Plant Community Classification of the Pakowki Sandhills and Sand Plains

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Executive Summary

The Resource Data Division of Alberta Sustainable Resource Development contracted Geowest Environmental Consultants Ltd. to produce a classification of sand dune and sand plain plant community types within the Grassland Natural Region of Alberta. This initiative is in support of the Alberta Natural Heritage Information Centre (ANHIC). ANHIC collects, evaluates and makes available data on elements of natural biodiversity in Alberta, including flora, fauna and native plant communities. ANHIC develops tracking lists of elements that are considered of high priority because they are considered rare or special in some way. ANHIC's long-term goal is to develop a list of plant community types that occur throughout the province and to attempt to identify community types that require conservation initiatives.

The primary objective of this project was to develop a plant community classification of sand dune and sand plain plant communities of the Grassland Natural Region based on field survey, correlations with other surveys and any available previously-collected data. Furthermore, each identified community type was evaluated and assigned a preliminary provincial rank, based on its rarity/endemism or threats to its condition. This was accomplished by developing a sampling protocol and subsequently collecting field data on plant communities of the sand dune and sand plain landscapes of the Pakowki Sandhills. Furthermore, a comparison of defined plant community types to similar types described in previously conducted field surveys in similar landscapes in Alberta and adjacent provinces and states was completed. A similarity rating based on a scale provided by Corns (1983) was also provided.

This classification will provide a better understanding of plant community biodiversity in Alberta and will contribute to the development of a Canadian National Vegetation Classification (CNVC), the Canadian component of the International Classification of Ecological Communities (ICEC). The ICEC system has been adopted by the United States and it is a national standard for vegetation classification known as the U.S. National Vegetation Classification (USNVC).

An exhaustive literature search was completed, to locate references relating to sand dune and sand plain plant communities in Alberta. Literature related to other jurisdictions was also obtained, primarily for Saskatchewan, Montana, Idaho, Wyoming, North and South Dakota and Nebraska.

Field sampling occurred between July 26th and 30th, 2002 following a review of the sampling strategy with Alberta Sustainable Resource Development staff. In total 40 sampling plots were established, distributed throughout a range of community types and topographic positions. Survey sites were selected based on an initial review of the survey area, using aerial photographs and vegetation trends observed in the field.

Cluster and ordination analyses were performed on the field data resulting in 17 community types based on the hierarchical guidelines documented in the *International Classification of Ecological Communities: Terrestrial Vegetation of the United States: Volume 1 – The National Classification System: Development, Status and Application* (Grossman *et al.* 1998).

Each community type identified from the analysis of the plot data was compared against floristically similar community types described for Alberta and other jurisdictions. A summary of the findings are provided as correlation tables, which compare the Pakowki Sandhills community types against community types described in literature based on Alberta and other jurisdictions, respectively. A similarity rating between the community types, based on Corns (1983) and recently applied by Strong (2002), was also provided in the tables. A discussion of the community types and associated literature was also provided.

All proposed community types were assigned a preliminary provincial ranking. Knowledge gaps were identified and strategies to address these gaps were provided. The information in this report can be used to update the community-tracking list by including new community types. Finally, this report can also be used to decide which community types require further studies and to prioritize these studies.

Acknowledgements

We wish to thank Lorna Allen and Ksenija Vujnovic (Alberta Natural Heritage Information Centre – Alberta Community Development) and Keith Ainsley (Resource Data Division – Alberta Sustainable Resource Development) for assistance throughout this project. The services of Kathy Tannas are also greatly appreciated for identification and verification of plant species. We are also grateful to Erin Anderson for assistance with fieldwork, as well as Dennis O'Leary and Terry Lang (Geowest Environmental Consultants Ltd.) who contributed to the successful completion of this project.

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1.0 Introduction

1.1 Project Purpose and Objectives

The Resource Data Division of Alberta Sustainable Resource Development contracted Geowest Environmental Consultants Ltd. to produce a classification of sand dune and sand plain plant community types within the Grassland Natural Region of Alberta. This initiative is in support of the Alberta Natural Heritage Information Centre (ANHIC). ANHIC collects, evaluates and makes available data on elements of natural biodiversity in Alberta, including flora, fauna and native plant communities. ANHIC develops tracking lists of elements that are considered of high priority because they are rare or special in some way. ANHIC's long-term goal is to develop a list of plant community types that occur throughout the province and to attempt to identify community types that require conservation initiatives.

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This classification will provide a better understanding of plant community biodiversity in Alberta and will contribute to the development of a Canadian National Vegetation Classification (CNVC), the Canadian component of the International Classification of Ecological Communities (ICEC). The ICEC system has been adopted by the United States and it is a national standard for vegetation classification known as the U.S. National Vegetation Classification (USNVC).

1.2 Study Area Description

1.2.1 Climate, landforms and topography

The Pakowki Sandhills study area (Pakowki Sandhills) is located in the Dry Mixedgrass Natural Subregion (Achuff 1994) and is representative of sand dune and sand plain ecosystems of this subregion. The climate of the Dry Mixedgrass Subregion is the warmest and driest in all of Alberta (Table 1). It has a characteristic continental climate with cold winters, warm summers and relatively low precipitation. Total annual precipitation is generally 260-280 mm, the lowest summer precipitation values compared to every other subregion in the province (Alberta Environmental Protection 1997). Winds are often quite high and chinooks are regular events during the winter months.

Table 1. Summary of climatic data for the Dry Mixedgrass Natural Subregion.

Mean Annual Temperature	4 ^{o}C
Mean Summer Temperature	16 ^{o}C
Mean Winter Temperature	-7 ^{o}C
Total Annual Precipitation	260 – 280 mm

The topography of the Pakowki Sandhills is gently rolling with relatively shallow slopes. Dune fields are located in both the northern and southern blocks, comprising approximately 50% of the northern block and 30% of the southern block. Both parabolic and longitudinal dunes with blowouts are present in the area (Shetsen 1987). Dunes consist of fine to medium grained sand and silt and reach depths of up to 7 metres. Hummocky stagnation till and ridged end moraine are also prevalent in the study area, with localized fluvial deposits along Irrigation and Canal creeks.

Elevations range from approximately 860 m at the former Pakowki lakeshore in the southwestern portion of the northern block, to 900 m in the northeastern corner. Elevations in the southern block range from approximately 860 m in the east to 915 m in the southeast.

1.2.2 Disposition and Land-Use

The study area consists of a northern block adjacent to and east of the north end of Pakowki Lake and a southern block directly east of the south end of the lake. The Pakowki Sandhills are Crown land in right of the Province of Alberta, administered by Alberta Sustainable Resource Development. Current land uses consist primarily of cattle grazing on native and non-native pasture with some cultivation on adjacent parcels of privately owned land. There are approximately 10 grazing leaseholders within the Pakowki Sandhills.

2.0 Methods

2.1 Literature Search

An exhaustive literature search was completed to locate references relating to sand dune and sand plain plant communities in Alberta. Literature related to other jurisdictions was also obtained, primarily for Saskatchewan, Montana, Idaho, Wyoming, North and South Dakota and Nebraska. Lorna Allen, of Alberta Community Development, also provided many references.

2.2 Field Sampling

Field sampling occurred between July 26th and 30th, 2002 following a review of the sampling strategy with Alberta Sustainable Resource Development staff. In total 40 sampling plots were established, distributed throughout a range of community types and topographic positions. All survey sites were accessed on foot. Survey sites were selected based on an initial review of the survey area, using aerial photographs and vegetation trends observed in the field. In most instances, a minimum of three plots were established

in each observed community type. This was not possible for certain community types, as their distribution was quite limited.

Vegetation and site description forms (RDB 2002-3 and RDB 2002-1 respectively) were completed at each site. The forms were completed using definitions and guidelines from Alberta Environmental Protection (1994). Percent cover of vascular plant species was visually estimated in each plot, using the relevé method. All dominant, codominant and diagnostic species were recorded. Each grass species encountered was collected for expert identification. Furthermore, unknown species were also collected for identification.

Plots were documented with a 35mm photograph to characterize the structure and composition of the plant community. The location of each survey site was determined using a Trimble GeoExplorer III unit and the locations were recorded on the site description forms. Furthermore, the location of each plot was marked on the aerial photographs. Each plot was located with a pinprick and circled and annotated on the back of the aerial photograph.

2.3 Plant Identification Verification

Each grass species encountered was collected, as were any unknown species. Kathy Tannas, of Eastern Slopes Rangeland Seeds, verified these specimens. The plot forms and digital database were updated, to reflect Ms. Tannas' findings.

2.4 Vegetation Data Analysis and Classification

Vegetation data were entered into an Excel spreadsheet, comprising a matrix of field plot versus plant species abundance. The plant species were identified by stratum, as plant community structure was considered to be important in defining community types. The final database contained 40 plots and 65 species columns. The species columns may include duplicate species names, in cases where one species was found in more than one stratum (e.g. *Elaeagnus commutata* as both a tall and short shrub). However, the different strata were designated by a numeric value following the species code to allow for differentiation. The field data spreadsheet was then imported into PC ORD version 4.20, for classification analysis.

Cluster Analysis

The vegetation classification incorporated all stages of plant succession and was not restricted to potential or predicted climax associations, following Braun-Blanquet (1965). Cluster analysis was used to allow for a more objective classification of sand dune and sand plain communities based on species composition. An hierarchical, agglomerative clustering technique (Farthest Neighbour Analysis) was used to help identify plant community types. This clustering method progressively combines plots/samples from an individual based on their similarity until all samples are in one group (similarity analysis).

Several clustering options available in PC ORD v.4.20 were explored and the group linkage method with the lowest percent chaining (maximum information) was selected for analysis (Farthest Neighbor). The Bray-Curtis (Sorensen) and Relative Sorensen

distance measures were investigated and in combination with the Farthest Neighbor group linkage method, provided the lowest percent chaining values. Other distance measures were explored (Euclidean, Relative Euclidean), however, these measures had higher percent chaining values and seemed to introduce confusion into the clustering results.

Detrended Correspondence Analysis

Detrended correspondence analysis was also investigated to help identify plant community types. Detrended correspondence analysis (DCA) is an indirect gradient analysis/ordination technique that ordinates both species and samples (plots) concurrently (Hill and Gauch 1980). Indirect gradient analysis/ordination obtains axes characterizing major trends of environmental and community variation from calculations based on the sample data (Whittaker 1978). Conversely, direct gradient analysis (DGA) relates species directly to measured environmental factors. DCA therefore does not include analysis of environmental factors (indirect analysis), however, this data is used to help interpret and explain the results.

DCA is based on reciprocal averaging (RA) or correspondence analysis (CA). Its main advantage is that through the detrending process, an 'arch' effect is eliminated that commonly distorts the results of RA and CA. PC-ORD offers several options prior to running the ordination:

- Down-weighting rare species and
- Rescaling of axes.

By down-weighting rare species in DCA, the abundances of species rarer than

Fmax/5

(where Fmax is the frequency of the most common species)

are down weighted in a relative amount to their frequency. Species that are more common than Fmax/5 are not down weighted (McCune and Mefford 1999). This option was selected for the analysis to capture the influence of less prevalent species in the sandhills plant community composition without overly distorting the results.

Another option presented in DCA is the rescaling of axes. Another drawback to CA (aside from the arch effect) is that the axis extremes can be condensed. In particular the distances between samples along an axis may not reflect the actual variation in species composition. This compression of the ends of the gradients is corrected in DCA by *non-linear rescaling*. The non-linear rescaling is based on the average standard deviation of species turnover and follows the original version of DECORANA in multiplying the standard deviations by 100 and shifting the scales such that all scores are positive (McCune and Mefford 1999). This option was selected, using the default values in PCORD v.4.20 to eliminate the compression of species/samples at the extremes of axes.

2.5 Taxonomic Considerations

Plant scientific names used in this report correspond to Moss (1983) and Alberta Environmental Protection (1993). However, there is a discrepancy between these references and those used for the classification of ecological communities used by Natureserve, which follows *A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada* and *Greenland* (Kartesz 1999). A summary of the discrepancies is provided in Table 2.

Table 2. Synonymy of plant species for the Pakowki Sandhills.

Alberta Environmental Protection (1993)	Kartesz (1999) / Natureserve (2002)	Common Name
Agropyron dasystachyum	*Elymus lanceolatus spp. lanceolatus*	Northern wheatgrass
Agropyron sibiricum	*Agropyron fragile*	Sibirian wheatgrass
Agropyron smithii	*Pascopyrum smithii*	western wheatgrass
Carex lanuginosa	*Carex pellita*	Wooly sedge
Coryphantha vivipara	*Escobaria vivipara*	Cushion cactus
Eurotia lanata	*Krascheninnikovia lanata*	Winter fat
Franseria acanthicarpa	*Ambrosia acanthicarpa*	Bur ragweed
Helianthus subrhomboideus	*Helianthus pauciflorus ssp. subrhomboideus*	Rhombic leaved sunflower
Lactuca pulchella	*Lactuca tatarica var. pulchella*	Common blue lettuce
Lygodesmia rostrata	*Shinnersoseris rostrata*	Annual skeletonweed
Oryzopsis hymenoides	*Achnatherum hymenoides*	Indian rice grass
Smilacina stellata	*Maianthemum stellata*	Star-flowered Solomon's seal
Stipa comata	*Hesperostipa comata*	Needle and thread

The primary concern regarding the use of synonymous species names, is when searching Natureserve for ecological communities, using scientific plant names other than those of Kartesz (1999) will yield false results. For example, searching for *Oryzopsis hymenoides* within ecological communities will return no similar plant community types. However, searching for *Achnatherum hymenoides* will return numerous related alliances and associations.

Furthermore, no attempt to standardize species and community names was made when referencing other literature. Many recent reports from the United States describe community types using Kartesz (1999) as the taxonomic reference. As such, community names described in this report may not be completely synonymous with those stated in the literature, although they are referring to the same species. A glossary relating scientific and common plant species names is provided in Appendix 1.

2.6 Cross-referencing of Proposed Community Types to Literature

Based on the review of existing literature and the development of a preliminary classification of sandhill community types, two cross-reference tables were developed. The first table cross-referenced proposed community types with similar community types previously described for Alberta. The second table cross-referenced proposed community types with similar community types identified in other jurisdictions, including Saskatchewan, Montana, Idaho, Wyoming, North and South Dakota and Nebraska. In both tables, the proposed community types are also given a similarity rating to the previously identified community types, based on a scale provided by Corns (1983) and also recently used by Strong (2002). The tables facilitated the identification of similar types as well as the identification of information gaps.

2.7 Community Classification System

Community classification for the Pakowki Sandhills followed the hierarchical guidelines documented in the *International Classification of Ecological Communities: Terrestrial Vegetation of the United States: Volume 1 – The National Classification System: Development, Status and Application* (Grossman *et al.* 1998). The classification system outlined in this publication organizes terrestrial vegetation into five physiognomic and two floristic levels, as shown in Table 3.

Table 3. Hierarchical levels and definitions for the ICEC terrestrial vegetation classification system, adapted from (Grossman *et al.* 1998).

