**Developing Predictive Models for Tallgrass Prairie Plant Species at Risk in Manitoba, Phase 2.**

**Final Report on Manitoba SDIF Project # 210002**

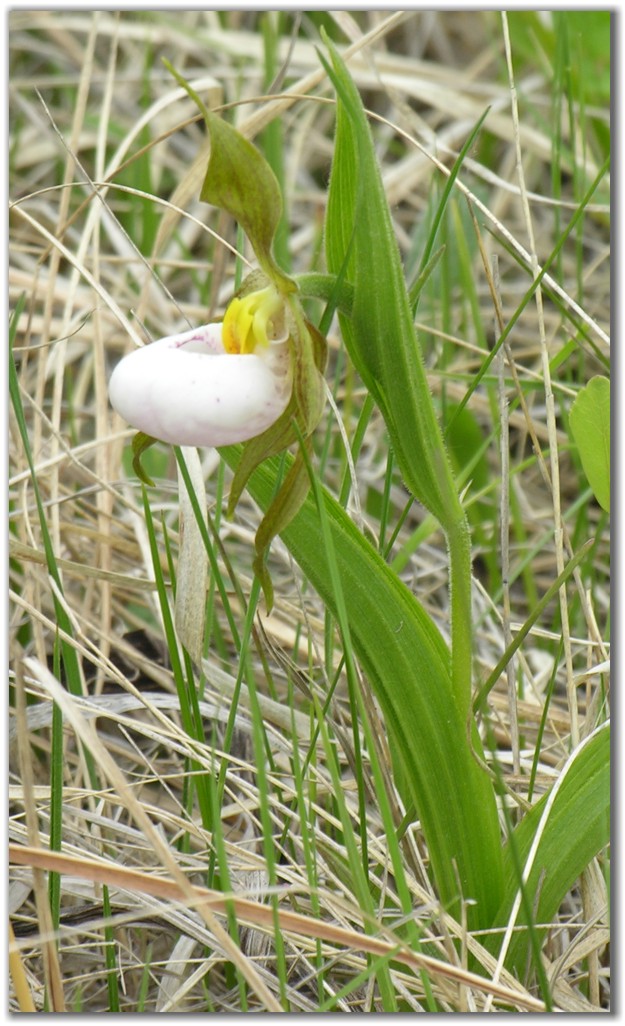


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# Executive Summary

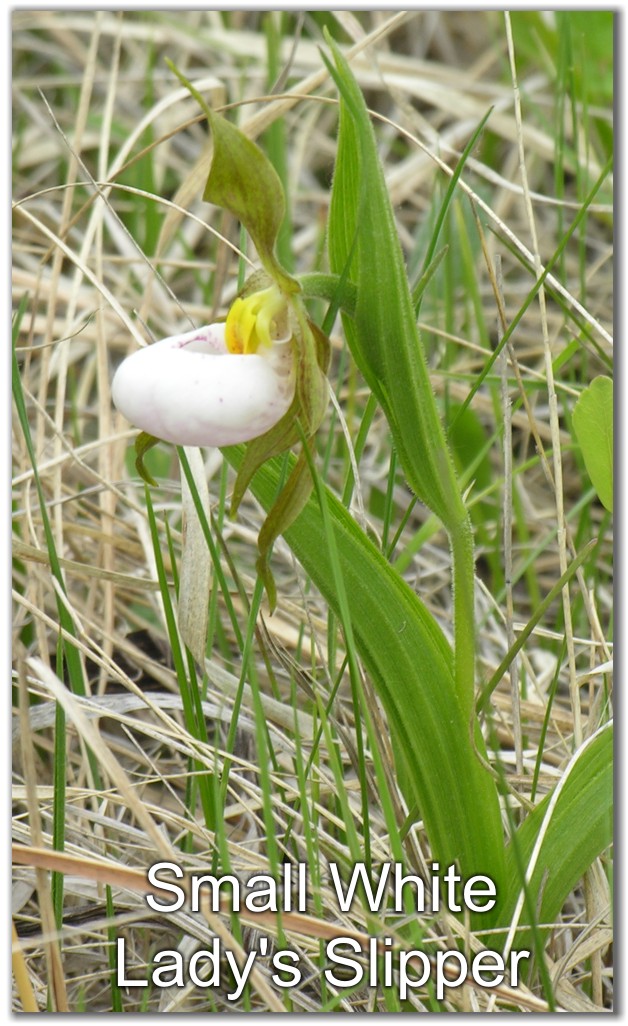
Five endangered or threatened plant species, the Western Silvery Aster (WSA) Small White Lady’s Slipper (SWLS), Western Prairie White Fringed Orchid (WPFO), Culver’s Root (CVRT) and Riddell’s Goldenrod (RDGR) were studied on 224 sites in southern Manitoba in 2007, 2008 and 2011. The main objectives of the research were to identify factors that could be used to predict those species’ distributions and refine them into predictive models (PMs) useful to land managers. The intent was to make field inventories more efficient in the future, leading to more effective and timely management and conservation.

Survey efforts using the PM developed for WSA were used to identify 13 new locations and formally define the range of this species in Manitoba. No clear indications were discovered regarding modeling SWLS occurrence, but significant differences in the plant communities among the three regions of Manitoba where this species occurs were noted. Potential new sites for WPFO were identified but no new populations were encountered. Our work points to the need for in-depth research into the edaphic and hydrological conditions that are the likely determinate factors to the limited distribution of this endangered species. Our research confirmed the ecotonal habitat for CVRT, a species found along the edges where tall grass prairie meets aspen forest. RDGR, with a wide distribution in southeastern Manitoba, was found to occupy similar wet prairie habitats to WPFO, further suggesting that habitat type and plant community are not the defining factors for WPFO distribution. Five new locations for Riddell’s Goldenrod were discovered.

The distribution in Manitoba of four of the five species studied lead to the recognition of the significance of a distinct biogeographical region in southeast Manitoba, the Sandilands Moraine Terrace. Though not all goals of the original project were attained, significant strides in developing predictive models for all five species were made. Publication in an appropriate scientific journal is anticipated.

