, pers. obs.). Frequent evidence of browsing of western spiderwort plants was noted in 2007 and 2008. However, this browsing was likely from native herbivores, since evidence of recent cattle grazing was not apparent in most of the area where western spiderwort grows (L. Matthias pers. obs.).

There is currently no petroleum exploration or extraction in the area northeast of Pakowki Lake, and there are some restrictions on development on public land in this area through the public land reservation system (J. Nicholson pers. comm.). However, there is concern for Alberta's western spiderwort population in the future, as oil and gas companies continue to look for new areas to develop (J. Nicholson pers. comm., Remarchuk 2006). Currently, Alberta Sustainable Resource Development is endeavouring to provide legal protection for *Endangered* and *Threatened* plant populations in Alberta.

5.4 Western spiderwort status

Between 1986 and 1999, the western spiderwort population was estimated to be between 27 and 210 plants. However, in 2002 western spiderwort was found to occur within a broader habitat type (stabilized sand hills) at Pakowki Lake North so the population estimate increased dramatically to approximately 7500 plants, and then to 28 400 in 2005. Our most recent estimation of population size is 37 200 individuals. However, the area occupied is still extremely limited, and the population is vulnerable to a number of threats. Further, its geographic isolation as a northern peripheral population that is genetically isolated from other populations (Remarchuk 2006) makes it of interest to conservation biologists and managers for its potential evolutionary significance and its contribution to diversity and uniqueness of the local flora (Lesica and Allendorf 1995). We need to continue with consistent monitoring of the population and limit threats to the plants and their habitat in Alberta.

6.0 MANAGEMENT AND CONSERVATION RECOMMENDATIONS

6.1 Population monitoring

6.1.1 Comprehensive population monitoring

Consistent monitoring of the western spiderwort population continues to be important in its management and conservation in Alberta (Alberta Western Spiderwort Recovery Team 2005). APA

volunteers conducting the population inventory in 2007 and 2008 felt that there was some risk of surveyors trampling western spiderwort plants, especially in dense plant patches. Because of this potential for damaging plants, and because perennial species like western spiderwort are more likely than annual species to be stable from year to year, annual surveys may be too frequent. Instead, comprehensive population monitoring every three years is recommended at Pakowki Lake North to minimize damage to the plants, and other potential associated threats (e.g., Cahill et al. 2001).

Surveys for new patches of western spiderwort at Pakowki Lake North and in other locations with suitable habitat are necessary for a comprehensive population inventory and monitoring program. These surveys should follow the detailed recommendations outlined by Henderson (2008) and the Alberta Native Plant Council (2000). To maximize the potential for detecting new patches of western spiderwort in suitable habitat, transect widths of 2 m and 5 m and walking speeds of 1 km/hr and 3 km/hr are recommended in tall/dense vegetation and in short vegetation, respectively (Henderson 2008). Since the species is easiest to detect when it is flowering, surveyors need to be careful to time surveys during peak flowering (late June – mid/late July). For example, surveys should be conducted earlier in years of warmer and/or dryer than average weather, in order to coincide with peak flowering. The ideal time of day to survey is from sunrise to noon, because the spiderwort flowers tend to close around noon or early afternoon under mid-day sun (L. Matthias, pers. obs.).

Henderson (2008) emphasizes that the tendency to gather population data at a known rare plant location rather than searching further a field can lead to under-sampling of available habitat. Broad searches for western spiderwort in sandy habitat in southern Alberta have been conducted (see Peters 2003b, Wallis and Wershler 1988). However, updated surveys targeting spiderwort in suitable habitat outside of Pakowki Lake North are needed to try to confirm if this site is the only occurrence in Alberta. Hierarchical sampling methods, adaptive cluster sampling, or other methods that recognize scale and spatial heterogeneity would be most profitable because they focus effort away from unlikely habitats. Once a population has been found, we recommend following the methods outlined in Henderson (2008) at the local scale. Bradley (2009) contains a practical discussion on prioritizing new search areas and developing a sampling approach for another rare grassland plant (slender mouse-ear-cress, *Halimolobos virgata*). Recording locations where western spiderwort is *not* found would be a valuable part of a systematic survey.

Developing a predictive habitat model for western spiderwort would be a good aid to planning fieldwork, in addition to the early comprehensive notes on sand hills habitat in southern Alberta (Wallis and Wershler 1988). Perhaps over time, additional populations of western spiderwort will be discovered by botanists. As well, increased awareness of western spiderwort in the ranching community as a result of the Maintenance and Recovery Plan for Western Spiderwort in Alberta may result in the reporting of additional sites, as it did with the western blue flag conservation program (Romanchuk et al. 2004).