	Hierarchical Level	Definition	Levels or Examples
Physiognomic Levels	**Formation Class**	Formation class is defined based on the vegetation structure of the dominant, uppermost life form	1. Forest/Woodland: Trees with crowns overlapping (25-99% cover) 2. Shrubland: Shrubs generally >0.5 m height forming >25% cover. 3. Dwarf-Shrubland: Shrubs <0.5 m height forming >25% cover. 4. Herbaceous: Graminoids, ferns and forbs dominant. 5. Non-vascular: Bryophytes, lichens and algae dominant. 6. Sparse: Abiotic substrate dominant
	Formation Subclass	Subclass is based on the growth-form characteristics of the dominant life form, predominantly leaf phenology	Evergreen, deciduous, mixed-deciduous for Forest/Woodland, Shrubland and Dwarf-Shrubland Classes. Perennial and Annual for the Herbaceous class. Substrate characteristics (e.g. rock, sand, cobbles, etc.) are used for the Sparse vegetation class.
	Formation Group	Group is defined based on leaf characters, the presence of a woody stratum or topographic position.	Broad leaf or needle leaf used for Forest/Woodland, Shrubland and Dwarf-Shrubland classes. Presence of a woody stratum separates groups in Herbaceous and Non-vascular classes. Sparse vegetation communities are separated based on topographic position (e.g. shore, cliffs, dunes, etc).
	Formation Subgroup	Subgroup is defined based on the level of anthropogenic disturbance.	All groups divide each community type into a Natural/Near Natural, Semi-Natural or Planted/Cultivated subgroup.
	Formation	Formations represent vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, landscape positions or hydrological regimes.	e.g. Temperate or sub-polar deciduous shrubland
Floristic Levels	**Alliance**	Alliance is a physiognomically uniform groups of plant associations sharing one or more diagnostic species, which as a rule are found in the uppermost stratum of the vegetation	e.g. *Populus tremuloides – Picea glauca / Linnea borealis* Forest Alliance e.g. *Carex utriculata* Herbaceous Alliance
	Association	Association is the lowest level of the hierarchy and is defined as a plant community type of definite floristic composition, uniform habitat conditions and uniform physiognomy.	Nomenclature is based on the diagnostic species. Species occurring in the uppermost stratum are listed first (separated by a hyphen if in the same stratum or a slash if in a different strata) followed successively by those occurring in lower levels. Within the same stratum, the order of species names generally reflects decreasing levels of dominance or constancy.

2.8 Evaluation and Assignment of Preliminary Provincial Ranking

Each community type was evaluated and assigned a preliminary provincial ranking. The ranking system used is based on The Nature Conservancy's species ranking system (Grossman *et al.* 1994), as used by ANHIC (Allen 2002). The two primary criteria for

developing community ranks are the total number of occurrences and the total area of each community, range-wide. Measures of geographic range, trends in status and immediate threats to the community's persistence are also considered in ranking. Preliminary ranks range from S1 (rare) to S5 (wide-spread) and are defined in Table 4.

Table 4. Provincial conservation ranks and definitions (adapted from Allen 2002).

Preliminary Rank*	Criteria
G1(S1)	Five or fewer occurrences or very few remaining hectares
G2(S2)	Six to 20 occurrences or few remaining hectares
G3(S3)	21 to 100 occurrences. May be rare and local throughout its range or found locally, even abundantly, in a restricted range (e.g. a single western province or physiographic region in the East)
G4(S4)	Apparently secure globally (State / Province wide), though it may be quite rare in parts of its range, especially at the periphery.
G5(S5)	Demonstrably secure globally (State / Province wide) thought it might be quite rare in parts of its range, especially at the periphery.
GU(SU)	Status is uncertain
GH(SH)	Historic. Presumed eliminated in the province with little or no likelihood that it will be rediscovered. There may be the potential for restoration.
GX(SX)	Believed to be eliminated throughout its range, with virtually no likelihood that it will be rediscovered (e.g. American Chestnut Forest)
GP(SP)	Potentially exists. Further documentation needed.
G?(S?)	Element is not yet ranked.
MODIFIERS	
Q	Can be added to any global rank to denote questionable taxonomy (e.g. G2Q= 6 to 20 known occurrences but questions exist concerning the classification of this type).
?	Can be added to any rank to denote an inexact numeric rank (e.g. G1? = Believed to be 5 or less occurrences but some doubt still exists concerning status).
*Ranks can be combined to indicate a range (e.g. G2G3 = May be between 6 to 100 occurrences throughout range but the exact status is uncertain). Combined ranks indicate a larger margin of error than ranks assigned a "?" qualifier.	

Where information was available, plant communities from the Pakowki Sandhills were compared with any similar communities found within the subregion, in other regions of the province, or from other provinces or states.

3.0 Results and Discussion

3.1 Vegetation Data Analysis and Classification

Results from the agglomerative clustering methods were examined to determine the ecological meaning of the clusters and interpret the community types (Figure 1). Examination of the resulting dendrogram revealed numerous small groups. Several community types were consistently clustered together, particularly:

- Plots with high *Prunus virginiana* cover (plots 10, 13, 14 and 34)
- Plots with high *Rosa woodsii* cover (and little grass cover) (plots 5, 16 and 26)
- Plots with high *Salix amygdaloides* - *Rosa woodsii* cover (plots 27 and 28)
- Plots with high *Salix exigua / Glycyrrhiza lepidota* cover (plots 2 and 7)
- Plots with high *Elaeagnus commutata* cover (plots 11, 18 and 32)
- Plots with high *Rumex venosus* cover (plots 6 and 30)

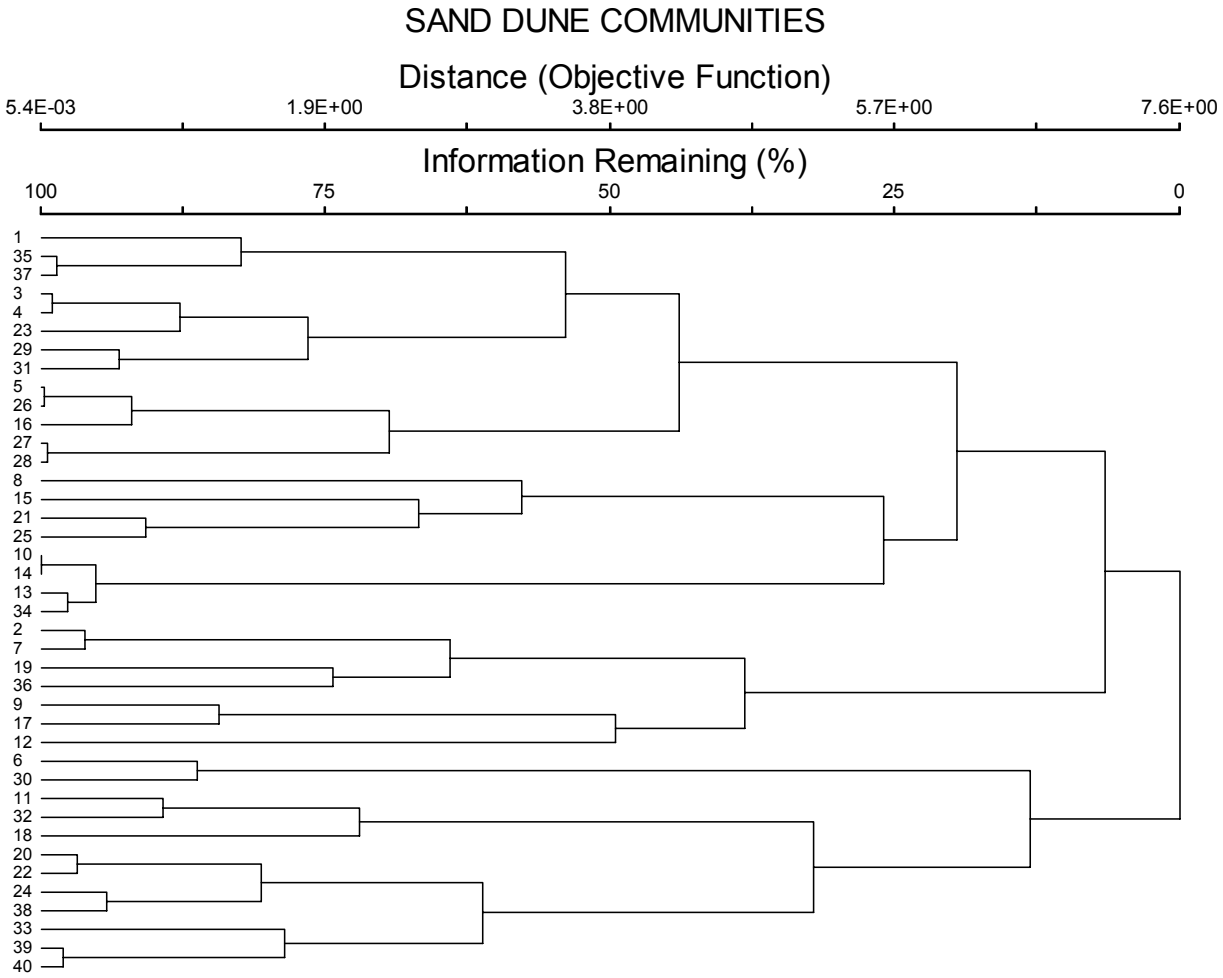

Figure 1. Cluster analysis of 40 plots collected July 2002. Linkage method: Farthest Neighbour. Distance Measure: Bray-Curtis (Sorensen). Percent Chaining=2.82%.

However, other community types, particularly grass and forb-dominated communities could not be easily discerned based on the cluster analysis alone.

Detrended correspondence analysis (DCA) helped to group plots with similar species compositions and also confirmed some of the community types observed from the grouping of plots in the cluster analysis. Approximately 17 groups were recognized based on the ordination of plots and species, with several 'groups' comprising only one sample plot as shown in Figure 2 and Figure 3. Output from the PC-ORD DCA is provided in Appendix 2.

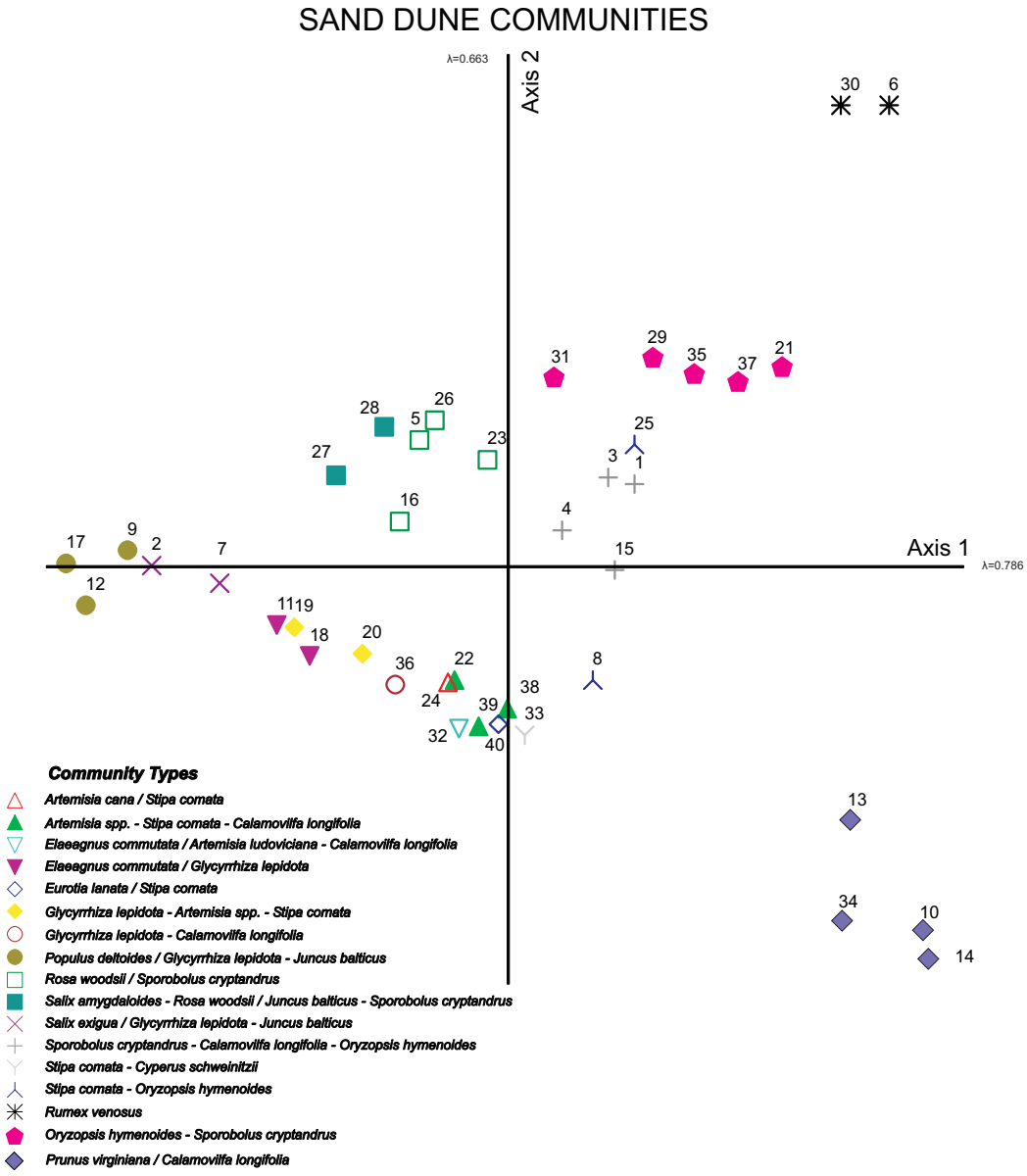

Figure 2. Ordination diagram based on Detrended Correspondence Analysis (DCA) of 40 plots collected in July 2002. Total variance in the species data (inertia) = 6.2854. Eigenvector 1 = 0.786 or 12.5% of the total variance in the species data. Eigenvector 2 = 0.663 or 10.54% of the total variance in the species data.

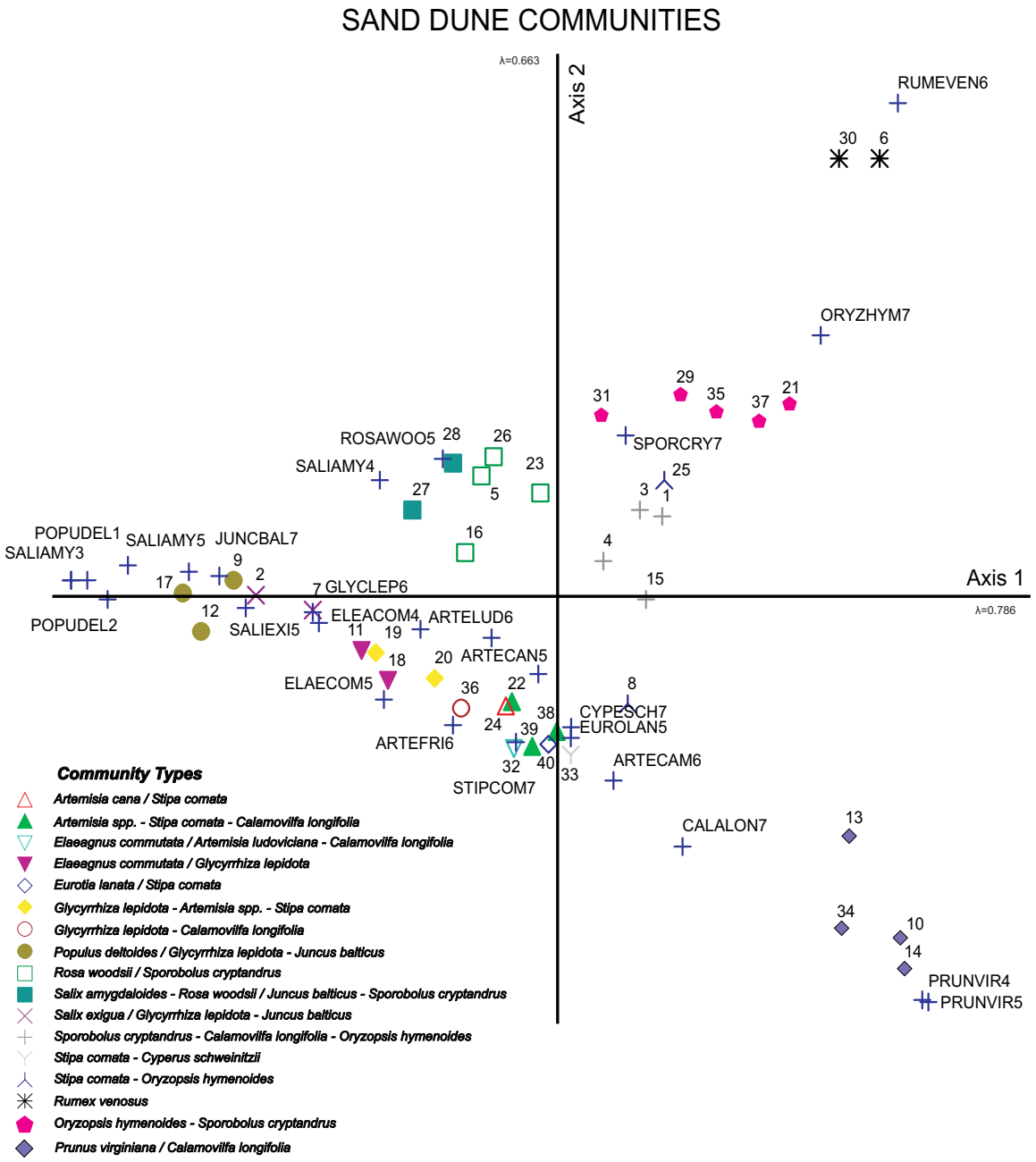

Figure 3. Biplot based on Detrended Correspondence Analysis (DCA) of sample plots (40) and plant species (65) collected at the Pakowki Sandhills in July 2002.