# Introduction

The tallgrass prairie habitat within the Prairies and Boreal Plains Ecozones in southern Manitoba has been greatly reduced by human encroachment and agricultural conversion. A number of recognized plant Species at Risk (SAR), federally and/or provincially occur in tallgrass prairie habitats in Manitoba. Five of these chosen for study here are high priority SAR in Manitoba: the Western Prairie Fringed-orchid (*Platanthera praeclara*) - endangered, Small White Lady's Slipper (*Cypripedium candidum*) - endangered, Western Silvery Aster (*Symphiotrichum sericeum*) – threatened, Riddell’s Goldenrod (*Solidago riddellii*) – threatened and Culver’s Root (*Veronicastrum virginicum* – threatened). The critical habitats of these species have not been well defined, and large-scale systematic surveys for these species and their remaining critical habitat have not been completed.



Predictive models (PMs) for critical habitat are statistical tools used to estimate the likelihood that a particular species may or may not occur in a given landscape. Increasingly, landowners and conservation agencies are required to determine the presence or absence of SAR on lands they own or for which they are responsible.

The standard practice followed in typical environmental impact assessments (EIAs) is to conduct an arbitrary survey for known plant SAR. These often are incomplete and inefficient, especially if large blocks of land are being assessed. PMs hold the promise of increasing efficiency for EIAs by focusing survey efforts on areas most likely to hold SAR. As well, PMs are important tools to locate new populations of plant SAR and develop overall strategies to best protect these species in Manitoba.

Phase 1 of this project (see Developing Predictive Models for Tallgrass Plant Species at Risk in Manitoba: Final Report on Manitoba SDIF Project # 26070, June 2009, accompanying this report), conducted in 2007 and 2008, aimed to prepare practical, landscape-based PMs of the critical habitat for three plant SAR in Manitoba: the Western Silvery Aster (WSA), Small White Lady's Slipper (SWLS), and Western Prairie Fringed-orchid (WPFO), and to develop techniques and protocols to apply in the preparation of PMs for other plant SAR.



In Phase 2 of this project, conducted in 2011, two additional species, Culver’s Root (CVRT) and Riddell’s Goldenrod (RDGR) were examined and additional surveys for WSA, SWLS and WPFO were undertaken.

## Project Funding

This project was originally proposed on a total budget of $50,000.00. Our December 2006 application to Manitoba’s Sustainable Development Innovations Fund (SDIF) presumed that we would be able to co-fund the project with a matching amount from a federal agency. Prairie Habitats Inc. received a $25,000.00 commitment from SDIF in March, 2007 which allowed us to proceed with Phase 1. However, we were unable to attain matching funding for this project at that time. Our application to Environment Canada’s Endangered Species Recovery Fund, made concomitant with our SDIF application was unsuccessful. An attempt to apply for funding to Environment Canada’s Habitat Stewardship Program in December 2007 also was rejected. A second application to the SDIF was submitted in October, 2010. In February 2011, SDIF granted a further $25,000 towards Phase 2, the completion of this project.

## Project Literature Review and Background

Baltic Rush (*Juncus balticus*) and Hedge Nettle (*Stachys palustris*) percent canopy cover were found to correlate positively with WFO occurrence in the Cheyenne National Grasslands (CNG) in southwestern North Dakota (Wolken, et. al. 2001). Soluble soil magnesium levels and standing water levels in WFO swales further influenced WFO distribution in this study. A model with these four factors successfully described 84% of existing study area swales that contained WFO. No attempt was made to use this model to locate new WFO sites at CNG.

Most other literature on predictive models examined to date have dealt with ecosystem modeling, or were not relevant to the current study (Anna et. al. 2002, Graffman & Turner 1995, Heikkinen 1996, Maes et. al. 2005, & Waser et. al. 2006).

A formal recovery strategy is in place for the WPFO, while strategies for the other species are in the draft stage. This project will address and help facilitate the following recommendations and recovery actions. The following are excerpts from the respective recovery plans.

“Recovery Strategy for the Western Prairie Fringed-orchid (Environment Canada 2006).

Objective 3: By 2007, develop a comprehensive applied research strategy to address knowledge gaps.

Basic biological attributes of the western prairie fringed-orchid require further research to guide protection and restoration efforts. Research should focus on population demographics, factors affecting seed production, including pollination biology, vegetation management techniques, and the effects of threats such as hydrological change and nutrient loading on the species and its habitat. A comprehensive list of required research can guide researchers and funding agencies to fill knowledge gaps.”

“Draft National Recovery Strategy for Western Silvery Aster (Symphyotrichum sericeum) 2006-2011 (Harris et al 2005):

b) Recovery Objectives

2. Assess the status and population viability of western silvery aster.

3. Establish adaptive management actions at extant sites to reduce threats and sustain and potentially increase populations.

5. Develop a comprehensive applied research strategy to address knowledge gaps.“

“Draft Recovery Strategy for the Small White Lady’s-slipper (Environment Canada 2006):

2.7 Knowledge gaps that, if filled, would assist with recovery include:

• Standardized guidelines for inventory and monitoring of existing populations

• Full extent of population and distribution”

Our proposal was discussed with Manitoba Conservation and several members of the appropriate recovery teams. They were, and remain, supportive of our project and its approach (Jason Greenall, Manitoba Conservation, WPFO recovery team chair, pers. comm.)

Previous work by Prairie Habitats Inc. has identified a strong correlation between the WSA, and a particular surficial geological feature, glacial lake beach ridges (GLBR, Prairie Habitats Inc. 2006). Working with a preliminary predictive model we located three new locations (confirmed by Manitoba Conservation) for this species in southern Manitoba during a single day's field work on September 7, 2006.

Our preliminary examination of the known locations of WPFO in Manitoba, Minnesota and North Dakota also lead us to believe that their distribution is linked to a particular geological feature. Since its discovery in Manitoba in 1984 the small region of the province where it occurs (only 48 sq. km) has been surveyed intensively to monitor orchid populations. Little work has been done, however, to determine why the species occurs where it does. Research in southern North Dakota has suggested a strong correlation between soil surface moisture and orchid distribution within areas of its occurrence in the Sheyenne National Grasslands (Wolken et al 2001). This work, however, does not explain why the species is found in that region.

Efforts to locate unique features or habitat characteristics for SWLS have yet to reveal any promising indicators other than their known relationship to high quality tallgrass prairie sites with calcareous soils.