In addition to surveying for western spiderwort, the Pakowki Lake area would benefit from a more comprehensive, multi-species inventory of rare plants and species at risk (e.g., smooth goosefoot, *Chenopodium subglabrum*) (D. Henderson pers. comm.).

6.1.2 Intensive population monitoring

Remarchuk (2006) emphasizes that standardized protocols for estimating population size will improve the detection of population fluctuations from year to year. The polygon extrapolation method has been used in a number of western spiderwort surveys in Alberta (Peters 2003a, 2003b; Remarchuk 2005; this report). It could be improved by stratifying polygons (i.e., patches of plants) by variability in habitat conditions (e.g., active and partially stabilized sand dunes, stabilized sand hills, flat terrain, sloped terrain) and estimating the plant density associated with each habitat. This would provide valuable information on the growth habits of western spiderwort. To improve sampling rigour and reduce effort, random locations could be sampled within several patches of each habitat type, in both known patch boundaries from the previous survey as well as new patch boundaries from the current survey. This provides a way to measure new or expanded patches, as well as recording the decline or disappearance of old patches. Circular plots of an area that considers the size of the plant and the habitat/patch should be used. The number of sampling plots per patch could be scaled to approximate patch size. Intensively monitoring the *same* plots on an annual basis will also allow rigorous comparisons of plant density, browsing intensity, timing of flowering, proportion of plants flowering, and other important trends. The centre of each circular plot would need to be marked with rebar and high-precision GPS, so they could be re-located annually. Furthermore, one or two of the patches identified as those to be intensively monitored should have their perimeters accurately recorded using high-precision GPS, in order to monitor changes in patch sizes from year to year.

Photographic monitoring is another potential tool the Alberta Western Spiderwort Recovery Team could consider for visually documenting changes in Alberta's western spiderwort population and habitat over time (Hall 2001). Repeat photographic monitoring at fixed locations is a fast and effective way to qualitatively document plant distribution and density, as well as habitat changes (e.g., dune erosion or stabilization). This tool would not replace actual plant sampling, but could be a useful supplement, especially if sampling plots were located within the photographic plots.

An appropriate long-term population monitoring design for western spiderwort, which will allow proper management and conservation of this species, should include multiple levels of monitoring intensity: comprehensive population monitoring, including broad-scale searches for new populations, as well as quantitative assessment of the size, distribution and condition of the known population (Menges and Gordon 1996). Schemske et al. (1994) emphasize the need to identify the life history stages that have the greatest impact on population growth and species persistence in order to guide efficient recovery efforts. We also need to understand the association between western spiderwort and specific sand dune/sand hill habitat features (i.e., specific habitat requirements) so that the implications of long- and short-term habitat changes on Alberta's western spiderwort population can be predicted. Ultimately, we want to be able to anticipate population trends and understand the mechanism behind them.

6.2 Invasive plant control

Pakowki Lake North should be visited annually to monitor and control the progression of invasive species, particularly crested wheatgrass and baby's breath. In addition, more comprehensive surveys for the presence of other invasive species known from southern Alberta (for example, leafy spurge, smooth brome [*Bromus inermis*], Canada thistle [*Cirsium arvense*]) should also be conducted

while botanists are on site. Invasive species surveys would be best conducted during less sensitive periods of western spiderwort growth (e.g., spring or early fall), in order to minimize trampling. However, control of invasive plants should be done in spring, to prevent seed development and dispersal. Locations of invasive species infestations should be recorded using GPS; furthermore, the encroachment of crested wheatgrass should be monitored, using permanent markers such as high-precision GPS.

An integrated and adaptive monitoring and control program for invasive plants needs to be developed for Pakowki Lake North. The approach should integrate a combination of effective and environmentally safe control techniques (for example, see Saskatchewan Watershed Authority 2009) as deemed appropriate by the recovery team and other experts. Control efforts should also be adaptive (i.e., their effectiveness should be monitored closely and re-evaluated on a regular basis to guide future control efforts). If chemical control is needed and recommended by the provincial and national recovery teams, it should be used with caution (Lesica and Atthowe 2000), and the Alberta Native Plant Council Herbicide Use Policy (ANPC 2005) should be followed.

The results of existing and upcoming studies on management of invasive plants should be compiled and considered for integrating into efforts at Pakowki Lake North. For example, crested wheatgrass control strategies developed by Frid (2006) for Grassland National Park may be helpful, since multiple funding and rate/type of spread scenarios are considered in his spatially explicit simulation model. The benefits and drawbacks of controlling known large infestations versus early detection and control of new infestations are considered (Frid 2006).

6.3 Grazing and habitat research needs

Several important knowledge gaps and research needs are outlined in the Maintenance and Recovery Plan for Western Spiderwort in Alberta 2005-2010. We will discuss two of these research needs, in light of the results of the 2007/2008 inventory work: grazing management and habitat requirements.