Data were summarized for the resulting community types, including mean percent cover of plant species and surface substrates, standard deviation and standard error and species prominence. This information is presented in section 3.2.1.

3.2 Preliminary Classification of Community Types

A total of 17 plant communities (associations) were found to occur in the Pakowki Sandhills. The majority of communities were ranked SU or S2S3. Community types included all classes, except Non-Vascular and are presented in Table 5 by major physiognomic level.

Table 5. Plant community types (associations) found in the Pakowki Sandhills.

Terrestrial	Associations
Forest/Woodland	
Deciduous Forest/Woodland	
Cold Deciduous Forest/Woodland	
Natural / Near Natural	
Temperate or subpolar cold deciduous forest/woodland	
Populus deltoides Forest/Woodland Alliance	*Populus deltoides / Glycyrrhiza lepidota - Juncus balticus*
Shrubland	
Deciduous Shrubland	
Cold Deciduous Shrubland	
Natural / Near Natural	
Temperate cold deciduous shrubland	
Rosa woodsii Shrubland Alliance	*Rosa woodsii / Sporobolus cryptandrus*
Salix amygdaloides Shrubland Alliance	*Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus*
Elaeagnus commutata Shrubland Alliance	*Elaeagnus commutata / Glycyrrhiza lepidota*
Elaeagnus commutata Shrubland Alliance	*Elaeagnus commutata / Artemisia ludoviciana - Calamovilfa longifolia*
Prunus virginiana Shrubland Alliance	*Prunus virginiana / Calamovilfa longifolia*
Dwarf shrubland	
Evergreen dwarf shrubland	
Extremely xeromorphic evergreen dwarf shrubland	
Natural / Near Natural	
Extremely xeromorphic evergreen subdesert dwarf-shrubland	
Eurotia lanata Dwarf-Shrubland Alliance	*Eurotia lanata / Stipa comata – Calamovilfa longifolia*
Herbaceous Vegetation	
Perennial forb vegetation	
Temperate or subpolar perennial forb	
Natural / Near Natural	
Low temperate or subpolar perennial forb	
Glycyrrhiza lepidota Herbaceous Alliance	*Salix exigua / Glycyrrhiza lepidota - Juncus balticus*
Glycyrrhiza lepidota Herbaceous Alliance	*Glycyrrhiza lepidota - Calamovilfa longifolia*
Glycyrrhiza lepidota – Artemisia spp. Herbaceous Alliance	*Glycyrrhiza lepidota – Artemisia spp. - Stipa comata*
Rumex venosus Herbaceous Alliance	*Rumex venosus*
Herbaceous Vegetation	
Perennial Graminoid Vegetation	
Temperate or sub-polar grasslands	
Natural / Near Natural	
Medium-tall bunch temperate or sub-polar grasslands	
Oryzopsis hymenoides Herbaceous Alliance	*Oryzopsis hymenoides – Sporobolus cryptandrus*
Stipa comata Bunch Herbaceous Alliance	*Stipa comata - Oryzopsis hymenoides*

Table 5 (cont.). Plant community types (associations) found in the Pakowki Sandhills.

Terrestrial	Associations
Herbaceous Vegetation	
Perennial Graminoid Vegetation	
Temperate or sub-polar grasslands	
Natural / Near Natural	
Medium-tall sod temperate or sub-polar grasslands	
Stipa comata Bunch Herbaceous Alliance	*Artemisia spp.* **-** *Stipa comata – Calamovilfa longifolia*
Herbaceous Vegetation	
Perennial Graminoid Vegetation	
Temperate or sub-polar grasslands	
Natural / Near Natural	
Tall sod temperate or sub-polar grasslands	
Calamovilfa longifolia Herbaceous Alliance	*Stipa comata – Calamovilfa longifolia – Cyperus schweinitzii*
Herbaceous Vegetation	
Perennial graminoid vegetation	
Temperate or subpolar grassland with a sparse shrub layer	
Natural / Near Natural	
Medium-tall temperate or subpolar grassland	
Sporobolus cryptandrus Herbaceous Alliance	*Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides*
Herbaceous Vegetation	
Perennial graminoid vegetation	
Temperate or subpolar grassland with a sparse shrub layer	
Natural / Near Natural	
Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer	
Artemisia cana Shrub Herbaceous Alliance	*Artemisia cana / Stipa comata*

3.2.1 Description of Community Types

A summary of the 17 community types (associations) found in the Pakowki Sandhills is described below. Representative photos for each community type are provided as Plates 1 – 17. A full listing of species codes is provided in Appendix 3. Table 6 provides an explanation of strata codes, which follow the seven-letter species code.

Table 6. Numeric codes used to define different vegetation structural strata.

Code	Stratum
1	Main Canopy Trees
2	Understorey Trees
3	Tall Shrubs
4	Medium Shrubs
5	Low Shrubs
6	Forbs / Herbs
7	Grasses

3.2.1.1 *Populus deltoides / Glycyrrhiza lepidota - Juncus balticus Association*

Western cottonwood / wild licorice – wire rush

Plate 1. *Populus deltoides / Glycyrrhiza lepidota – Juncus balticus* community type (Western cottonwood / wild licorice – wire rush) Plot 17.

This community was dominated by *Populus deltoides*, but occurred in association with *Populus tremuloides* or *Salix amygdaloides*, in tree form. Understorey shrubs such as *Rosa woodsii, Salix exigua* and *Elaeagnus commutata* were occasionally present, though they typically did not exceed more than 5 % cover. *Glycyrrhiza lepidota* was present at all sites and ranged in cover between 2 % and 20 % cover. *Thermopsis rhombifolia, Chenopodium fremontii, C. pratericola, Artemisia ludoviciana* and *Solidago missouriensis* were also typical forb species. *Juncus balticus* was the dominant graminoid species, although *Poa pratensis* and *Bouteloua gracilis* were also commonly present. Table 7 summarizes the species composition, mean percent cover, standard error and species prominence for this community type. Species prominence was calculated using the following formula:

$$\text{mean \% cover} \times \sqrt{\text{\% presence}}$$

Table 7. Summary statistics for the *Populus deltoides / Glycyrrhiza lepidota - Juncus balticus* community type (n = 3).

Species	Mean % Cover	Standard Error	Presence	Prominence
POPUDEL2	23.33	23.33	1	40.4
POPUDEL1	36.67	17.64	3	36.7
POPUTRE2	13.33	13.33	1	23.1
SALIAMY3	8.33	8.33	1	14.4
GLYCLEP6	12.33	5.36	3	12.3
JUNCBAL7	11.67	4.41	3	11.7
CHENPRA6	2.67	1.20	3	2.7
THERRHO6	2.00	1.53	2	2.4
POAPRA7	2.00	1.53	2	2.4
CHENFRE6	1.67	0.33	3	1.7
DESCSOP6	1.00	0.50	3	1.0
ROSAWOO5	0.67	0.33	2	0.8
SOLIMIS6	0.67	0.17	3	0.7
ARTELUD6	0.50	0.29	2	0.6
ELAECOM5	0.33	0.33	1	0.6
BOUTGRA7	0.33	0.33	1	0.6
TARAOFF6	0.33	0.17	2	0.4
CRYPFEN6	0.33	0.17	2	0.4
SALIEXI5	0.17	0.17	1	0.3
CLEOSER6	0.17	0.17	1	0.3
HELISUB6	0.17	0.17	1	0.3
EQUIHYE6	0.17	0.17	1	0.3
TRAGDUB6	0.17	0.17	1	0.3
CHENSUB6	0.17	0.17	1	0.3
SMILSTE6	0.17	0.17	1	0.3
SOLICAN6	0.17	0.17	1	0.3
HETEVIL6	0.17	0.17	1	0.3
ELYMCAN7	0.17	0.17	1	0.3
DECAY9	0.50	0.00		
MINERAL9	11.67	4.41		
ORG9	50.00	5.77		

This community was found in localized depressions between dunes and in more open sand plain areas. Soils were sandy, but with some organic matter buildup on the soil surface. A summary of site data is provided in Table 8.

Table 8. Summary of site data for the *Populus deltoides / Glycyrrhiza lepidota - Juncus balticus* community type.

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
9	870	n/a	0	Rapid	Level	Straight	Submesic	Mesotrophic
12	863	n/a	0	Rapid	Level	Straight	Subxeric	Submesotrophic
17	864	n/a	0	Rapid	Level	Straight	Subxeric	Submesotrophic

This community was typically well used by both livestock and wild ungulates, with many pellet groups observed.

3.2.1.2 *Rosa woodsii / Sporobolus cryptandrus* Association

Common wild rose / sand dropseed

Plate 2. *Rosa woodsii / Sporobolus cryptandrus* community type (Common wild rose / sand dropseed) Plot 16.

This community was dominated by *Rosa woodsii* in the shrub layer, although other species such as *Ribes oxyacanthoides* and *Salix exigua* were also present. *Glycyrrhiza lepidota* was the dominant forb species with a cover ranging up to 30 %. Other typical forb species included *Chenopodium pratericola, C. fremontii* and *Heterotheca villosa*. *Sporobolus cryptandrus* was the dominant graminoid species, although *Calamovilfa longifolia* was quite common, while *Oryzopsis hymenoides* was occasionally present. Table 9 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 9. Summary statistics for the *Rosa woodsii / Sporobolus cryptandrus* community type (n = 4).

Species	Mean % Cover	Standard Error	Presence	Prominence
ROSAWOO5	42.50	12.08	4	42.5
SPORCRY7	12.50	4.08	4	12.5
GLYCLEP6	7.75	7.01	3	8.9
RIBEOXY5	2.50	2.50	1	5.0
ARTELUD6	2.50	2.50	1	5.0
CALALON7	3.00	2.38	2	4.2
THERRHO6	0.50	0.50	1	1.0
CHENPRA6	0.75	0.35	4	0.8
SOLIMIS6	0.50	0.29	2	0.7
HELIANN6	0.38	0.24	2	0.5
ORYZHYM7	0.38	0.24	2	0.5
PRUNVIR5	0.25	0.25	1	0.5
AGRODAS7	0.25	0.25	1	0.5
AGROSIB7	0.25	0.25	1	0.5
CARELAN7	0.25	0.25	1	0.5
HETEVIL6	0.38	0.00	4	0.4
SALIEXI5	0.25	0.48	2	0.4
LYGOROS6	0.25	0.14	2	0.4
CHENFRE6	0.25	0.13	3	0.3
CORYVIV6	0.13	0.13	1	0.3
LATUPUL6	0.13	0.13	1	0.3
ELYMCAN7	0.13	0.13	1	0.3
CHENSUB6	0.13	0.14	2	0.2
RUMEVEN6	0.13	0.14	2	0.2
MINERAL9	17.50	5.95		
ORG9	17.63	8.45		

This community was typically found on the north to southeast, leeward slopes of partially stabilized dunes. Soils were sandy, with some organic matter buildup on the soil surface and some exposed sand. A summary of site data is provided in Table 10.

Table 10. Summary of site data for the *Rosa woodsii / Sporobolus cryptandrus* community type (n = 4).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
5	898	104	45	Rapid	Upper Slope	Straight	Xeric	Submesotrophic
16	866	5	18	Rapid	Middle Slope	Straight	Subxeric	Submesotrophic
23	886	158	10	Rapid	Middle Slope	Straight	Xeric	Submesotrophic
26	883	35	15	Rapid	Upper Slope	Straight	Subxeric	Submesotrophic

3.2.1.3 *Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus* Association

Peach-leaf willow – common wild rose / wire rush – sand dropseed

Plate 3. *Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus* (Peach-leaf willow – common wild rose / wire rush – sand dropseed) Plot 27.

This community was co-dominated by *Salix amygdaloides* and *Rosa woodsii* in the shrub layer. *Juncus balticus* and *Sporobolus cryptandrus* were the dominant graminoids, although *Glycyrrhiza lepidota* and *Thermopsis rhombifolia* constituted a substantial forb cover at certain sites. Other typical species, though with low percent cover, included *Prunus virginiana, Chenopodium pratericola* and *C. fremontii*. Table 11 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 11. Summary statistics for the *Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus* community type (n = 2).

Species	Mean % Cover	Standard Error	Presence	Prominence
SALIAMY4	40.00	10.00	2	40.0
ROSAWOO5	40.00	0.00	2	40.0
GLYCLEP6	22.50	22.50	1	31.8
SPORCRY7	25.00	0.00	2	25.0
THERRHO6	22.50	2.50	2	22.5
JUNCBAL7	15.00	0.00	2	15.0
PRUNVIR5	1.00	0.00	2	1.0
CHENPRA6	1.00	0.00	2	1.0
CHENFRE6	1.00	0.00	2	1.0
SOLIMIS6	0.50	0.50	1	0.7
AGROSIB7	0.50	0.50	1	0.7
POAPRA7	0.50	0.50	1	0.7
ELYMCAN7	0.50	0.50	1	0.7
DESCSOP6	0.50	0.00	2	0.5
TRAGDUB6	0.25	0.25	1	0.4
HETEVIL6	0.25	0.25	1	0.4
AGRODAS7	0.25	0.25	1	0.4
DECAY9	7.50	2.50		
MINERAL9	12.50	2.50		

This community was found in relatively level sand plain sites, with rapidly to well drained sandy soils. Organic matter buildup on the soil surface was commonly greater than 30% cover, though exposed sand was still at the soil surface. A summary of site data is provided in Table 12.

Table 12. Summary of site data for the *Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus* community type (n = 2).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
27	875	n/a	0	Well	Level	Straight	Subxeric	Submesotrophic
28	874	n/a	0	Rapid	Level	Straight	Xeric	Submesotrophic

3.2.1.4 *Elaeagnus commutata / Glycyrrhiza lepidota* Association

Silverberry / wild licorice

Plate 4. *Elaeagnus commutata / Glycyrrhiza lepidota* community type (Silverberry / wild licorice) Plot 18.

This community was dominated by *Elaeagnus commutata* in the mid-shrub-layer. *Glycyrrhiza lepidota* was the dominant forb, averaging about 15% cover. Other typical forbs that may have a low percent cover included: *Artemisia ludoviciana, Thermopsis rhombifolia, Cryptantha fendleri* and *Chenopodium pratericola*. *Juncus balticus* was the dominant graminoid species, although other species such as *Stipa comata, Koeleria macratha* and *Agropyron dasystachyum* also occurred. Table 13 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 13. Summary statistics for the *Elaeagnus commutata / Glycyrrhiza lepidota* community type (n = 2).