Krause Danielsen and Friesen (2009) summarized the state of knowledge regarding Culver’s Root and Riddell’s Goldenrod in Manitoba. CVRT is known to be a prairie/forest edge species found in SE Manitoba, east of the Red River. RDGR is a species of wet prairies also found in the SE, east of the Red River. Recovery plans for both species are not currently being developed (Chris Friesen, Manitoba Conservation, pers. com.)

Our preliminary findings and suspicions regarding these species were the catalyst for this project. Similar correlations with geographical features or other variables are likely to occur for other plant SAR, but have not been addressed in Manitoba as yet. Our effort to develop PMs for these species will lead to a better understanding of their critical habitat, and promote a more systematic approach to defining the range and conserving these and other species in Manitoba.

Prairie Habitats Inc.'s experience with EIAs over many years has demonstrated the need for PMs for SAR. Many types of development or land-use decision making often require determination of the presence or absence of plant SAR. Effective PMs would provide land managers with important tools to effectively conduct EIAs, rather than relying solely on field surveys. The common practice currently employed relies on non-targeted, extensive, labour-intensive ground surveys. It often is expensive, ineffective and beyond agency budgets to do in a proper, systematic and timely fashion. There are serious risks in missing significant SARs using this method, resulting in the unacceptable and preventable loss of more SAR and their critical habitat. The approach investigated here, developing PM’s for individual plant species, offers a more productive and effective means of assessing areas for the presence or absence of SAR and their associated plant species.

# Methods

Manitoba’s tallgrass prairie occurred where it did not by chance, but because of underlying climatic, geographical and biological features. Our working assumption is that each individual species' distribution reflects its association with, or dependence on, certain definable environmental characteristics or features. There are few protocols or guidelines existing for the production of predictive habitat models for plant SAR in Manitoba, so this was a pioneering project. As we progressed our planned course of action changed significantly to accommodate new findings or opportunities.

## Project Work Plan

Compilation of Existing Information and Development of Preliminary Predictive Models

We conducted a literature review for examples of plant SAR predictive habitat modeling applicable for use in our work and for information relating to the target species throughout their North American ranges. It was apparent that information on these species was scant, as it related to this project, and that we were pursuing a fairly novel approach. For budgetary considerations we did not pursue an extensive literature review and made only cursory attempts to obtain information from surrounding jurisdictions. The literature review on predictive models for other species did reveal that this is a little known area for plant species.

The most recent information on the known habitat of the target SAR was obtained from Manitoba Conservation (Foster and Hamel 2006, Foster and Reimer 2007, Foster 2008, Krause Danielsen and Friesen 2009.)

We obtained location information for the five species from the Manitoba Conservation Data Centre as ESRI compliant shape files. Geo-referenced environmental information was obtained from the Manitoba Land Initiative (MLI), also in the form of shape files. Manitoba Science, Technology, Energy and Mines provided additional geo-referenced mapping information to complement the MLI files. Geo-referenced information was analyzed using ArcGIS 9.3 software. Location data for our target species were overlain with landscape-scale geographical information to search for environmental attributes associated with known distributions of these species. Plots of known populations against the underlying environmental attributes served to develop the larger, landscape-based aspect of our preliminary PMs.

Species Association Field Sampling

The field sampling component of this project focused on collecting species association data largely from sites that were known habitat for the target SAR. This reflected our practical aim to determine if there were obvious means to find our target species based on their association with other more easily located plant species.

All sampling was conducted in areas known to harbour the target species or in arbitrarily selected high quality native prairie habitats (control sites). Specific sampling sites in known areas of target species habitat were selected in two manners. In some cases individual specimens of a target species were selected as centre points for sampling radii. When target species were not used as centres for sampling, locations were selected at random within areas of known habitat. At control sites sampling locations were selected at random.

In Phase 1 all plant species were identified and recorded within a 1m radius of the selected point, then again within a 5m radius. Additional plant species within the selected habitat (up to 30 m away), but outside the formal sampling radii were also noted. In Phase 2 separate sampling within a 1 m radius was not conducted. All sampling locations were recorded as GPS waypoints and some were marked with small wooden stakes. Notations were made of any significant habitat factors relating to each sampling site.

In Phase 1 field surveys were conducted in southern Manitoba between April and November 2007. Two potential SWL sites identified were revisited in June, 2008. In Phase 2 field surveys were conducted from June 6 to October 4, 2011. Surveys were done at the optimum time of year to determine the presence or absence of our target species, during the blooming periods for each: mid-May to early June for SWLS, late June to mid-July for WPFO, late July for CVRT, late August for RDGR and late August to early October for WSA. In Phase 1 some SWLS and WPFO sites were re-sampled later in the season to better identify late-season-blooming plants. Also in Phase 1 some WSA sites were sampled early in the year and again during the flowering period in late summer. WSA was easy to locate before its blooming season, unlike the other species.

Field Testing Predictive Models: Surveys to locate new populations.

Field testing of our preliminary PM’s, essentially surveys to locate new populations, were pursued selectively in both phases of this work and are presented by species below.

Western Silvery Aster

Initial findings confirmed our suspicions of a strong relationship between WSA and glacial lake beach ridges (GLBR) and some testing of this PM was pursued by searching for new locations for this species in Phase 1. In Phase 2 an extensive survey was undertaken to determine the geographic range of WSA in Manitoba. Potential sites in southeastern Manitoba, the Interlake region and west of the Red River in southern Manitoba were compiled using our PM. From Sept. 1 to Oct. 4, 2011, 217 sites were surveyed.

In the later surveys for WSA a checklist of indicator species was annotated to record the numbers of indicator species present at the site (see Appendix 1.)

Small White Lady’s Slipper

For SWLS no specific geospatial associations were apparent. In Phase 1 potential habitats for SWLS were inventoried as part of another, unrelated project on rare plant surveys along a pipeline route in southwestern Manitoba. Two possible SWLs areas identified late in 2007 were checked in 2008 at the peak of blooming for SWLS. No systematic searches for new SWLS locations were carried out as part of Phase 1.

In Phase 2 one cursory survey for SWLS was conducted. On June 17, 2011, seven sites near Lundar, Manitoba were surveyed for SWLS. Sites were selected based on location data for Dakota Skippers (*Hesperia dakotae*) as the skippers were known to inhabit high quality tall grass prairie sites.

Western Prairie Fringed Orchid

Analysis of geospatial information suggested a strong association of WPFO for certain wetland/wet meadow soil conditions. In Phase 1 no surveys for new locations of WPFO were carried out.