In Alberta, western spiderwort has persisted despite grazing (by cattle and native herbivores) for many years. Grazing of spiderwort has been documented (i.e., proportion of stems grazed) at Pakowki Lake North (Peters 2003a, 2003b), and in Manitoba (Goulet and Kenkel 1997), where authors suggested that light to moderate cattle grazing may benefit the population. However, there has been no intentional research on optimum levels of grazing (by cattle and native herbivores) to maintain western spiderwort and its habitat. Documenting the current cattle grazing regime (i.e., stocking rate, timing and duration of grazing), and how that influences plant life history (e.g., seed set) and habitat (e.g., stabilization/de-stabilization of dunes) would support the development of a Best Management Practices document for western spiderwort (Alberta Western Spiderwort Recovery Team 2005). Grazing patterns from year to year could be investigated using a landowner/leaseholder questionnaire; the questionnaire used by the Western Blue Flag Recovery Team could potentially be adapted for western spiderwort (see Appendix B in Romanchuk et al. 2004).

Grazing is likely one of several factors that plays an important role in the long-term sustainability of Alberta's western spiderwort population, because it removes the reproductive structures, limiting future viable seeds, its main mechanism of dispersal and establishment. However, grazing may also play in important role in maintaining sand dune/sand hill habitat by disturbing the habitat. Until we know whether western spiderwort tolerates or prefers stabilized sandy habitats (i.e., the long-term

prognosis for western spiderwort under the current trend of sand dune stabilization), we should maintain the current habitat conditions. Since grazing is one factor that we potentially have some level of control over, it would be prudent to make grazing management decisions based on research. The intensive patch monitoring suggested (section 6.1.2) should help us to better understand how habitat qualities, such as level of dune stabilization and browsing, relate to population parameters, such as plant density and abundance.

6.4 Long-term involvement of volunteers through *Adopt-a-Plant Alberta*

APA is committed to providing data on native flora, including species at risk, for use in conservation and planning. By recruiting, training, and coordinating the efforts of volunteer plant enthusiasts, APA can contribute to the recovery actions for western spiderwort. APA provides education and awareness to its volunteers and the broader public through workshops, newspaper articles, radio interviews, and information brochures. In 2007 and 2008, volunteers provided their time and energy to survey and monitoring efforts for western spiderwort, as well as for stewardship and management activities for western spiderwort habitat. These efforts continued in 2009, including the production of an information brochure about the threats to western spiderwort and its habitat posed by baby's breath and invasive species. The work of the APA program aligns well with one of the guiding principles outlined in western spiderwort's recovery plan: a cooperative approach with land managers, landowners, industry and other agencies is essential to the success of the plan (Alberta Western Spiderwort Recovery Team 2005).

6.5 Summary of recommended management actions for western spiderwort

6.5.1 Population monitoring recommendations:

- Conduct a comprehensive population survey every three or four years, during peak flowering period, using the same methods as outlined in this report to facilitate comparisons
- Survey for new patches of western spiderwort at Pakowki Lake North and in other locations with suitable habitat, making sure to record not only locations where spiderwort is found, but also where it is searched for and not found
- Conduct a comprehensive, multi-species inventory of rare plants and species at risk in the Pakowki Lake area
- Closely monitor (for plant density, browsing, and phenology) each western spiderwort plant within sampling plots in a small subsample of patches, on an annual or biannual basis
- Monitor annual changes in patch location and size by recording (using high-precision GPS) the perimeter of at least two closely monitored patches

6.5.2 Invasive plant recommendations:

- Annually monitor and control the progression of invasive species at Pakowki Lake North, particularly crested wheatgrass and baby's breath, during less sensitive periods of western spiderwort growth
- Conduct comprehensive surveys for the presence of other invasive species known from southern Alberta (for example, leafy spurge, smooth brome, Canada thistle)
- Control/remove invasive plants in spring/early summer to prevent seed development and dispersal

- Record invasive plant locations and monitor the encroachment of crested wheatgrass and other infestations using permanent markers or high-precision GPS
- Develop an integrative and adaptive monitoring and control program for invasive plants at Pakowki Lake North, incorporating only the control measures endorsed by provincial and national recovery teams for plant species at risk
- Closely monitor the longer-term effectiveness of invasive plant control and re-evaluate on a regular basis

6.5.3 Research recommendations:

- Research optimum levels of grazing (by cattle and native herbivores) to maintain western spiderwort and its habitat; document the current cattle grazing regime (i.e., stocking rate, timing and duration of grazing) at Pakowki Lake North, and how that influences plant life history (e.g., seed set) and habitat (e.g., stabilization/de-stabilization of dunes)

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