Species	Mean % Cover	Standard Error	Presence	Prominence
ELAECOM5	50.00	15.00	2	50.0
GLYCLEP6	15.00	10.00	2	15.0
SALIEXI5	10.00	10.00	1	14.1
JUNCBAL7	10.00	10.00	1	14.1
ELEACOM4	2.50	2.50	1	3.5
ARTELUD6	2.50	2.50	1	3.5
STIPCOM7	2.75	2.25	2	2.8
THERRHO6	1.50	1.50	1	2.1
POAPRA7	1.50	1.50	1	2.1
PRUNVIR5	1.00	1.00	1	1.4
SOLIMIS6	1.00	1.00	1	1.4
LYGOROS6	1.00	1.00	1	1.4
CYPESCH7	1.00	1.00	1	1.4
SPORCRY7	1.00	1.00	1	1.4
CALALON7	1.00	1.00	1	1.4
KOELMAC7	1.25	0.75	2	1.3
AGRODAS7	1.25	0.75	2	1.3
CRYPFEN6	0.75	0.25	2	0.8
HETEVIL6	0.75	0.25	2	0.8
ROSAWOO5	0.50	0.50	1	0.7
CHENPRA6	0.50	0.00	2	0.5
CHENFRE6	0.25	0.25	1	0.4
HELIANN6	0.25	0.25	1	0.4
DECAY9	0.25	0.25		
MINERAL9	15.00	5.00		
ORG9	20.00	10.00		

This community types was found in depressional locations on the windward side of dunes, with well-drained soils. Surface organic matter ranged from 10 % to 30 %, with only 10 % to 20% exposed sand at the soil surface. A summary of site data is provided in Table 14.

Table 14. Summary of site data for the *Elaeagnus commutata / Glycyrrhiza lepidota* community type (n = 2).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
11	864	n/a	0	Well	Depression	Straight	Subxeric	Mesotrophic
18	863	n/a	0	Well	Depression	Concave	Subxeric	Submesotrophic

3.2.1.5 *Elaeagnus commutata / Artemisia ludoviciana - Calamovilfa longifolia* Association

Silverberry / prairie sagewort – sand grass

Plate 5. *Elaeagnus commutata / Artemisia ludoviciana – Calamovilfa longifolia* (Silverberry / prairie sagewort – sand grass) Plot 32.

This community type was dominated by *Elaeagnus commutata* in the mid-shrub layer. *Calamovilfa longifolia* was the dominant graminoid, with a cover in this plot of 25 %. Other graminoid species included *Stipa comata, Cyperus schweinitzii, Sporobolus cryptandrus, Koeleria macrantha* and *Agropyron dasystachyum* generally with covers of less than 1%. *Artemisia ludoviciana* was the dominant forb with about 5 % cover, although other species also occur including *Solidago missouriensis* and *Heterotheca villosa*. Table 15 summarizes the species composition and percent cover for this community type

Table 15. Summary statistics for the *Elaeagnus commutata / Artemisia ludoviciana / Calamovilfa longifolia* community type (n = 1).

Species	Percent Cover
ELAECOM5	40
CALALON7	25
ARTELUD6	5
STIPCOM7	5
PRUNVIR5	1
SOLIMIS6	1
HETEVIL6	1
CYPESCH7	1
SPORCRY7	1
CRYPFEN6	0.5

Species	Percent Cover
CHENPRA6	0.5
CHENFRE6	0.5
LYGOROS6	0.5
OPUNPOL6	0.5
HELIANN6	0.5
KOELMAC7	0.5
AGRODAS7	0.5
DECAY9	0.5
MINERAL9	10
ORG9	5

This community type was found in a small downslope-trending depression or gully on the windward side of a dune. The dune appeared to be quite stabilized with a high vegetative cover. The soil was rapidly drained and the site had a concave surface shape. A summary of site data is provided in Table 16.

Table 16. Summary of site data for the *Elaeagnus commutata / Artemisia ludoviciana - Calamovilfa longifolia* community type (n = 1).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
32	879	281	10	Rapid	Lower Slope	Concave	Subxeric	Submesotrophic

3.2.1.6 *Prunus virginiana / Calamovilfa longifolia* Association

Choke cherry / sand grass

Plate 6. *Prunus virginiana / Calamovilfa longifolia* community type (Chokecherry / sand grass) Plot 14.

This community type was dominated by *Prunus virginiana* in the mid- and low-shrub strata. Mean percent cover for this species was greater than 60% and it formed dense thickets that were impossible to walk through. *Calamovilfa longifolia* was the dominant graminoid species. *Oryzopsis hymenoides* was also present at every sample location although with a low percent cover. *Sporobolus cryptandrus* was also commonly found, although generally with a mean percent cover of less than 3 %. Total graminoid cover was typically between 5-10 %. Common forbs included *Helianthus annuus, Lygodesmia rostrata*, *Heterotheca villosa* and *Cryptantha fendleri*. Although these species were present at most sample plot locations, their total percent cover was relatively low. Table 17 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 17. Summary statistics for the *Prunus virginiana / Calamovilfa longifolia* community type (n = 4).

Species	Mean % Cover	Standard Error	Presence	Prominence
PRUNVIR5	63.75	8.26	4	63.8
CALALON7	4.25	2.14	4	4.3
PRUNVIR4	2.00	1.22	2	2.8
SPORCRY7	2.25	1.60	3	2.6
HELIANN6	1.75	1.09	4	1.8
ORYZHYM7	1.75	0.48	4	1.8
RUMEVEN6	1.00	0.58	2	1.4
STIPCOM7	1.00	0.71	2	1.4
ARTELUD6	0.50	0.50	1	1.0
LYGOROS6	0.63	0.24	3	0.7
CHENPRA6	0.50	0.29	2	0.7
HETEVIL6	0.63	0.13	4	0.6
AGRODAS7	0.38	0.24	2	0.5
CHENFRE6	0.25	0.25	1	0.5
CRYPFEN6	0.38	0.13	3	0.4
ROSAWOO5	0.13	0.13	1	0.3
SOLIMIS6	0.13	0.13	1	0.3
ARTECAM	0.13	0.13	1	0.3
SALSKAL6	0.13	0.13	1	0.3
EQUIHYE6	0.13	0.13	1	0.3
CHENSUB6	0.13	0.13	1	0.3
DESCSOP6	0.13	0.13	1	0.3
ARTEFRI6	0.13	0.13	1	0.3
OPUNPOL6	0.13	0.13	1	0.3
FRANACA6	0.13	0.13	1	0.3
ELYMCAN7	0.13	0.13	1	0.3
DECAY9	3.88	3.71		
MINERAL9	46.25	5.54		
ORG9	6.00	2.31		

This community was consistently found on upper slope or crest topographic positions on dunes, with very rapid to rapid drainage. Slopes were strong, ranging from a minimum of 25 % to 75 % and generally had a south to southwesterly aspect. Little organic matter was present on the soil surface, typically with up to 40 % exposed sand.

A summary of site data is provided in Table 18.

Table 18. Summary of site data for the *Prunus virginiana / Calamovilfa longifolia* community type (n = 4).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
10	874	228	55	Very Rapid	Crest	Straight	Xeric	Submesotrophic
13	876	239	75	Very Rapid	Upper Slope	Straight	Xeric	Submesotrophic
14	876	6	25	Rapid	Upper Slope	Straight	Xeric	Submesotrophic
34	891	199	25	Rapid	Crest	Convex	Xeric	Submesotrophic

3.2.1.7 *Eurotia lanata / Stipa comata - Calamovilfa longifolia* Association

Winter fat / needle and thread – sand grass

Plate 7. *Eurotia lanata / Stipa comata – Calamovilfa longifolia* community type (Winterfat / needle and thread – sand grass) Plot 40.

This community type was dominated by *Stipa comata* with a low shrub layer composed of *Eurotia lanata* and *Rosa woodsii. Stipa comata* constituted 60 % cover, with *Eurotia lanata* providing 20 % cover. *Calamovilfa longifolia* contributed approximately 15% cover. Forbs provided less than 10% cover and typical forbs included *Opuntia polycantha, Chenopodium pratericola, Artemisia frigida* and *Heterotheca villosa.* The community was extensive with localized dense clumps of *Eurotia lanata* scattered throughout the *Stipa comata,* which formed pure localized grasslands. Table 19 summarizes the species composition and mean percent cover for this community type.

Table 19. Summary statistics for the *Eurotia lanata / Stipa comata* community type (n = 1).

Species	Percent Cover
STIPCOM7	60
EUROLAN5	20
CALALON7	15
ROSAWOO5	5
OPUNPOL6	2
CHENPRA6	1
ARTEFRI6	1
HETEVIL6	1
EQUIHYE6	0.5
ARTELUD6	0.5
CRYPFEN6	0.5
CHENSUB6	0.5
MINERAL9	10
ORG9	40

This community was found mid-slope on an elevated dune flank, which graded into a level plain to the east. The soils were rapidly drained with a straight surface shape. A summary of site data is provided in Table 20.

Table 20. Summary of site data for the *Eurotia lanata / Stipa comata* community type (n = 1).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
40	866	n/a	0	Rapid	Level	Straight	Xeric	Submesotrophic

3.2.1.8 *Salix exigua / Glycyrrhiza lepidota - Juncus balticus Association*

Sandbar willow / wild licorice – wire rush

Plate 8. *Salix exigua / Glycyrrhiza lepidota – Juncus balticus* community type (Sandbar willow / wild licorice – wire rush) Plot 7.

This community type was co-dominated by *Glycyrrhiza lepidota* in the forb layer and *Juncus balticus* in the graminoid layer. *Salix exigua* was the dominant shrub, with a cover ranging from 7 to 20 %. Other prevalent species included *Carex lanuginosa* and *Poa pratensis* in the graminoid layer and *Solidago missouriensis* in the forb layer. However, these species each typically had a cover of less than 3 %. Table 21 summarizes the species composition, mean percent cover and standard error and species prominence for this community type.

Table 21. Summary statistics for the *Salix exigua / Glycyrrhiza lepidota - Juncus balticus* community type (n = 2).

Species	Mean % Cover	Standard Error	Presence	Prominence
GLYCLEP6	45.00	5.00	2	45.0
JUNCBAL7	42.50	17.50	2	42.5
SALIEXI5	13.50	6.50	2	13.5
ARTEFRI6	2.50	2.50	1	3.5
SOLIMIS6	1.50	0.50	2	1.5
SALIAMY5	1.00	1.00	1	1.4
CHENSUB6	1.00	1.00	1	1.4
HELIANN6	1.00	1.00	1	1.4
CARELAN7	0.75	0.25	2	0.8
POAPRA7	0.75	0.25	2	0.8
SOLICAN6	0.50	0.50	1	0.7
DESCSOP6	0.25	0.25	1	0.4
SMILSTE6	0.25	0.25	1	0.4
CHENFRE6	0.25	0.25	1	0.4
OENONUT6	0.25	0.25	1	0.4
HETEVIL6	0.25	0.25	1	0.4
ANTIMIC6	0.25	0.25	1	0.4
LATUPUL6	0.25	0.25	1	0.4
AGRODAS7	0.25	0.25	1	0.4
ELYMCAN7	0.25	0.25	1	0.4
SPORCRY7	0.25	0.25	1	0.4
CALALON7	0.25	0.25	1	0.4
MINERAL9	2.00	0.00		

This community type was most commonly found in concave, well-drained depressions between sand dunes. The soil moisture regime ranged from subxeric to submesic. A summary of site data is provided in Table 22.

Table 22. Summary of site data for the *Salix exigua / Glycyrrhiza lepidota - Juncus balticus* community type (n = 2).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
2	879	n/a	0	Well	Depression	Concave	Submesic	Submesotrophic
7	862	n/a	0	Well	Depression	Concave	Subxeric	Mesotrophic

3.2.1.9 *Glycyrrhiza lepidota - Calamovilfa longifolia* Association

Wild licorice – sand grass

Plate 9. *Glycyrrhiza lepidota – Calamovilfa longifolia* community type (Wild licorice – sand grass) Plot 36.

This community type was dominated by *Glycyrrhiza lepidota* in the forb stratum and *Calamovilfa longifolia* in the grass stratum. Where this community was surveyed, *Glycyrrhiza lepidota* had a cover 60 %. A sparse shrub layer was present, which included *Prunus virginiana* and *Rosa woodsii* with a cover of less than 10 %. Several forbs were present including *Artemisia ludoviciana, A. frigida* and *Chenopodium pratericola,* among others. *Stipa comata, Juncus balticus* and *Agropyron dasystachyum* were also present, but with a total cover of less than 10 %. Table 23 summarizes the species composition and percent cover for this community type.

Table 23. Summary statistics for the *Glycyrrhiza lepidota - Calamovilfa longifolia* community type (n = 1).

Species	Percent Cover
GLYCLEP6	60
CALALON7	25
STIPCOM7	7
PRUNVIR5	5
ARTELUD6	2
ROSAWOO5	1
CHENPRA6	1
ARTEFRI6	1
HETEVIL6	1
JUNCBAL7	1

Species	Percent Cover
CORYVIV6	0.5
EQUIHYE6	0.5
CRYPFEN6	0.5
CHENSUB6	0.5
DESCSOP6	0.5
CHENFRE6	0.5
OPUNPOL6	0.5
CERAARV6	0.5
AGRODAS7	0.5
MINERAL9	5
ORG9	10

This community type was found in a small inter-dune depression with well-drained soils. A summary of site data is provided in Table 24.

Table 24. Summary of site data for the *Glycyrrhiza lepidota - Calamovilfa longifolia* community type (n = 1).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
36	893	n/a	0	Well	Depression	Concave	Subxeric	Submesotrophic

3.2.1.10 *Glycyrrhiza lepidota – Artemisia spp. - Stipa comata* Association

Wild licorice – sage – needle and thread

Plate 10. *Glycyrrhiza lepidota – Artemisia* spp. – *Stipa comata* community type (Wild licorice – sage – needle and thread) Plot 19.

This community type was co-dominated by *Glycyrrhiza lepidota* in the forb stratum and *Stipa comata* in the graminoid stratum. Several species of *Artemisia* were also common, including *Artemisia ludoviciana* and *A. frigida*. Other common species with lower percent covers included *Heterotheca villosa, Chenopodium pratericola* and *Tragopogon dubius* in the forb layer and *Juncus balticus* in the graminoid layer. Table 25 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 25. Summary statistics for the *Glycyrrhiza lepidota - Artemisia spp. - Stipa comata* community type (n = 2).

Species	Mean % Cover	Standard Error	Presence	Prominence
GLYCLEP6	32.50	7.50	2	32.5
STIPCOM7	25.00	15.00	2	25.0
ARTELUD6	13.00	12.00	2	13.0
JUNCBAL7	5.00	5.00	1	7.1
HETEVIL6	2.50	2.50	1	3.5
ARTEFRI6	3.00	2.00	2	3.0
CHENPRA6	1.50	0.50	2	1.5
ROSAWOO5	1.00	1.00	1	1.4
TRAGDUB6	0.75	0.25	2	0.8
KOELMAC7	0.50	0.50	1	0.7
AGROSIB7	0.50	0.50	1	0.7
POAPRA7	0.50	0.50	1	0.7
ACHIMIL6	0.25	0.25	1	0.4
CRYPFEN6	0.25	0.25	1	0.4
CHENSUB6	0.25	0.25	1	0.4
DESCSOP6	0.25	0.25	1	0.4
HELIANN6	0.25	0.25	1	0.4
AGRODAS7	0.25	0.25	1	0.4
MINERAL9	12.50	2.50		
ORG9	30.00	0.00		

This plant community was typically found in level, very rapidly drained sand plain habitats. Organic matter accumulation at the soil surface averaged 30 % cover. A summary of site data is provided in Table 26.