In Phase 2 a one-day survey to attempt to locate new populations of WPFO was conducted on June 29, 2011. Twenty-eight sites were selected for inspection in the region surrounding the known populations of WPFO. Potential sites were selected based on the presence of extremely calcareous soil types and the presumed presence of native prairie plant communities, selected from Google Earth observations. Known WPFO sites were visited to ensure that plants were at detectable stages in their phenology; i.e., had tall stalks or open flowers.

Culver’s Root and Riddell’s Goldenrod

Surveys to test PMs or attempt to find new locations for CVRT and RDGR were not undertaken.

# Results

## Geospatial Analyses

Overall Findings

Geospatial analyses proved fruitful in gaining insight into the distribution of some of the target species, but less so for other species (see individual results below). Overall our analyses lead to a better understanding of the biogeography of the species studied.

The Sandilands Moraine Terrace

One particular geographical feature seems to play a major role in the distribution of our target species in southeastern Manitoba. A terrace of relatively flat land occurs west of the Sandilands Moraine ([Figure 1](Images/Figure%201%20Terrace.jpg)). It rises abruptly on its western edge to an elevation approximately 80-100 m above the flat plain of the Red River Valley. The terrace is composed of deposits of glacial till, sand and gravel. Soils on the terrace are much coarser and better drained than in the Red River Valley where soils formed on silt and clay deposited on the floor of glacial Lake Agassiz. For the purposes of this report this geographic feature is referred to as the Sandilands Moraine terrace (SMT).

The SMT comprises most of the southernmost district of the Boreal Plains Ecozone. This ecozone, which extends from the region of the SMT northwestward through the Interlake region is the transitional zone between the Prairie Ecozone and the various boreal forest ecozones to the north and east. As such much of this region can be classed as parkland habitat with mixtures of grasslands interspersed with forest. In general within the region, to the north and east the grassland component diminishes and forests come to dominate.

The entire known distributions of WPFO, CVRT and RDGR lie within the SMT, as does most of the contiguous distribution of WSA. North of the SMT, near Hwy No. 1, the distribution of WSA is limited to isolated outcrops of glacial sand/gravel deposits. Only SWLS has a distribution that isn’t primarily limited to this terrace. This region also contains the entire known distribution for at least one other plant SAR, Great Plains Lady’s Tresses (*Spiranthes magnicamporum*). Figures 2-6 show the known distributions of our target species across southern Manitoba. ([Figure 2 – WSA](Images/Figure%202%20Whole%20Study%20Area%20WSA.jpg), [Figure 3 – SWLS](Images/Figure%203%20Whole%20Study%20Area%20SWLS.jpg), [Figure 4 – WPFO](Images/Figure%204%20Whole%20Study%20Area%20WPFO.jpg), [Figure 5 – CVRT](Images/Figure%205%20Whole%20Study%20Area%20CVRT.jpg), [Figure 6 – RDGR](Images/Figure%206%20Whole%20Study%20Area%20RDGR.jpg))

Western Silvery Aster

Analysis of available geo-referenced information revealed a strong association of WSA with glacial lake beach ridges (GLBR, 6b in Table 1.) specifically, and with glacial lake sand/gravel deposits (3, 3a, 3b, 6, 6a, 6b in Table 1.) in general.

Table 1: Definitions of surficial geological features associated with target species (from SE\_MB\_surficial\_geology.shp).

|  |  |
| --- | --- |
| 3 | PROXIMAL GLACIOFLUVIAL SEDIMENTS: -Sand and gravel; 1-20m thick; occur in belts with single or multiple esker ridges, kames, and kettle holes; proximal sediments deposited by meltwater in contact with glacial ice. |
| 3a | -Sand and gravel predominantly derived from Precambrian rocks. |
| 3b | -Sand and gravel predominantly derived from Paleozoic rocks; |
| 6 | GLACIAL LAKE SHORELINE SEDIMENTS: -Sand and gravel; 1-5m thick; beach ridges, spits, bars, and nearshore sand and gravel >1m thick; sediments reworked by the wave action of glacial Lake Agassiz. |
| 6a | -Sandy nearshore sediments. |
| 6b | -Sand and gravel beach ridges; |
| 2 | GLACIAL TILL: calcareous silt diamicton; 1-50m thick; fluted surface; subdued morphology due to reworking by waves; basal till; northwestern provenance indicated by abundant carbonate in gravel fraction; thicker sequences consist of multiple units of varying texture. |

Statistical analyses were not conducted on these apparent associations, but visual inspections in ArcGIS show that nearly all known WSA locations are in or very close to these surficial geological features ([Figure 7](Images/Figure%207%20SE%20Region%20WSA%20with%20Sand%20Gravel.jpg), [Figure 8](Images/Figure%208%20SE%20Region%20WSA%20Close-up.jpg) and [Figure 8b](Images/Figure%208b%20SE%20Region%20WSA%20Close-up%20St%20Anne.jpg)).

Small White Lady’s Slipper

Available information did not reveal any significant trends or explanations to the distribution of SWLS in Manitoba. This species occurs in a wide range of geological formations across southern Manitoba, encompassing a number of soil and surficial geological types. ([Figure 3](Images/Figure%203%20Whole%20Study%20Area%20SWLS.jpg) and [Figure 9](Images/Figure%209%20SE%20Region%20SWLS%20with%20Sand%20Gravel%20and%20TIll.jpg))

Western Prairie Fringed Orchid

There is a strong association of WPFO with certain very calcareous soil types in the region of this species’ known distribution. There are additional underlying geological features that seem to support the idea of this region being fairly unique both in soil drainage and chemistry, and underlying geology. The known WPFO range is in a region of extremely calcareous soils, overlaying calcareous glacial till (defined in Table 1), in turn overlaying a region of distinct dolomitic limestone ([Figure 10](Images/Figure%2010%20SE%20Region%20WPFO%20with%20Sand%20Gravel%20and%20TIll.jpg)).

Culver’s Root

CVRT populations occur mainly in regions of glacial till, but also in regions characterized by sand and gravel deposits. There did not seem to be any strong associations with particular geological features within the SMT region. ([Figure 11](Images/Figure%2011%20SE%20Region%20CVRT%20with%20Sand%20Gravel%20and%20Till.jpg))

Riddell’s Goldenrod

RDGR populations reflect the situation as described for CVRT. Most are in regions of glacial till, but some occur in sand/gravel deposits. No strong association with particular geological features was apparent ([Figure 12](Images/Figure%2012%20SE%20Region%20RDGR%20with%20Sand%20Gravel%20and%20TIll.jpg)).

## Species Association Results

Our species association data collection was conducted on an ad hoc basis without strict attention to formal statistical techniques. Results are presented here as qualitative information without rigorous statistical analyses.

A total of 224 different sites were sampled: 32 in WSA habitat, 57 in SWLS habitat, 31 in WPFO habitat, 31 in RDGR sites, 26 in CVRT sites and 47 in Control sites.

Though species association data was collected as separate 1 and 5 m radius plots surrounding arbitrarily chosen loci in 2007, ultimately it proved most useful to combine all the records for each site sampled. 2011 data consisted of 5 m radius plots only. In the end, our data consisted of a species list for each of the 224 sites. Data from 2007 and 2011 were lumped and re-analyzed as a single grouping. (See Praire\_Habitats\_Final\_Report\_Proj\_#26070.doc for prior analyses.)

Although we conducted a number of analyses on our species association data the most valuable of these proved to be the simplest. For each of the target species’ habitats we determined the frequency of occurrence of all species recorded (# times a species was recorded / total # samples). This produced a list of associated species and their % frequency of occurrence for each target species, referred to as Raw Association (RA) data. (Please refer to **Page 1**, in <Data_Summarized_for_Final_Report_2011.xlsx> – **NOTE: keep file open for further references, given by Page # or Graph #**)

(*For all graphs appearing at the top of the pages the complete set of data can be found below the graphs on the same page. Please refer to the appropriate charts in the accompanying spreadsheet for the lists of species. Presenting and commenting on the associated species for each target SAR here would have been too voluminous*.)

A total of 329 species of plants were recorded in all the sampling. The frequency of occurrence of these in the combined data ranged from 0.5% for several species found only once in all sampling to more than 80% for big bluestem which proved to be the most commonly encountered plant in all our sampling sites.

Upon inspection of these lists it became apparent that a number of species were found commonly in all target species sampling sites, as well as in the control sites. For example, big bluestem and stiff goldenrod had high frequencies of occurrence, ranging from 77 % to 87 % for big bluestem and 71% to 77% for stiff goldenrod. As such they may be considered good indicators of high quality native prairie, but they provide no means to distinguish between habitat types of the target species and have little value as indicators to distinguish habitat for any one of the target species.

A simple extension of this analysis, however, proved very revealing. As a comparative measure we combined all our data from target species and control sites and determined an overall frequency of occurrence for all species recorded in all samples (**Page 1, Graph 7**). The % frequency occurrence of each species for the combined data was then subtracted from that species’ % occurrence within each of the target species data. This served to highlight plant species that had a high association with each particular target species, and filtered out species that had high or low associations with all habitat types. These results are referred to as **Corrected Association (CA) data**. Species with a high CA value (displayed as a %, but really just an index) can be considered good indicator species for the particular SAR. (**Page 2, Graphs 8-13**).

[*For ease of comparison, lists of the top 30 most commonly occurring species for RA and CA data are provided on Pages 5 and 6. Page 5 lists by alphabetical order and Page 6 by % occurrence*.]

Regional Interpretation

The low CA values for the overall SWLS (<30%) data initially suggested that there were few good indicators for this species. However, a more likely interpretation of the data is that there are, in fact, three distinct or at least different plant communities in the three regions where this species was sampled. This, combined with the realization of the significance of the SMT to the biogeography of 4 of 5 species being studied lead to a re-analysis of our data as explained below. Final discussions of our results focus mainly on our re-analyzed data taking into account the specific regions where our target species occurred. Figure 13 displays the general regions where our species association data was collected.

Southeast Subset of Data

Of the five species selected for study in this project, only SWLS are known to occur outside the southeast region of the province, so the data was re-analyzed using only sampling data, both target and control samplings, from that region to search for further insight. The RA and CA data for the southeast region are presented in **Page 3, Graphs 14 – 20 and Page 4, Graphs 21 – 26**, respectively. A total of 301 plant species were recorded in the southeast data.

For WSA, WPFO, CVRT and RDGR there are no differences between the overall and southeast RA data (as all sampling for these species was in the Southeast region) and only slight differences in the species lists when CA data is considered. Viewing only the southeast data served to better define the plant communities where each of these four is found.

SWLS Data by Region

RA and CA data for SWLS were analyzed separately by the three distinct regions where this species is found, the Southeast, Interlake and Brandon regions (Figure 3). RA data is found in **Graphs 27-29, Page 7** while CA data is in **Graphs 30-32, Page 8**. Corrected data was derived using the Lumped occurrence data, **Graph 7, Page1**.

When RA data is viewed the 3 regions’ plant communities appear similar, but inspection of CA data reveals that the plant communities and therefore indicator species for SWLS are quite different, though all could be considered as high quality mesic tallgrass prairie. A numerical comparison of the associated species is given below.

Species Comparisons

A comparison of the species that occur most commonly in association with each of our target species revealed further insights. The top 30 most frequently occurring species for each of our target species were compared with the top 30 species for each of the other target species to look for species in common. Lists of these comparisons are found on **Pages 9 and 10**. Matrices of these comparisons are provided on **Page 11**.

Cross comparisons of RA data (Page 11) showed few species in common when drier habitats (WSA) and mesic habitats (SWLS) were compared with the wetter habitats (WPFO, CVRT and RDGR). When the wetter habitat species were compared one noteworthy result is the high degree of similarity between WPFO and RDGR, which shared 19 and 20 RA species when the overall and southeast region data were compared, respectively. They also had the greatest number of shared species for CA data, both overall (11) and southeast data (9). As expected, comparisons of CA data show few species in common between the other target species.

For SWLS data, regional comparisons showed that SWLS plant communities shared relatively few CA species. Despite being supposedly similar habitats the regions shared only 17 of the top 30 RA species. If all three regions are cross compared together, only 5 of the top 30 species are shared, one of which was SWLS itself. These four species: Yellow Star Grass (*Hypoxis hirsuta*), Small Yellow Lady’s Slipper (*Cypripedium parviflorum*), Horsetail (*Equisetum spp.*) and Low Prairie Rose (*Rosa arkansana*), are perhaps the best indicators of the presence of SWLS.