Table 26. Summary of site data for the *Glycyrrhiza lepidota - Artemisia spp. - Stipa comata* community type (n = 2).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
19	866	n/a	0	Very Rapid	Level	Straight	Xeric	Submesotrophic
20	865	n/a	0	Very Rapid	Level	Straight	Xeric	Submesotrophic

3.2.1.11 *Rumex venosus* Association

Wild begonia

Plate 11. *Rumex venosus* community type (Wild begonia) Plot 6.

This community type was dominated by *Rumex venosus* in the forb stratum. It was typically found on the leeward side of active sand dunes, where sand accumulation was occurring. There was little grass cover, although *Sporobolus cryptandrus* was found in both plots (under 2 % cover) and at one site, *Oryzopsis hymenoides* provided 5 % cover. Table 27 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 27. Summary statistics for the *Rumex venosus* community type (n = 2).

Species	Mean % Cover	Standard Error	Presence	Prominence
RUMEVEN6	42.50	17.50	2	42.5
ORYZHYM7	2.50	2.50	1	3.5
FRANACA6	1.00	1.00	1	1.4
HELIANN6	1.00	1.00	1	1.4
SPORCRY7	1.25	0.75	2	1.3
THERRHO6	0.50	0.50	1	0.7
ROSAWOO5	0.25	0.25	1	0.4
HETEVIL6	0.25	0.25	1	0.4
ELYMCAN7	0.25	0.25	1	0.4
CALALON7	0.25	0.25	1	0.4
MINERAL9	55.00	15.00		
ORG9	0.50	0.00		

This community type was typically found on the leeward side of dunes with slopes ranging from 18 - 30 % and a north to northeast aspect. Sites were located on the mid to upper slopes of dunes and were very rapidly to rapidly drained. Exposed mineral soil comprised 40 to 70 % cover, with virtually no organic matter accumulation at the soil surface. A summary of site data is provided in Table 28.

Table 28. Summary of site data for the *Rumex venosus* community type (n = 2).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
6	863	37	18	Rapid	Middle Slope	Straight	Xeric	Submesotrophic
30	887	48	30	Very Rapid	Upper Slope	Straight	Xeric	Submesotrophic

3.2.1.12 *Oryzopsis hymenoides – Sporobolus cryptandrus* Association

Indian rice grass – sand dropseed

Plate 12. *Oryzopsis hymenoides – Sporobolus cryptandrus* community type (Indian rice grass – sand dropseed) Plot 35.

This community was co-dominated by *Oryzopsis hymenoides* and *Sporobolus cryptandrus* in the graminoid stratum, however, total percent cover was generally less than 40 %. This community was typically found on dune sites, where sand movement was active. As such, only one shrub species (*Elaeagnus commutata*) was encountered with less than 1 % cover. Two forb species were common to all or most survey sites, including *Helianthus annuus* and *Heterotheca villosa*. Other forb and graminoid species were found at different survey sites, but few were common to all or most plots. Table 29 summarizes the species composition, mean percent cover and standard error and species prominence for this community type.

Table 29. Summary statistics for the *Oryzopsis hymenoides – Sporobolus cryptandrus* community type (n = 5).

Species	Mean % Cover	Standard Error	Presence	Prominence
SPORCRY7	17.20	5.69	5	17.2
ORYZHYM7	10.00	2.24	5	10.0
THERRHO6	4.40	3.92	2	7.0
HELIANN6	2.80	0.92	5	2.8
RUMEVEN6	1.30	0.94	3	1.7
HETEVIL6	0.70	0.20	4	0.8
CALALON7	0.30	0.20	2	0.5
SOLIMIS6	0.20	0.20	1	0.4
LYGOROS6	0.20	0.20	1	0.4
FRANACA6	0.20	0.20	1	0.4
GLYCLEP6	0.20	0.20	1	0.4
CYPESCH7	0.20	0.20	1	0.4
KOELMAC7	0.20	0.20	1	0.4
ELYMCAN7	0.20	0.20	1	0.4
CHENPRA6	0.20	0.12	2	0.3
ELAECOM5	0.10	0.10	1	0.2
AGRODAS7	0.10	0.10	1	0.2
DECAY9	2.00	2.00		
MINERAL9	62.00	12.71		
ORG9	3.80	2.81		

This community type was commonly found on south to southwest facing slopes of active dunes. Sand movement was evident and in most sites the percentage of exposed sand at the soil surface exceeded 60 % (reaching up to 90 %). There was little organic matter accumulation at the soil surface and some decaying wood (shrub branches) was found at one survey site. A summary of site data is provided in Table 30.

Table 30. Summary of site data for the *Oryzopsis hymenoides – Sporobolus cryptandrus* community type (n = 5).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
21	862	168	15	Very Rapid	Upper Slope	Straight	Very Xeric	Oligotrophic
29	888	11	25	Very Rapid	Middle Slope	Straight	Xeric	Oligotrophic
31	894	284	25	Rapid	Upper Slope	Straight	Xeric	Submesotrophic
35	891	n/a	0	Rapid	Upper Slope	Concave	Xeric	Submesotrophic
37	886	207	10	Very Rapid	Lower Slope	Concave	Very Xeric	Oligotrophic

3.2.1.13 *Stipa comata – Oryzopsis hymenoides* Association

Needle and thread – Indian rice grass

Plate 13. *Stipa comata – Oryzopsis hymenoides* community type (Needle and thread – Indian rice grass) Plot 8.

This community was co-dominated by *Stipa comata* and *Oryzopsis hymenoides,* although their combined cover was typically less than 20 %. This community was found on partially stabilized dunes. Shrub species, including *Elaeagnus commutata, Rosa woodsii* and *Salix exigua* were encountered though with very low percent covers (generally less than 2 %). Forb species that were relatively common (at low percent cover) included *Helianthus annuus, Chenopodium pratericola, C. subglabrum* and *Lygodesmia rostrata*. Table 31 summarizes the species composition, mean percent cover, standard error and species prominence for this community type.

Table 31. Summary statistics for the *Stipa comata – Oryzopsis hymenoides* community type (n = 2).

Species	Mean % Cover	Standard Error	Presence	Prominence
ORYZHYM7	6.50	3.50	2	6.5
STIPCOM7	5.00	0.00	2	5.0
CRYPFEN6	2.50	2.50	1	3.5
SPORCRY7	2.50	2.50	1	3.5
HELIANN6	2.50	0.50	2	2.5
THERRHO6	1.50	1.50	1	2.1
AGROSMI7	1.50	1.50	1	2.1
CHENSUB6	0.75	0.25	2	0.8
CHENPRA6	1.50	0.50	2	1.5
LYGOROS6	0.75	0.25	2	0.8
ROSAWOO5	0.50	0.50	1	0.7
HETEVIL6	0.50	0.50	1	0.7
GLYCLEP6	0.50	0.50	1	0.7
ELAECOM5	0.25	0.25	1	0.4
SALIEXI5	0.25	0.25	1	0.4
RUMEVEN6	0.25	0.25	1	0.4
KOELMAC7	0.25	0.25	1	0.4
MINERAL9	22.50	12.50		
ORG9	7.50	2.50		

This community was typically found on mid to upper slope positions of moderately inclined south to southeast facing slopes. Exposed sand at the soil surface ranged from 10 to 35 % and organic matter accumulation was typically less than 10 % cover. A summary of site data is provided in Table 32.

Table 32. Summary of site data for the *Stipa comata – Oryzopsis hymenoides* community type (n = 2).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
8	868	162	15	Rapid	Upper Slope	Straight	Xeric	Submesotrophic
25	885	149	20	Rapid	Middle Slope	Concave	Xeric	Submesotrophic

3.2.1.14 *Artemisia spp. - Stipa comata – Calamovilfa longifolia* Association

Sage – needle and thread – sand grass

Plate 14. *Artemisia spp. – Stipa comata – Calamovilfa longifolia* (Sage – needle and thread – sand grass) Plot 39.

This community was dominated by *Stipa comata* in the graminoid stratum and a variety of *Artemisia* species in the forb layer. *Artemisia frigida* was found at all sites, while *A. ludoviciana* was found at two sites and *A. campestris* was found at one site. Several other forbs were common in this community including *Heterotheca villosa, Chenopodium pratericola* and *C. subglabrum,* all with relatively low percent covers. *Rosa woodsii* was common to all survey sites, with a mean cover of less than 2 %. Several other grasses were common, including *Calamovilfa longifolia, Koeleria macrantha* and *Sporobolus cryptandrus* but with low percent covers. Table 33 summarizes the species composition, mean percent cover and standard error and species prominence for this community type.

Table 33. Summary statistics for the *Artemisia* spp. - *Stipa comata –Calamovilfa longifolia* community type (n = 3).

Species	Mean % Cover	Standard Error	Presence	Prominence
STIPCOM7	40.00	5.77	3	40.0
ARTECAM	3.33	3.33	1	5.8
CALALON7	5.33	2.60	3	5.3
ARTEFRI6	2.67	1.20	3	2.7
ARTELUD6	2.00	1.53	2	2.4
HETEVIL6	2.00	0.58	3	2.0
OPUNPOL6	1.33	0.88	2	1.6
ROSAWOO5	1.50	0.76	3	1.5
SOLIMIS6	1.00	0.58	2	1.2
THERRHO6	0.83	0.60	2	1.0
KOELMAC7	1.00	0.00	3	1.0
CHENPRA6	0.83	0.17	3	0.8
SPORCRY7	1.00	0.58	3	1.0
LYGOROS6	0.33	0.33	1	0.6
AGRODAS7	0.33	0.33	1	0.6
CHENSUB6	0.50	0.00	3	0.5
LEPIDEN6	0.33	0.17	2	0.4
ACHIMIL6	0.33	0.17	2	0.4
PRUNVIR5	0.17	0.17	1	0.3
PLANPAT6	0.17	0.17	1	0.3
CRYPFEN6	0.17	0.17	1	0.3
DESCSOP6	0.17	0.17	1	0.3
GLYCLEP6	0.17	0.17	1	0.3
ORYZHYM7	0.17	0.17	1	0.3
MINERAL9	18.33	1.67		
ORG9	16.83	8.66		

This community type was found on level, sand plain habitats that were very rapidly to well drained. A summary of site data is provided in Table 34.

Table 34. Summary of site data for the *Artemisia* spp. - *Stipa comata – Calamovilfa longifolia* community type (n = 3).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
22	866	n/a	0	Very Rapid	Level	Straight	Xeric	Submesotrophic
38	883	n/a	0	Well	Level	Straight	Xeric	Submesotrophic
39	878	n/a	0	Rapid	Level	Straight	Xeric	Submesotrophic

3.2.1.15 *Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* Association

Needle and thread – sand nut-grass – sand grass

Plate 15. *Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* community type (Needle and thread – sand nut-grass – sand grass) Plot 33.

This community type was dominated by graminoids, with *Stipa comata, Cyperus schweinitzii* and *Calamovilfa longifolia* having the highest percent covers. Several forbs were typical, including *Artemisia campestris, Lygodesmia rostrata, Opuntia polycantha* and *Heterotheca villosa*. *Rosa woodsii* was also present, but with only a 1 % cover. Table 35 summarizes the species composition and mean percent cover for this community type.

Table 35. Summary statistics for the *Stipa comata – Cyperus schweinitzii –Calamovilfa longifolia* community type (n = 1).

Species	Percent Cover
STIPCOM7	25
CYPESCH7	20
CALALON7	10
ROSAWOO5	1
ARTECAM	1
LYGOROS6	1
OPUNPOL6	1
HETEVIL6	1
CRYPFEN6	0.5
HELIANN6	0.5
SPORCRY7	0.5
MINERAL9	70
ORG9	2

This site was located on a shallow, windward, south-facing dune slope. The site was very exposed to the wind and likely had active sand movement. The community had approximately 70% exposed sand at the soil surface and was very rapidly drained. A summary of site data is provided in Table 36.

Table 36. Summary of site data for the *Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* community type (n = 1).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
33	877	195	15	Very Rapid	Upper Slope	Straight	Xeric	Submesotrophic

3.2.1.16 *Sporobolus cryptandrus – Calamovilfa longifolia –Oryzopsis hymenoides* Association

Sand dropseed – sand grass – Indian rice grass

Plate 16. *Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides* community type (Sand dropseed – sand grass – Indian rice grass) Plot 4.

This community type occurred on dunes in the very early stages of stabilization, but that still have active sand movement. It was co-dominated by *Sporobolus cryptandrus* and *Calamovilfa longifolia*, with lesser amounts of *Oryzopsis hymenoides*. Low shrubs were present at some survey sites, however, the percent cover was quite low and included shrubs such as *Eurotia lanata, Rosa woodsii* and *Elaeagnus commutata.* A forb layer was typically present and included species such as *Helianthus annuus, Lygodesmia rostrata* and *Heterotheca villosa.* Table 37 summarizes the species composition, mean percent cover and standard error and species prominence for this community type.

Table 37. Summary statistics for the *Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides* community type (n = 4).

Species	Mean % Cover	Standard Error	Presence	Prominence
SPORCRY7	13.00	4.36	4	13.0
STIPCOM7	2.50	2.50	1	5.0
CALALON7	4.25	0.75	4	4.3
HELIANN6	3.38	2.30	3	3.9
ORYZHYM7	3.25	1.03	4	3.3
EUROLAN5	2.00	1.68	2	2.8
ROSAWOO5	2.00	1.68	2	2.8
ELAECOM5	1.25	1.25	1	2.5
GLYCLEP6	0.88	0.72	2	1.2
LYGOROS6	0.75	0.43	3	0.9
CHENSUB6	0.38	0.24	2	0.5
CHENPRA6	0.38	0.24	2	0.5
LATUPUL6	0.25	0.25	1	0.5
HETEVIL6	0.38	0.13	3	0.4
CRYPFEN6	0.25	0.14	2	0.4
ELYMCAN7	0.25	0.14	2	0.4
CORYVIV6	0.13	0.13	1	0.3
SALSKAL6	0.13	0.13	1	0.3
ARTELUD6	0.13	0.13	1	0.3
ARTEFRI6	0.13	0.13	1	0.3
OPUNPOL6	0.13	0.13	1	0.3
CERAARV6	0.13	0.13	1	0.3
KOELMAC7	0.13	0.13	1	0.3
MINERAL9	55.00	2.89		
ORG9	1.75	0.25		

This community was typically found on gentle to moderate southeast to southwest facing dune slopes. The dunes were partially active, however vegetation growth was beginning to stabilize the dune. Typically, there was greater than 50 % exposed sand at the soil surface, with very little organic matter accumulation. A summary of site data is provided in Table 38.

Table 38. Summary of site data for the *Sporobolus cryptandrus - Calamovilfa longifolia – Oryzopsis hymenoides* community type (n = 4).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
1	883	221	16	Very Rapid	Crest	Straight	Very Xeric	Oligotrophic
3	885	300	27	Very Rapid	Upper Slope	Straight	Very Xeric	Oligotrophic
4	878	120	9	Very Rapid	Upper Slope	Straight	Very Xeric	Oligotrophic
15	872	152	5	Very Rapid	Middle Slope	Straight	Very Xeric	Submesotrophic

3.2.1.17 *Artemisia cana / Stipa comata* Association

Silver sagebrush / needle and thread

Plate 17. *Artemisia cana / Stipa comata* community type (Silver sagebrush / needle and thread) Plot 024.