Field Testing PMs: Surveys for new populations of WSA, SWLS and WPFO and to define the geographical range of WSA.

Western Silvery Aster

Phase 1- Our preliminary PM for WSA consisted of searching for GLBR that still held high quality native prairie communities. On two occasions, Sept. 11 and Oct.1, 2007, attempts were made to find new locations for WSA by visiting selected sites, based on the presence of GLBR. Sites which held high quality native prairie plant communities were inspected closely, while sites that had been disturbed extensively or were agricultural fields were not inspected. Of 12 sites deemed as potential for WSA, four new locations for this species were located in 2007. Three new locations for WSA had been located using essentially the same PM on September 6, 2006.

Phase 2 - Survey to determine the geographical range of WSA and locate additional new populations.

Of the 217 originally selected sites 105 proved to be not worth intensive inspection; they were crop land, forest or too disturbed. Of the 112 sites surveyed 92 were inspected and 20 were formally sampled. Surveys for WSA in the Interlake and Western regions, involving inspection of 33 sites (Figure 14), did not locate any sites containing the species. No new populations were discovered in the Southeastern region north of the known populations near Beausejour (28 sites checked). Presumed suitable habitat and plant communities were found throughout these regions, but populations of WSA were not found. In the Southeast region south of Hwy 1, five new populations of WSA were discovered (156 sites checked). A total of 13 new WSA populations have been discovered in the southeast since 2006 as a result of our efforts. Locations of newly discovered WSA populations are shown in [Figure 7](Images/Figure%207%20SE%20Region%20WSA%20with%20Sand%20Gravel.jpg).

[Figure 15](Images/Figure%2015%20SE%20Region%20WSA%20Range.jpg) presents our proposed distribution for WSA in Manitoba. We have taken advantage of the known boundaries of the southernmost district of the Boreal Plains Ecozone, which encloses the SMT, and modified these at the northern edge of our suggested range. WSA seems to be distributed somewhat contiguously (as relic blocks of habitat) in the region of the SMT, but then only as disjunct populations N of Hwy #1, where outcrops of sandy, gravelly soils occur, primarily Bird’s Hill Park and south of Beausejour. (Historic locations, of uncertain status, including Stony Mountain and Winnipeg’s Living Prairie Museum no longer harbor this species.)

Small White Lady’s Slipper

In Phase 1 no extensive PM-based searches were conducted for SWLS and no new locations were discovered. Two sites, east of Wawanesa, and along the Pipestone Creek valley southwest of Virden identified in 2007 were checked in early June 2008, at the peak of flowering time for this species. Both sites turned out to contain Small Yellow Lady’s Slippers (SYLS).

In Phase 2, on June 17, 2011, seven sites near Lundar, Manitoba were surveyed for SWLS. No new populations were found.

Western Prairie Fringed Orchid

On June 29, 2012, 16 sites were directly inspected on foot or by binocular from adjacent roadsides. No new WPFO populations were located, however, some sites located south of Arbakka were deemed to be worthy of further investigation as they seemed to be appropriate habitat and contained many of what are considered indicator species for WPFO ([Figure 16](Images/Figure%2016%20WPFO_Survey.jpg)).

Survey Efforts and Discovery of New Populations of Target Species

During the course of this and related studies, encompassing more than 10,000 km travelled and more than 500 sites visited (driven by, checked or sampled), 13 new locations for WSA and 7 for RDGR were discovered, but none for the other three target species. All of the newly discovered populations of WSA and RDGR were within the SMT. (Locations of newly discovered populations of WSA and RDGR are given on **Page 12**. See [Figure 7](Images/Figure%207%20SE%20Region%20WSA%20with%20Sand%20Gravel.jpg) and [Figure 12](Images/Figure%2012%20SE%20Region%20RDGR%20with%20Sand%20Gravel%20and%20TIll.jpg))

Total time and effort committed to searching for new WSA sites in Phase 2 was much higher than in Phase 1, but for that effort relatively few new sites were discovered. During Phase 1, approximately 50 sites were checked with 4 new populations discovered. In Phase 2, more than 200 sites were checked with only 5 new populations discovered. This suggests there may not be many more remaining undiscovered populations of WSA.

The seven new RDGR populations were all discovered incidentally during searches for other species or sampling activities for this as well as other species. This suggests that RDGR is a fairly common species within the SMT, but is likely restricted to this region.

That no new populations were discovered for SWLS, WPFO and CVRT is discouraging. While it seems plausible that WPFO is restricted to a small range for certain yet unknown environmental conditions, habitat for SWLS and CVRT does not seem to be limiting within the SMT and other regions.

**Discussions**

Geospatial Inferences

Overall, our analyses of available geospatial information had mixed results, as far as helping to define PMs for the five target species. For one species, WSA, a strong correlation was apparent with specific surficial geological features (see individual species accounts below), while for another species, SWLS, no such correlations could be identified. Of the other three target species, only WPFO showed a strong association with particular geophysical features, but the identified features still do not seem to explain the isolated distribution of this species. CVRT and RDGR distributions don’t correlate strongly with any apparent surficial geological features.

Sandilands Moraine Terrace

Our search for individual PMs for our target species has provided insight into the biogeography of southeastern Manitoba. The known distributions for four of the five species studied here lie almost entirely within one geographical feature, the SMT, which lies within and largely defines the southernmost district of the Boreal Plains Ecozone. The original plant communities within this region could best be defined as parkland, mixed forest alternating with open prairies, with prairies declining in dominance from west to east. Agricultural development virtually eliminated the native tall grass prairies within the Red River Valley to the west, but the coarser, often stony soils of the terrace precluded the elimination of native grasslands in this district. Within this region the impacts of agricultural development seem to decrease from north to south, likely as soils are much sandy/stonier southward; the presence of relic tall grass prairie sites increases southward in this region.

Our experiences within this region suggest that there is a significant array of prairie plant species that reach the northwestern limits of their North American ranges in the SMT. We suggest that this is because of a unique pattern of colonization of this region after the recession of glacial Lake Agassiz. It’s likely that certain species entered Manitoba from grasslands to the southeast along lands first exposed on the eastern shores of Lake Agassiz. Species which thrived on the coarse, sandy soils of the SMT may have found the heavier clay soils and differing climatic conditions of the Red River Valley unsuitable, thus limiting their distribution.

The SMT should be recognized as a unique biogeographical region. Better understanding of the physical features of the SMT, its topography, soil types and chemistry, drainage, climate, etc., will lead to better understanding of plant species distributions, especially those of SAR, in this region.

Species Associations

Our species association data provide significant insight into the plant communities where each of our target species occurs. RA data served to define the general types of prairie habitats where each species is found: xeric (sandy) prairie habitats for WSA, mesic tall grass prairie for SWLS, wet prairie habitats for WPFO and RDGR, and ecotonal wet prairie and forest edge habitats for CVRT. Initial identification of high quality prairie habitats is an important first step in locating prairie plant SAR.

CA data provided lists of indicator species for each of our target SAR. These have the potential to aid in the assessment of habitats for the presence or absence of these species and as guides to help locate new populations during the course of future surveys.

Though CA data provides lists of good indicator species for each of our target species the RA data gives lists of species that help define potential habitats to begin with.

## Discussions by Individual SAR

Western Silvery Aster

It has long been known that WSA tended to occur in areas with sandy, gravely soils (Foster, C. 2008, etc.). Our work has primarily served to highlight and formalize that relationship. Analyses of the available geospatial information show a strong correlation between the distribution of known WSA locations and glacial lake sand and gravel deposits, in particular glacial lake (Agassiz) beach ridges (GLBRs).

The mere presence of glacial lake sand and gravel deposits, however, is not necessarily an indicator of potential WSA habitat. Over much of southeastern Manitoba where these deposits are in regions of fairly flat terrain they have developed soils that permitted agricultural development. This has lead to the removal of the original prairie plant communities. Sites where WSA occurs now tend to display significant physical relief that has precluded agricultural use. In our searches for new WSA populations it quickly became apparent that GLBR’s with low relief often were incorporated into crop fields, whereas all sites where we did find new WSA populations were distinct hills or ridges that had little soil development and appeared to host relatively undisturbed prairie plant communities. They were often associated with sand and aggregate mining operations. Some GLBR’s also held only forested communities and therefore did not represent suitable habitat for WSA.

Species association data for WSA indicate that this species is most often found within xeric native prairie plant communities. Species listed in **Graph 21, Page 4** are good indicators for the presence of WSA. (See Appendix 1 for further discussions.)

Our work lead to an effective PM for WSA. This PM suggests that landscapes underlain by glacial Lake Agassiz beach ridges, and characterized by raised sand/gravel deposits supporting xeric native prairie plant species have a high probability of harbouring WSA. Chances of finding WSA increase as the number of indicator (high value CA) species increases. However, it must be remembered that this represents only the now-relic distribution of this species. The sort of habitat that the species occupied prior to European settlement can only be estimated.

In this regard the WSA populations near Beausejour and Richer are thought provoking. Both consist of small patches of seemingly undisturbed prairie which contain good numbers of WSA adjacent to large fields that are clearly formerly disturbed sites and which now host large concentrations of WSA. Both relic prairie sites are also vegetatively denser and more mesic than most other WSA sites, perhaps representing the wetter end of WSA habitat types. The two “go back” sites next to these sites contain the highest concentrations and total numbers of WSA encountered in this study.

One of the most common land uses around WSA sites were gravel pits. This is of concern because the disturbance they create removes potential habitat. On the other hand, WSA is a short lived perennial and may require some level of disturbance for its seeds to germinate. This fine balance between disturbance and protection may be one of the factors limiting this species. Experience with WSA in a greenhouse and nursery setting by Prairie Habitats Inc. staff has indicated that plants rarely live beyond three years when grown from seed, even in good habitat. Thus the presence of suitable open soil for reseeding appears necessary.

Range of WSA in Manitoba

Given the fragmentary distribution of WSA in southeastern Manitoba it is difficult to extrapolate the original, pre-European settlement, distribution of this species. However, it is likely fair to assume that this was one of a number of species that entered Manitoba after glacial recession along the eastern edge of former Lake Agassiz and reached the northwestern limit of its North American distribution.

[Figure 15](Images/Figure%2015%20SE%20Region%20WSA%20Range.jpg) displays our proposed range for WSA in Manitoba. The region including the SMT likely represents the original, perhaps contiguous range for the species, while populations in BHP and near Beausejour seem to be outliers. There seems to be no good areas of sandy soil habitat that would have formed contiguous habitat for this species beyond the SMT. No new populations of WSA were discovered north of Beausejour in the Southeast region, nor anywhere else in southern Manitoba.

Small White Lady’s Slipper

SWLS generally are found on sites supporting high quality mesic native prairie plant communities. A number of the known locations of SWLS, however, are roadside or railway rights-of-way, which demonstrates the species is capable of re-colonizing disturbed locations. Why this species does not spread more aggressively, like the closely related yellow lady’s slippers, is unknown.

We were unable to find any particular geophysical features associated with the presence of SWLS and that would help to explain the distribution of this species.

Our species association data suggests SWLS require habitats that are high quality mesic native prairie plant communities. The species found most commonly in association with SWLS (refer to **Graphs 27-29, Page 7**) are well representative of mesic tall grass prairie. A complicating factor to the analysis of species association for SWLS is the distinct geographical regions where it occurs. A comparison of the RA and CA data for the three regions, Southeast, Interlake and Brandon, shows that the plant communities at each are quite different. Our proposed PM for SWLS is therefore simplistic at this point: areas of high quality mesic tall grass prairie which contain significant numbers of indicator species, in particular the four species mentioned above: Yellow Star Grass, Small Yellow Lady’s Slipper, Horsetails and Low Prairie Rose .

Western Prairie Fringed Orchid

The restricted geographical range of the WPFO in southeastern Manitoba has been fairly well documented, but the underlying reasons for its limited range are still not known. Our analysis of the available geospatial information suggest that the small region known to harbor WPFO may be geologically distinct from surrounding regions and this may be a factor in the restricted range of this species.

Species association data for WPFO support the idea that this species is limited to very wet prairie communities. The plant species with the highest RA and CA values for WPFO are all indicative of wet native prairie plant communities.