This sand plain community type was dominated by *Stipa comata* in the grass layer with a sparse low shrub layer, dominated by *Artemisia cana*, although *Koeleria macrantha* and *Agropyron dasystachyu*m were also present but with low covers. Other low shrub species were also present at low levels of abundance including *Eurotia lanata* and *Rosa woodsii.* Typical forbs included *Erigeron caespitosus, Thermopsis rhombifolia, Artemisia frigida* and *Polycantha vivipara*. Table 39 summarizes the species composition and mean percent cover for this community type.

Table 39. Summary statistics for the *Artemisia cana / Stipa comata* community type (n = 1).

Species	Percent Cover
STIPCOM7	30
ARTECAN5	10
ERIGCAE6	2
THERRHO6	2
ARTEFRI6	2
KOELMAC7	2
EUROLAN5	1
ROSAWOO5	1
CORYVIV6	1
ANTEPAR6	1

Species	Percent Cover
HETEVIL6	1
POTEPEN6	0.5
LEPIDEN6	0.5
CLEOSER6	0.5
ARTELUD6	0.5
CHENSUB6	0.5
AGRODAS7	0.5
MINERAL9	10
ORG9	0.5

This community was found on a level sand plain and its distribution was quite limited. Soils generally had a higher silt content than any of the other soils encountered in the Pakowki Sandhills study area. There was approximately 10 % exposed mineral soil at the soil surface, with little organic matter accumulation. A summary of site data is provided in Table 40.

Table 40. Summary of site data for the *Artemisia cana / Stipa comata* community type (n = 1).

Plot	Elevation	Aspect	Slope	Drainage	Site Position	Surface Shape	Moisture Regime	Nutrient Regime
24	883	n/a	0	Rapid	Level	Straight	Very xeric	Submesotrophic

3.3 Cross-Referencing of Proposed Community Types with Literature

Each community type identified from the analysis of the plot data was compared against floristically similar community types described for Alberta and other jurisdictions. A summary of the findings are provided in Appendices 4 and 5, which compare the Pakowki Sandhills community types against community types described in literature based in Alberta and other jurisdictions, respectively. A similarity rating between the community types, based on Corns (1983) and recently applied by Strong (2002), is also provided in the tables. A discussion of the community types and associated literature is provided below.

3.3.1 *Populus deltoides / Glycyrrhiza lepidota - Juncus balticus* Association

Western cottonwood / wild licorice – wire rush

Community types, dominated by *Populus deltoides* have been described for Alberta, though with some variation, particularly in the associated habitat. A floristically similar community type was found occasionally in the Manyberries region, though it was located in moist coulees (Smoliak 1985). A *P. deltoides* association was also described for CFB-Suffield, where it was found on floodplains and alluvial terraces of the South Saskatchewan River (Adams *et al.* 1997). In a 1993 survey of the Pakowki Sandhills *P. deltoides* was found on sand dunes and plains although a community type was not described in detail. Isolated *Populus deltoides* were reported to occur in low areas, although aspen clones were reported to be more common (Komex 1993).

Outside Alberta, a floristically similar community type has been described occurring throughout the Great Plains in North America, including Saskatchewan, Montana, Idaho, Wyoming, South and North Dakota and Nebraska. Epp and Townley-Smith (1983) noted *Populus deltoides* and *P. tremuloides* community types in low areas in sand flats of the Great Sand Hills in Saskatchewan. The community type was reported in locations where soil salinity was low and they also noted that *Glycyrrhiza lepidota* was an understorey forb species in those locations.

A *Populus deltoides – (Salix amygdaloides) / Salix exigua* Woodland has been described for numerous locations within the Great Plains region of the United States. At Scotts Bluff National Monument (Nebraska), this community was found on level to gently sloping locations, at the base of low, north-facing slopes. The soils were described as silty rather than sandy and contained more eastern species such as *Fraxinus pennsylvanica* and *Acer negundo* (USGS 2002a). At Devil's Tower National Monument (Wyoming) this community was found on river floodplains with sandy soils (USGS 2002b). At this location, the community was very small and had a high cover of invasive, exotic species. Faber-Langendoen (2001) also noted this association in the mid-western United States where it was typically found along the banks of streams and rivers and developed on newly deposited alluvium. This report noted that *Glycyrrhiza lepidota* was a common forb where site disturbance was low. At Agate Fossil Beds NM (Nebraska) this community was found on the floodplain of the Niobara River. The community type was typically located on level or sloping ground, on the banks or in old channels of the primary floodplain. Soils were described as fine sands and sandy loams that are

somewhat poorly drained (USGS 2002c). At Badlands National Park, in South Dakota this community was found along river and creek floodplains, pond and reservoir margins, seeps and springs in mesic draws and seeps and springs that occur along the edge of sandhill complexes (USGS 2002d).

According to Natureserve (2002) " This cottonwood - willow woodland is found widely in the central Great Plains of the United States. Stands occur on recently deposited alluvial material along rivers and streams. The soils are derived from alluvial sand, silt and clay and are poorly developed. The water table fluctuates with the level of the adjacent river or stream. *Populus deltoides* is the dominant species in this community, although *Salix exigua* and/or *Salix interior* is generally more dominant in the initial stage following a major flood event. *Salix amygdaloides* is rare to codominant. The shrub/sapling layer is conspicuous, especially near the stream bank and consists mainly of *Salix exigua, Populus deltoides* and *Salix amygdaloides*, or occasionally *Salix lutea*. In the more easterly parts of the range, *Salix interior* may replace *Salix exigua*. On the older margins of this community *Fraxinus pennsylvanica* is often found as a sapling or small canopy tree. The herbaceous stratum is variable. Graminoids typical of undisturbed sites include *Carex emoryi, Carex pellita (= Carex lanuginosa), Pascopyrum smithii* and *Spartina pectinata*. *Equisetum arvense* and *Glycyrrhiza lepidota* are common forbs in these sites. Widely distributed species that are adapted to these sites include *Ambrosia psilostachya, Artemisia campestris ssp. caudata, Artemisia ludoviciana, Calamovilfa longifolia, Cenchrus longispinus, Chamaesyce serpyllifolia (= Euphorbia serpyllifolia), Euphorbia esula, Grindelia squarrosa, Helianthus petiolaris, Heterotheca villosa, Phyla lanceolata (= Lippia lanceolata), Opuntia macrorhiza, Poa pratensis* and *Sporobolus cryptandrus*. These sites are prone to invasion by exotic grasses and forbs, the most widely established being *Agrostis stolonifera, Bromus tectorum, Cirsium arvense, Bassia scoparia (= Kochia scoparia), Melilotus* spp., *Taraxacum officinale* and *Tragopogon dubius*." It was also noted that many sites were overgrazed and invaded by exotic woody and herbaceous species.

A *Populus deltoides / Pascopyrum smithii* woodland was found in Thunder Basin National Grassland (Wyoming) along the Cheyenne River (Jones 1998a). In this location, the community type forms linear groves of trees that run parallel to the stream course on alluvial materials. A *Populus deltoides / Calamovilfa longifolia* woodland was also described in Thunder Basin National Grassland, along Antelope Creek (Jones 1998b).
A *Populus deltoides / Symphoricarpos occidentalis* Woodland was found in the Bitter Creek Badlands region of Montana, where it was found along rivers on unstabilized floodplains where it colonized alluvial deposits on meanders of streams and rivers (Cooper *et al.* 2001). In this location, the authors noted that a well-developed shrub layer was typically present. A *Populus tremuloides / Symphoricarpos alba* forest has been described from the Medicine Lake Sandhills in Montana (Heidel *et al.* 2000). There was no *P. deltoides* observed at this site and the community type did not have a native understorey.

3.3.2 *Rosa woodsii / Sporobolus cryptandrus* Association

Common wild rose / sand dropseed

Rosa woodsii was also found on dunes in the 1993 during a survey of the Pakowki Sandhills (Komex 1993). The species was reported to occur in low areas between dunes, often in association with wild licorice, although a full community description was not provided.

Outside Alberta, a shrubland, dominated by *Elaeagnus commutata, Rosa woodsii, Symphoricarpos occidentalis or Prunus virginiana* was noted for the Great Sandhills in Saskatchewan (Epp and Townley-Smith 1980). They noted that these species formed closed shrublands on stabilized slip faces that were typically north facing. The shrub composition varied from location to location and each shrub species could be dominant at specific sites, where at others the species were co-dominant. Furthermore, Epp and Townley-Smith (1980) noted a *Rosa woodsii* community that was dominant in areas "where sand has been whipped off dune by strong winds, creating areas of slow sand accumulation." Coupland (1950) noted that a *Rosa woodsii (Artemisia cana / Elaeagnus commutata*) community type was found in undulating to gently rolling areas between stabilized dunes in the prairie provinces. He noted that the water table was typically within eight to twelve feet of the soil surface where this community was found. Thorpe and Godwin (1993) noted a grass and shrub / sand type in the Manito Sand Hills of Western Saskatchewan. While this community type was dominated by *Symphoricarpos occidentalis*, *Rosa* spp. and *Prunus virginiana* were also present in 50% of plots in this type. The community type was typically found on stabilized dunes, with rapidly drained, sandy soils. However, *Sporobolus cryptandrus* was not listed as a prevalent species.

Natureserve (2002) notes a Rosa woodsii Temporarily Flooded Shrubland Alliance. These shrublands were typically found in the foothills and plains of Montana and Idaho. Elevations for the community type ranged from 650-1700 m and typically occurred on floodplains and alluvial terraces along rivers and streams. This alliance was also located on hillsides below springs and in ravines and swales where overland flow from snowmelt and summer precipitation provided additional moisture. Sites were generally flat to moderately steep and had soils that ranged from sandy loams to silt loams. Although these sites are considered temporarily flooded, they were well drained and were not found to have a shallow water table.

Cooper *et al.* (1999) noted a *Rosa woodsii* Shrubland community type in Beaverhead Mountain region of Montana. Although it was listed as a community type for this area, it was not described in detail in the associated report. The Montana and Idaho natural heritage programs (MNHP 2002; Rust 1997) listed a *Rosa woodsii* Shrubland as a natural plant community for their states. However, detailed descriptions of the community and associated habitats were not provided.

3.3.3 *Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus* Association

Peach-leaf willow – common wild rose / wire rush – sand dropseed

Salix amygdaloides was reported on dunes during a 1993 survey of the Pakowki Sandhills (Komex 1993). It was typically found in low areas, in both a tree and shrub form. Unfortunately, a community description was not provided. A general *Salix spp. / Stipa comata* association was reported for CFB-Suffield, where it was found on floodplains and alluvial terraces of the South Saskatchewan River (Jaques 1977). No reports of a similar community could be found for other Canadian provinces.

A *Salix amygdaloides* Woodland type was reported by Natureserve (2002) and was found in the Northern Rocky Mountains and potentially into parts of the western Great Plains. Stands occurred in riparian areas and the vegetation was dominated by *Salix amygdaloides*. Specifically, the *Salix amygdaloides* Woodland was documented in the Black Hills of South Dakota at the confluence of two creeks where it formed a tall-shrub stratum with *Salix bebbiana* and *Cornus sericea* and was more a shrubland than a woodland (Faber-Langendoen 2001; Marriott and Faber-Langendoen 2000).

A *Salix amygdaloides* Woodland was listed as a natural plant community for Montana where it was ranked G3/S3 by the Montana Natural Heritage Program (2002).

A *Salix amygdaloides / Salix exigua* Woodland was also reported by Natureserve (2002) where the association occurred in riparian habitats on the Columbian Plateau in the interior Northwest and in northeastern Utah. The association was found at elevations ranging from 100-1600 m and was located in overflow channels of large rivers and on narrow floodplains of small creeks. Soil textures were reported to be quite variable, but did not include clay. This community has been reported to have a moderately open canopy dominated by the small tree *Salix amygdaloides*. S*alix exigua* dominated the tall-shrub layer. Other tree species reported for this community type included *Populus fremontii, Acer negundo, Populus angustifolia, Populus deltoides* and the introduced *Elaeagnus angustifolia*.

3.3.4 *Elaeagnus commutata / Glycyrrhiza lepidota* Association

Silverberry / wild licorice

An *Elaeagnus commutata* Shrubland was identified during a 1993 survey of the Pakowki Sandhills (Komex 1993). This community was reported to occur as thickets on some north-facing slopes and at the base of some dunes. However, a detailed description of the community type was not provided. An *Elaeagnus commutata* community has been described for Alberta based on three reports in Central Parkland, at Dillberry Lake Provincial Park, near Rumsey and in Dry Island Buffalo Jump (Wheatley and Bentz 2002). This community occurred as low shrublands and shrubby meadows along the perimeter of saline lakes, adjacent to marshes and graminoid meadows. At Dillberry Lake Provincial Park, *Elaeagnus commutata* occurred as a shrubland primarily with *Symphoricarpos occidentalis, Rosa acicularis, Calamovilfa longifolia, Agropyron trachycaulum* and *Carex* spp.. As a meadow community, *E. commutata* was more common with *Rosa woodsii, Glycyrrhiza lepidota, Juncus balticus* and *Calamovilfa*

longifolia. An *Elaeagnus commutata / Symphoricarpos occidentalis – Rosa woodsii / Poa palustris* community was also described from Central Parkland occurring near Wainwright on subxeric to submesic dune sites with good internal soil drainage. Currently, ANHIC lists an *Elaeagnus commutata / Pascopyrum smithii* Shrubland community for the Grassland Natural Region and it is ranked S3 (Allen 2002).

Epp and Townley-Smith (1980) reported an *Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* closed shrubland in the Great Sand Hills of Saskatchewan. The community was typically found on stabilized slip faces that were north facing. They noted that the shrub composition varied from location to location and that each shrub species could be dominant at specific sites, where at others they may be co-dominant. The authors also noted an *Elaeagnus commutata* shrubland that was often found inhabiting blowouts away from bare sand (Epp and Townley-Smith 1980). Coupland (1950) described a *Rosa woodsii (Artemesia cana / Elaeagnus commutata*) community type for the prairie provinces that was found in undulating to gently rolling areas between stabilized dunes. At these locations, the water table was typically within 8 to 12 feet of the soil surface.

Heidel *et al.* (2000) reported an *Elaeagnus commutata* Shrubland community for northern Montana, located east of the Continental divide. The community type was generally classified as temporarily flooded. At the Medicine Lake sandhills, sites typically had a shrub cover of 10% and grass cover of 70% and sites were not flooded but the water table was within the rooting zone.

An *Elaeagnus commutata* Shrubland Alliance was reported by Natureserve (2002) for the northern Great Plains in a mixedgrass prairie matrix. The alliance was dominated by mid to tall shrubs, particularly *Elaeagnus commutata*. *Pascopyrum smithii* was reported as the dominant species in the herbaceous layer and was typically accompanied by *Koeleria macrantha, Schizachyrium scoparium* and *Hesperostipa comata.* They also note that *Elaeagnus commutata* was most abundant on flat sandy sites in southern Saskatchewan.

Natureserve (2002) also reported an *Elaeagnus commutata / Pascopyrum smithii* Shrubland Association, within the shrubland alliance that typically occurred on a variety of glacial landforms including kames, eskers and areas of till and outwash. The association was most common on north-facing slopes and sites where moisture is more abundant, including river valley slopes.

An *Elaeagnus commutata* Shrubland was listed as a natural plant community for Montana and was ranked G2Q/S2? by the Montana Natural Heritage Program (2002). Unfortunately no description of the community type is given.