The presence of this species in roadside rights-of-way shows it is capable of re-colonizing disturbed sites. No signs are evident, however, of spreading from its known range. This may be taken as evidence that some soil, drainage or other geological factors exist in this region that WPFO is dependent on. There is a close correlation of the WPFO range and regions of extremely calcareous soils.

As a PM for WPFO we would suggest that it is found in areas of high quality native prairie plant communities in wet areas with extremely calcareous soils. The species listed in **Graph 23 on Page 4** should be considered as good indicators for the presence of WPFO. Our model suggests the best potential for new WPFO discoveries lie in the areas of extremely calcareous soils overlying calcareous glacial till overlying dolomitic limestone/sandstone bedrock ([Figure 10](Images/Figure%2010%20SE%20Region%20WPFO%20with%20Sand%20Gravel%20and%20TIll.jpg)).

Our data for RDGR provide some additional insight. RDGR is known to occur in association with WPFO and both are known to prefer wet prairie habitats. Comparison of our lists of associated species for both RDGR and WPFO show a high degree of similarity. RDGR is common throughout the known range of the WPFO, often growing in close proximity. Yet RDGR is relatively common throughout the SMT, in wet prairies and roadside ditches, while WPFO is restricted to one 48 square km region. This suggests that factors other than plant community composition are responsible for the isolated distribution of the WPFO.

Based on our work assessing the distribution of WPFO we feel it is fair to suggest that the region where it occurs contains some unique array of edaphic and, or drainage conditions that provides optimum habitat for WPFO. Further research efforts directed towards WPFO should focus on identifying these unique conditions.

Culver’s Root

CVRT occurs throughout the region of the SMT in mesic to wet prairie habitats, but seems to be an ecotonal species, never occurring far from forests or woody vegetation of some sort. It is found within the known distribution of WPFO, but only on sites with higher relief, small hillocks or ridges, that support woody vegetation.

No new populations of CVRT were discovered during the course of this project, despite extensive travel and observation within the region of its occurrence. This is a relatively easy plant to spot, especially during the flowering season, so it is discouraging that no new locations were discovered.

A cursory PM for this species would include ecotonal habitats containing both high quality TGP and aspen forest within the SMT region. CA species listed in **Graph 24, Page 4** can be considered as good indicators for this species.

Riddell’s Goldenrod

RDGR has proven to be a fairly common species within the region of the SMT, though it seems to be restricted to this region. Seven new locations for this species were identified during the course of this project, even though no deliberate attempts were made to survey for this species.

RDGR is found primarily in regions of glacial till where soil conditions are very wet. The plant community it is part of is common in this region (see comments above re WPFO). Our PM for this species is relatively simple: wet prairie areas within the SMT region. Indicators species include those listed in **Graph 25, Page 4**.

Communication Strategy

Communication of the results of our study began with the presentation of 2007 results to the Manitoba Endangered Species Committee in May 2008. It is anticipated that a further such presentation will be made in autumn 2012. Publication of the results in an appropriate scientific journal also is anticipated. Our results may be published in the 2012 North American Prairie Conference Proceedings. Our complete project report will be made available online through NatureNorth.com. It is hoped that the approach we have taken will stimulate other research in this area once published.

# Conclusions

This project has made significant progress towards developing predictive models for five of Manitoba’s plant SAR and gathered insight into the biogeography relating to these species. Our PM for WSA lead to the development of a formal distribution range for this species in Manitoba and resulted in the discovery of 13 new locations for this threatened species. We demonstrated the need for additional research into the habitat requirements of SWLS by specific geographic region and identified a number of indicator species that may be used to locate new populations. Our work on WPFO has accentuated the need for specific research into the edaphic conditions that seem to define this species’ limited range. As WPFO is an endangered species it is high time such research was undertaken. We have also gained new insights into the biology and biogeography of CVRT and RDGR.

Ultimately, our PMs are not complex arithmetic or statistical equations, but simple statements of correlations and associations of geological features, habitat and plant communities. In this regard, however, they are simple, effective and useful to biologists, consultants and land managers.

An unanticipated result of our work was the insight gained into the biogeography of southern Manitoba, especially as it relates to 4 of the 5 species studied. The Sandilands Moraine Terrace (SMT) is a unique and distinct region of the province which contains most of the remaining tall grass prairie in the southeastern region. Further research and understanding gained from recognition of this distinct region will aid in conservation of all the SAR it contains.

Overall our work has demonstrated the need to take a broad ecosystem approach to understanding the distributions of plant SAR. In particular we have demonstrated the value of comparisons between plant communities as a means of gaining new insight. Our findings of the similarity between RDGR and WPFO habitats are a case in point.

The findings of our research will allow for more effective efforts to assess habitats in Manitoba for the presence or absence of plant SAR and will aid in locating new populations. This will in turn aid in the process of environmental impact assessment and in efforts to conserve plant SAR.

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Appendix 1. Checklists for WSA RA and CA.

In the latter part of our surveys for WSA a check list of the most commonly associated plant species was annotated when sites were visited. This process was not followed for much of the earlier sampling. This is unfortunate, as this proved to be an effective quantitative means of assessing sites for their suitability for WSA.

A printout of a list of the 15 most commonly occurring RA and CA species, considered the best “indicators”, was used as a field data sheet. When a site was surveyed species were checked-off as they were identified on the site. This provided a numerical index of the numbers of indicator species present. No formal statistical analyses were conducted on this data, but a “score” for each site visited was amassed by counting the number of indicator species identified.

Of the site visited scores ranged from 2 to 12 for RA species and 0 to 12 for CA species. Highest scores were associated with either known or newly discovered WSA sites. Scores for RA and CA lists were added to produce an overall score which proved insightful. These ranged from 2 to 24, again with known or newly discovered WSA sites having the highest scores. Overall scores near 20 seem to strongly suggest the presences of WSA. At least 2 sites with high scores were found (Sites: Site\_23, 16b and S39E), at which no WSA was identified. Based on our experiences with other sites, it is recommended that these be surveyed more intensively in the future. Data is presented in **Pages 14-15**.

It is unfortunate that this technique was not applied to all our WSA sampling, as it would have provided more quantitative evidence for our estimates of the geographical range of WSA in Manitoba. We would strongly suggest using this technique whenever sites are being assessed for the presence or absence of SAR. In the case of WSA it proved to be a valuable tool to supplement and quantify the habitat present.