3.3.5 *Elaeagnus commutata / Artemisia ludoviciana - Calamovilfa longifolia* Association

Silverberry / prairie sagewort – sand grass

An *Elaeagnus commutata* Shrubland was identified during a 1993 survey of the Pakowki Sandhills (Komex 1993). This community was reported to occur as thickets on some north-facing slopes and at the base of some dunes. However, a detailed description of the community type was not provided. An *Elaeagnus commutata* community has been

described for Alberta based on three reports in Central Parkland, at Dillberry Lake Provincial Park, near Rumsey and in Dry Island Buffalo Jump (Wheatley and Bentz 2002). This community occurred as low shrublands and shrubby meadows along the perimeter of saline lakes, adjacent to marshes and graminoid meadows. At Dillberry Lake Provincial Park, *Elaeagnus commutata* occurred as a shrubland primarily with *Symphoricarpos occidentalis, Rosa acicularis, Calamovilfa longifolia, Agropyron trachycaulum* and *Carex* spp.. As a meadow community, *E. commutata* was more common with *Rosa woodsii, Glycyrrhiza lepidota*, *Juncus balticus* and *Calamovilfa longifolia*. An *Elaeagnus commutata / Symphoricarpos occidentalis – Rosa woodsii / Poa palustris* community was also described from Central Parkland occurring near Wainwright on subxeric to submesic dune sites with good internal soil drainage. Currently, ANHIC lists an *Elaeagnus commutata / Pascopyrum smithii* Shrubland community for the Grassland Natural Region and it is ranked S3 (Allen 2002).

Epp and Townley-Smith (1980) reported an *Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* closed shrubland in the Great Sand Hills of Saskatchewan. The community was typically found on stabilized slip faces that were north facing. They noted that the shrub composition varied from location to location and that each shrub species could be dominant at specific sites, where at others they may be co-dominant. The authors also noted an *Elaeagnus commutata* shrubland that was often found inhabiting blowouts away from bare sand (Epp and Townley-Smith 1980). Coupland (1950) described a *Rosa woodsii (Artemesia cana / Elaeagnus commutata*) community type for the prairie provinces that was found in undulating to gently rolling areas between stabilized dunes. At these locations, the water table was typically within 8 to 12 feet of the soil surface.

Heidel *et al.* (2000) reported an *Elaeagnus commutata* Shrubland community for northern Montana, located east of the Continental divide. The community type was generally classified as temporarily flooded. At the Medicine Lake sandhills, sites typically had a shrub cover of 10% and grass cover of 70% and sites were not flooded but the water table was within the rooting zone.

An *Elaeagnus commutata* Shrubland Alliance was reported by Natureserve (2002) for the northern Great Plains in a mixedgrass prairie matrix. The alliance was dominated by mid to tall shrubs, particularly *Elaeagnus commutata*. *Pascopyrum smithii* was reported as the dominant species in the herbaceous layer and was typically accompanied by *Koeleria macrantha, Schizachyrium scoparium* and *Hesperostipa comata.* They also note that *Elaeagnus commutata* was most abundant on flat sandy sites in southern Saskatchewan.

Natureserve (2002) also reports an *Elaeagnus commutata / Pascopyrum smithii* Shrubland Association, within the shrubland alliance that typically occurred on a variety of glacial landforms including kames, eskers and areas of till and outwash. The association was most common on north-facing slopes and sites where moisture is more abundant, including river valley slopes.

An *Elaeagnus commutata* Shrubland was listed as a natural plant community for Montana and was ranked G2Q/S2? by the Montana Natural Heritage Program (2002). Unfortunately no description of the community type is given.

3.3.6 *Prunus virginiana / Calamovilfa longifolia* Association

Choke cherry / sand grass

A 1993 survey of the Pakowki Sandhills reported a *Prunus virginiana* shrubland (Komex 1993). The authors of this survey noted that this community typically occurred along low dune ridges and slopes. A *Prunus virginiana – Amelanchier alnifolia / Agropyron trachycaulum – Poa pratensis* community was described for the Central Parkland (Wheatley and Bentz 2002). This community was found on a steep, south-facing slope in the Blackfoot Provincial Recreation Area.

Epp and Townley-Smith (1980) reported an *Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* closed shrubland in the Great Sand Hills of Saskatchewan. The community was typically found on stabilized slip faces that were north facing. They noted that the shrub composition varied from location to location and that each shrub species could be dominant at specific sites, where at others they may be co-dominant. Thorpe and Godwin (1993) reported a grass and shrub / sand type that was dominated by *Symphoricarpos occidentalis*, however, *Rosa* spp. and *Prunus virginiana* were present in 50% of plots. This community type was typically found on stabilized dunes, with rapidly drained, sandy soils and *Calamovilfa longifolia* was listed as a common graminoid species.

Heidel *et al.* (2000) and the Montana Natural Heritage Program (2002) both report a *Prunus virginiana* Shrubland in Montana. The Natural Heritage Program does not provide a description of the community but gives it a rank of G4Q/S4. Heidel *et al.* (2000) noted that the shrubland was small in area when it occurred in the Medicine Lake Sandhills. They noted that the community type typically had a high shrub cover and low understorey cover due to the density of shrubs, although *Hesperostipa comata* was a common understorey graminoid species. *Prunus virginiana* has a deep root system, allowing the shrubs to reach the water table in the Medicine Lake Sandhills. Elsewhere in Montana the community type was considered to be a riparian community (Heidel *et al.* 2000).

Cooper et al (1999) reported a *Prunus virginiana – (Prunus americana*) Shrubland community in Montana. It was found in the Bitter Creek Badlands, located at heads of coulees feeding into badlands. The community occurred as very small patches, often linear in shape and very dense. Very few other species were present because of the density of the *Prunus*.

Natureserve (2002) reported a *Prunus virginiana* Shrubland Alliance. The community was typically found along streams, rivers, lakes and ponds and on terraces, or in canyons or steep gullies where elevations range from 716 m to about 1600 m in Montana, Wyoming and Colorado and up to 2440 m in Nevada. In certain locations, the alliance occurred on side slopes, immediately below a seep or spring. Some examples of this alliance have been classified as having an intermittently or temporarily flooded hydrologic regime. Soils were typically well developed and well drained and were typically composed of shallow to deep alluvial deposits.

A *Prunus virginiana – (Prunus americana*) Shrubland was reported occurring in Badlands National Park, South Dakota (USGS 2002d). This community, however, was dominated by *Prunus americana*, with some *P. virginiana.* It was typically found in

sloping to nearly level mesic draws and nearly level oxbows, although a few stands were also found at seep zones on the edge of sandhills (USGS 2002d).

3.3.7 *Eurotia lanata / Stipa comata – Calamovilfa longifolia* Association

Winter fat / needle and thread – sand grass

Within Alberta, Smoliak (1985) reported a *Stipa – Bouteloua – Agropyron* type near Manyberries, in southern Alberta. The author noted that this type was typically found on upland prairie, with *Eurotia lanata* as a common shrub.

Looman (1980) recorded a *Stipa comata* Association for the prairie provinces in Canada. The author noted that this community was found to be common (with *Bouteloua gracilis*) on dry prairie. A variation of the community was also noted and included *Calamovilfa longifolia*, occurring on sandy loam or loamy sand soils. *Eurotia lanata* was not mentioned as occurring.

Natureserve (2002) reported a *Krascheninnikovia lanata / Hesperostipa comata* Dwarf-Shrubland Alliance. It was considered to be a minor alliance and included dwarf-shrublands scattered across the interior western U.S. Stands occur on plateaus, plains, mesas, hillslopes, alkaline flats around playas and along drainages. Some habitats were intermittently flooded wetlands. It was typically found on flat to gently sloping sites occurring on any aspect, but stands have also been reported from moderately steep slopes. Soils were commonly calcareous to moderately alkaline and are typically stony, sandy loam. The ground cover was mostly bare soil. The cover of *Krascheninnikovia lanata* and *Hesperostipa comata* varied from 5 to 60%. The vegetation was reported to be sparse in many of these stands and might be better classified in a sparsely vegetated alliance.

The Montana Natural Heritage Program (2002) reported a *Krascheninnikovia lanata / Stipa comata* Dwarf-Shrubland community for Montana and ranked it as G3/S3. A *Eurotia lanata / Poa secunda* extremely xeromorphic dwarf-shrubland was listed as a natural plant community type for Idaho (Rust 1997) 3. Unfortunately no descriptions were given for either of these communities.

Faber-Langendoen (2001) reported a *Krascheninnikovia lanata / Bouteloua gracilis* Dwarf Shrub Herbaceous community type for the mid-western United States. The vegetation contained open shrub and graminoid layers, where the short herbaceous layer was dominated by *Bouteloua gracilis, Echinacea angustifolia* and *Liatris punctata.* This community type was found in the southwestern Great Plains and semi-desert mountains, from Colorado south to New Mexico and Arizona and was also reported in Kansas.

3.3.8 *Salix exigua / Glycyrrhiza lepidota - Juncus balticus* Association

Sandbar willow / wild licorice – wire rush

No community types with a similar plant species composition could be found for Alberta. However, many have been described for the Great Plains region in the United States.

Faber-Langendoen (2001) described a *Salix exigua /* Mesic Graminoids Shrubland for the Midwestern United States. For this community type, the vegetation was dominated by

shrubs with a fairly dense (at least 30 %) ground cover of mesic graminoids and forbs. *Juncus* spp. was noted as a common herbaceous species. The community was most commonly found on sandbars, islands and shorelines of stream channels and braided rivers and soils are typically poorly developed. This community was predominantly found in the Great Plains but also in parts of Rocky Mountains and intermountain semi-desert regions, from Wyoming west to possibly Idaho, south to Utah and east to Oklahoma. The author also reported a *Salix exigua* Temporarily Flooded Shrubland community that was dominated by 2 – 4 m tall *Salix exigua* with a moderate to high stem density. This community was dominantly found on recently deposited or disturbed alluvial materials, composed primarily of sands. It was found at lower elevations throughout the northwestern US and Great Plains and into Manitoba.

Cooper *et al.* (1999) noted a *Salix exigua* Temporarily Flooded Shrubland community in the Beaverhead Mountains of Montana. At this location, the community was typically found on gravelly alluvial materials on floodplains and terraces in river bottoms. Understorey species were minimal due to the high disturbance rate, but the most common were reported to be *Cirsium arvense, Mentha arvensis* and *Phalaris arundinacaea.*

Several natural plant community types, dominated by *Salix exigua,* were reported by the Montana Natural Heritage Program (2002). They included a *Salix exigua* / Barren Shrubland, a *Salix exigua* / Mesic Graminoid Shrubland and a *Salix exigua* Temporarily Flooded Shrubland. Unfortunately no descriptions of the community types were provided but all were ranked as G5/S5.

Several natural plant community types dominated by *Salix exigua* were reported for the State of Idaho (Rust 1997) and are listed below:

- *Salix exigua* / Barren seasonally flooded cold-deciduous shrubland,
- *Salix exigua / Equisetum arvense* seasonally flooded cold-deciduous shrubland,
- *Salix exigua* / Mesic Forb seasonally flooded cold-deciduous shrubland,
- *Salix exigua* / Mesic Graminoid seasonally flooded cold-deciduous shrubland and
- *Salix exigua / Rosa woodsii* seasonally flooded cold-deciduous shrubland.

Unfortunately, no detailed descriptions were provided for these community types.

A *Salix exigua* Shrubland community, has been described from the margins of the North Platte River at Scotts Bluff National Monument in Nebraska (USGS 2002a) This community type was reported to occur on recently deposited alluvial sands where there was little soil development. The understorey species composition was quite different from that found at the Pakowki Sandhills and the occasional *Populus deltoides* was also noted to occur. A similar *Salix exigua* Shrubland [Provisional] community was found along the Niobara River, at the Agate Fossil Beds NM in Nebraska (USGS 2002c). At this location, the community was found along lower floodplain terraces, with sandy loam soils that were poorly to somewhat poorly drained. *Juncus balticus* was listed as an abundant species and the authors noted that species diversity was quite high.

A *Salix exigua* Temporarily Flooded Shrubland community has been described from Badlands National Park, in South Dakota (USGS 2002d) At this location, the community was found along banks of several creeks within the park. The authors noted that the sites for this plant community were nearly all level and that ground water was present.

3.3.9 *Glycyrrhiza lepidota - Calamovilfa longifolia* Association

Wild licorice – sand grass

A 1993 survey of the Pakowki Sandhills reported the occurrence of *Glycyrrhiza lepidota* with *Calamovilfa longifolia* and *Artemesia ludoviciana* (Komex 1993). Although a detailed description of the community type was not provided, the authors noted that wire rush (*Juncus balticus*) was also commonly found in *Glycyrrhiza lepidota* sites.

The only reported *Glycyrrhiza lepidota* community type from outside Alberta was found in Montana. The Montana Natural Heritage Program (2002) recorded a *Glycyrrhiza lepidota* Herbaceous Vegetation community for the state and it is currently ranked as S? . Unfortunately, no detailed description of the plant community was provided.

3.3.10 *Glycyrrhiza lepidota – Artemisia spp. - Stipa comata* Association

Wild licorice – sage – needle and thread

A 1993 survey of the Pakowki Sandhills reported the occurrence of *Glycyrrhiza lepidota* with *Calamovilfa longifolia* and *Artemesia ludoviciana* (Komex 1993).

Looman (1980) recorded a *Stipa comata* Association for the prairie provinces in Canada. The author noted that this community was found to be common (with *Bouteloua gracilis*) on dry prairie. A variation of the community was also noted and includes *Calamovilfa longifolia*, occurring on sandy loam or loamy sand soils, although *Glycyrrhiza lepidota* was not noted to occur.

Hulett *et al.* (1966) recorded a *Stipa comata – Artemesia frigida* plant community that was dominant on stabilized dunes in Great Sand Hills of Saskatchewan *Glycyrrhiza lepidota* was not reported to be present in the community.

The only reported *Glycyrrhiza lepidota* community type from outside Alberta was found in Montana. The Montana Natural Heritage Program (2002) recorded a *Glycyrrhiza lepidota* Herbaceous Vegetation community for the state and it is currently ranked as S? . Unfortunately, no detailed description of the plant community was provided.

3.3.11 *Rumex venosus* Association

Wild begonia

No community types with a similar plant species composition could be found for Alberta. However, several have been described for areas outside Alberta, but not in the United States.

Looman (1980) described a *Rumex venosus* Alliance that was dominant on highly mobile dunes, during early stages of development. Epp and Townley-Smith (1980) also noted that *Rumex venosus* occurred on active sand dune complexes, typically towards the edge of the deflation zone and on sides of dunes in their Active Sand Dune Complex. However, no *Rumex venosus* community type was described.

3.3.12 *Oryzopsis hymenoides – Sporobolus cryptandrus* Association

Indian rice grass – sand dropseed

Only one community type with a somewhat similar plant species composition could be found for Alberta. Fehr (1984) reported a *Carex foenea – Calamovilfa longifolia – Elymus canadensis – Oryzopsis hymenoides* community in the Wainwright sand dune area, on active blowouts. ANHIC reported an *Oryzopsis hymenoides / Leymus canadensis* sparsely vegetated plant community that they have ranked as S2 for the province (Allen 2002), but no detailed description was provided.

Outside Alberta, there are numerous reports of related community types. Looman (1980) reported an *Oryzopsis hymenoides* Order within the Calamovilfetea class for the Canadian prairie provinces, though no details were provided on its species composition or the associated habitat. Hulett *et al.* (1966) reported a *Psoralea lanceolata – Oryzopsis hymenoides* community that was a dominant association in the Great Sand Hills (Saskatchewan) on active sand dune complexes. Epp and Townley-Smith (1980) also reported a *Psoralea lanceolata – Oryzopsis hymenoides* community type from the Great Sand Hills where it formed a sparse cover located on the edge of deflation zones away from the active portions of the dune. The authors noted that the vegetative cover tended to increase as the distance from deflation zone increased.

In Montana, Heidel *et al.* (2000) reported an *Oryzopsis hymenoides – Psoralidium lanceolatum* community in the Medicine Lake Sandhills in Montana, that was restricted to slopes and crests of sand dunes recently disturbed by soil erosion. *Sporobolus cryptandrus* was also present and often formed up to 10% cover. The community type was most commonly found in blowouts and was thought to be the driest and earliest stage of succession.

An *Oryzopsis hymenoides – Psoralidium lanceolatum* Herbaceous vegetation association was reported to be a natural plant community for the state of Montana, where it was ranked G3Q/S? (MNHP 2002).

An *Achnatherum hymenoides* Herbaceous Alliance was reported by Natureserve (2002) where it occurred in two distinctively different habitats: sandy areas and shale barrens, in different geographic areas. Sandy areas included 'blowouts' in the Great Plains and in arid and semi-arid dune systems in the Chihuahua Desert, San Luis Valley, Colorado Plateau and Great Basin. Substrates were dominantly sand or shale. This alliance was characterized by a sparse to moderately dense herbaceous layer that was dominated by *Achnatherum hymenoides* (= *Oryzopsis hymenoides*). An *Achnatherum hymenoides - Psoralidium lanceolatum* Herbaceous Vegetation association and a *Calamovilfa longifolia - Achnatherum hymenoides* Herbaceous Vegetation association was also listed by Natureserve (2002) but no descriptions were given.

3.3.13 *Stipa comata – Oryzopsis hymenoides* Association

Needle and thread – Indian rice grass

Only one community type with a somewhat similar plant species composition could be found for Alberta. Fehr (1984) reported a *Carex foenea – Calamovilfa longifolia –*

Elymus canadensis – Oryzopsis hymenoides community in the Wainwright sand dune area, on active blowouts. However, *Stipa comata* was not listed as a component of this community.

Looman (1980) recorded a *Stipa comata* Association for the prairie provinces in Canada. The author noted that this community was found to be common (with *Bouteloua gracilis*) on dry prairie. A variation of the community was also noted and includes *Calamovilfa longifolia*, occurring on sandy loam or loamy sand soils although *Achnatherum hymenoides* was not noted to occur. Looman (1980) also reported an *Oryzopsis hymenoides* Order within the Calamovilfetea class for the Canadian prairie provinces, though no details are provided on its species composition or the associated habitat. Hulett *et al.*(1966) reported a *Psoralea lanceolata – Stipa comata* community that was a dominant association in Dundurn Sand Hills (Saskatchewan) on stabilized dune complexes. Hulett *et al.*(1966) reported a *Psoralea lanceolata – Oryzopsis hymenoides* community that was a dominant association in the Great Sand Hills (Saskatchewan) on active sand dune complexes. This same report also recorded a *Stipa comata – Artemesia frigida* plant community that was dominant on stabilized dunes in the Great Sand Hills of Saskatchewan.

Epp and Townley-Smith (1980) also reported a *Psoralea lanceolata – Oryzopsis hymenoides* community type from the Great Sand Hills where if formed a sparse cover located on the edges of deflation zones away from the active portions of the dune. The authors noted that the vegetative cover tended to increase as the distance from the deflation zone increased.

Heidel *et al.* (2000) reported a *Stipa comata / Psoralidium lanceolatum* Herbaceous Vegetation association from the Medicine Lake sand hills in Montana. This community was restricted to wind-blown sand deposits with undeveloped soils and was found on choppy dunes to rolling plains. It was thought to be a seral stage between the *Oryzopsis hymenoides / Psoralidium lanceolatum* and the *Pascopyrum smithii - Stipa comata* association. Grass cover was typically 20-40% and most was composed of *Stipa comata*. This community was most common on stabilized to partially stabilized sand dunes. An *Oryzopsis hymenoides – Psoralidium lanceolatum* Herbaceous vegetation association was reported to be a natural plant community for the state of Montana, where it is ranked G3Q/S? (MNHP 2002).

Natureserve (2002) reported an *Hesperostipa comata - Achnatherum hymenoides* Herbaceous Vegetation association. This grass type has been reported from the Great Divide Basin in south-central Wyoming. *Hesperostipa comata* and *Achnatherum hymenoides* co-dominated the graminoid stratum, while *Pascopyrum smithii* was a secondary species. Scattered shrubs were present, primarily *Artemisia tridentata ssp. wyomingensis.* This type apparently has not been described outside the Great Divide Basin of south-central Wyoming. Other basins in south-central and southwestern Wyoming and the northwestern quarter of Colorado are similar in climate and geology and this association may well extend over a wide area of the two states.

An *Hesperostipa comata* Bunch Herbaceous Alliance was also reported by Natureserve (2002). This grassland alliance was found on sandy soils in the Intermountain Steppe, Wyoming Basin, Colorado Plateau, Great Basin and Columbia Plateau. The community

typically occurred on upland sites with coarse-textured soils such as sandstone outcrop ridges in the plains, dry-sandy sites in the Columbia Basin and on dissected alluvial fans below sandstone plateaus, but not on dunes.

3.3.14 *Artemisia spp. - Stipa comata – Calamovilfa longifolia* Association

Sage – needle and thread – sand grass

Smoliak (1985) reported a *Calamovilfa longifolia – Artemisia* community on upland prairie with sandy soils in the Manyberries region of southern Alberta. However, no other description of the community type was provided.

Looman (1980) recorded a *Stipa comata* Association for the prairie provinces in Canada. The author noted that this community was found to be common (with *Bouteloua gracilis*) on dry prairie. A variation of the community was also noted and included *Calamovilfa longifolia*, occurring on sandy loam or loamy sand soils. However, no mention of *Artemisia* spp. being a component of this community was noted.

Hulett *et al.* (1966) recorded a *Stipa comata – Artemesia frigida* plant community that was dominant on stabilized dunes in the Great Sand Hills of Saskatchewan, but did not elaborate on its composition or distribution.

3.3.15 *Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* Association

Needle and thread – sand nut-grass – sand grass

Adams *et al.* (1997) described a similar *Calamovilfa longifolia – Hesperostipa comata* community from CFB Suffield, in southeastern Alberta. Site conditions differed in that this community was described as occurring on fluvial slump features along the South Saskatchewan River, where a sand veneer was present. Soils were typically loamy sand and slopes ranged from 5 to 15 %, although some 60% slopes were reported. This community type was also found on glaciofluvial outwash plains, with minimal eolian action. Soil textures were loamy sand and slopes ranged from 0 to 5%. Smoliak (1985) reported two similar community types in the Manyberries area of southern Alberta. The author described a *Calamovilfa longifolia – Artemesia* plant community that was found on upland prairie with sandy soils and a *Calamovilfa longifolia – Stipa comata* community found on sandy soils, in coulee bottoms.

Looman (1980) recorded a *Stipa comata* Association for the prairie provinces in Canada. The author noted that this community was found to be common (with *Bouteloua gracilis*) on dry prairie. A variation of the community was also noted and includes *Calamovilfa longifolia*, occurring on sandy loam or loamy sand soils.

Hulett *et al.* (1966) recorded a *Stipa comata – Artemesia frigida* plant community that was dominant on stabilized dunes in the Great Sand Hills of Saskatchewan and noted that *Calamovilfa longifolia* was present. Hulett *et al.* (1966) also described a *Psoralea lanceolata - Stipa comata* plant community that was dominant at the Dundurn Sand Hills (Saskatchewan) on stabilized dunes. *Calamovilfa longifolia* was reported to be present in this community. Furthermore, the authors described a *Stipa comata – Calamovilfa longifolia – Agropyron spp.* community that was found in the Dundurn Sand Hills. The

authors noted that this community was most common in dune depressions and appeared to be intermediate between stabilized blowouts and stabilized dunes.

Cooper *et al.* (2001) reported a *Calamovilfa longifolia – Hesperostipa comata* Herbaceous Vegetation association from the Rock Creek Canyon and a few sandy outcrops in the Bitter Creek Badlands area of Montana. This community was found to occur most abundantly where sandy substrates were dominant, on stabilized dunes, interdunal swales and colluvial sands. The authors reported that the community was found to be highly restricted in area and occurred mainly on colluvial sands.

Heidel *et al.* (2000) also reported a *Calamovilfa longifolia – Stipa comata* Herbaceous Vegetation association in the Medicine Lake Sandhills in Montana. The authors considered it to be a minor type. It did not appear to be a widespread community in the Medicine Lake Sandhills, occurring only in small patches on low ridges and in a mosaic pattern on gentle plains of Medicine Lake.

Jones (1998a; 1998b) noted *Calamovilfa longifolia - Hesperostipa comata* Grassland communities along several rivers and streams in northeastern Wyoming. The author described this community type on sandy soils at an intermediate height above the river channel and noted it was a major community type in the region. Other dominant species included *Calamovilfa longifolia, Stipa comata* and *Psoralea lanceolata*.

Faber-Langendoen (2001) and Natureserve (2002) reported a *Calamovilfa longifolia – Hesperostipa comata* Herbaceous Vegetation community from the mid-western United States. The vegetation had an open canopy dominated by *Calamovilfa longifolia* and *Hesperostipa comata*. This community was found to occur on stabilized sand dunes as well as in interdunal valleys or draws, colluvial sands and less commonly on silty terraces of intermittent streams. Soils were generally medium to fine sands, formed from either eolian or colluvial processes. The author noted that this community was found in the central and northern Great Plains, ranging from Colorado to Nebraska and north to Wyoming and South Dakota.

3.3.16 *Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides* Association

Sand dropseed – sand grass – Indian rice grass

Wheatley and Bentz (2002) and Meijer and Karpuk (1999) described a *Sporobolus cryptandrus – Calamovilfa longifolia – Koeleria macrantha – Carex obtusata* community type from the Central Parkland of Alberta. This community type was found on active dunes and blowouts at Dillberry Lake Provincial Park where it was generally located on south to west-facing aspects and had a sparse vegetative cover. *Heterotheca villosa* was also reported to be present. In a 1993 survey of the Pakowki Sandhills, a *Calamovilfa longifolia – Sporobolus cryptandrus* sparsely vegetated active sand dune complex was reported (Komex 1993). Other reported species included *Helianthus couplandii, Thermopsis rhombifolia* and *Heterotheca villosa*.

ANHIC currently ranks *Sporobolus cryptandrus* sparsely vegetated active dune plant communities as S2 (Allen 2002).

Looman (1980) described a *Calamovilfa longifolia* vegetation Class from the Canadian prairie provinces. This class was reported to be dominant in well-developed sandhill prairie and could include other characteristic species such as *Elymus canadensis, Helianthus couplandii and Sporobolus cryptandrus.*

Thorpe and Godwin (1993) described a *Carex pennsylvanica – Sporobolus cryptandrus – Cyperus schwentzeii – Calamovilfa longifolia* community on active sand in the Manito Sandhills of west-central Saskatchewan. This community type was found on sparsely vegetated, active east/west oriented sand dunes that were rapidly drained. The soils were coarse-textured and had little to no organic matter to retain moisture.

The Montana Natural Heritage Program (2002) listed a *Sporobolus cryptandrus* Shrub Herbaceous Vegetation association as a natural plant community for the state. The community was ranked G2/S2 for Montana, but unfortunately, no description of the community was provided.

The State of Idaho also listed several natural *Sporobolus cryptandrus* plant communities, including:

- *Sporobolus cryptandrus – Poa secunda* Medium-tall bunch temperate or subpolar grassland,
- *Sporobolus cryptandrus* Medium-tall temperate or subpolar grassland with a needle-leaved or microphyllous evergreen shrub layer and
- *Heterotheca villosa / Sporobolus cryptandrus* Low temperate or subpolar forb vegetation.

Natureserve (2002) listed two Alliances and one Association with *Sporobolus cryptandrus* as the dominant species. A *Sporobolus cryptandrus* Herbaceous Alliance was described for the lower Salmon and Snake river canyons of Idaho, Oregon and Washington, the Columbia River in central Washington and the Green and Virgin rivers in Utah (Natureserve 2002). This alliance typically occurred on river terraces, lower slopes of benches and alluvial fans. The elevation ranges from 240 - 1460 m and sites are flat to gently sloping (up to 30%) and tend to occur on all aspects. The climate in the canyon bottoms was relatively hot and dry and soils were moderately deep and derived from loess and alluvium-colluvium. The soil texture varies from sandy loam to silt loam.

A *Sporobolus cryptandrus - Poa secunda* Herbaceous Vegetation association was described by Natureserve (2002) for the Columbia Basin and lower Snake River, where it occurred on gentle, lower slopes. It was also found on river terraces in the valleys of the Snake and Clearwater rivers. Sites were typically dominated by *Sporobolus cryptandrus*, although *Poa secunda* was common but varied in abundance. *Aristida purpurea var. longiseta (= Aristida longiseta)* and *Hesperostipa comata (= Stipa comata)* were also frequently present in low abundance.

A *Sporobolus cryptandrus* Shrub Herbaceous Alliance was described from Montana, Idaho and New Mexico (Natureserve 2002). In New Mexico, the alliance occurred in the northwestern part of the state on alluvial flats at an elevation of approximately 2140 m. The climate was semi-arid with most of the highly variable annual precipitation falling during the summer as high-intensity storms. Sites are nearly level, soils are calcareous, loamy and generally less than 25 cm deep.

3.3.17 *Artemisia cana / Stipa comata* Association

Silver sagebrush / needle and thread

A similar community type has been described in several sources for Alberta. Holcroft Weerstra (2001) describe an *Artemisia cana / Stipa comata* community that was found to occur along old river terraces, badlands, ravine side slopes and valley walls on a range of parent materials, but occurred most often on sandy glacial drift and alluvium. Adams *et al.* (1997) also described an *Artemisia cana / Calamovilfa longifolia – Stipa comata* from CFB-Suffield in southeastern Alberta. This community was typically found on glaciofluvial channel banks, with slopes greater than 15% and also on glaciofluvial terraces, with superimposed sand dunes. On both parent materials, the soil texture was sand to loamy sand. ANHIC currently lists an *Artemisia cana / Stipa comata* Shrub Herbaceous community and an *Artemisia cana / Stipa comata – Calamovilfa longifolia* Shrub Herbaceous community, both of which are currently ranked S2S3.

Coupland (1950) described a *Rosa woodsii (Artemesia cana / Elaeagnus commutata*) community type for the prairie provinces that was found in undulating to gently rolling areas between stabilized dunes. At these locations, the water table was typically within eight to twelve feet of the soil surface. However, the author did not describe the associated graminoid composition.

Cooper *et al.* (2001) described an *Artemisia cana / Hesperostipa comata* Shrub Herbaceous Vegetation association in the Bitter Creek / Frenchman Creek area in Montana. It was considered to be a minor type, due to limited distribution of coarse textured materials. At this location, the community type was found on benches to gently inclined slopes (30% maximum recorded) in the vicinity of breaklands. This community type was found to occur on a variety of parent materials but was located dominantly on well-drained, often sandy glacial drift and sandy alluvium. The Montana Natural Heritage Program (2002) lists an *Artemisia cana / Stipa comata* Shrub Herbaceous Vegetation natural plant community for Montana. It is currently ranked S3 for the state.

Faber-Langendoen (2001) described an *Artemisia cana / Hesperostipa comata* Shrub Herbaceous Vegetation from the Midwestern United States. The author considered this community to be a small patch type, with a narrow geographic distribution, though it may be expected to occur in Saskatchewan and North Dakota. The author considered habitats with the potential to support this type to be relatively abundant, but the type itself to be comparatively uncommon. The community was typically found on well-drained benches and gently inclined landforms in a primarily agricultural landscape and thus puts it at a moderate risk for agriculture conversion. Fortunately this landform also occurred in breakland and badland environments that are less attractive for agriculture, thus reducing the risk of this type being converted to agriculture.

Natureserve (2002) reported an *Artemisia cana / Hesperostipa comata* Shrub Herbaceous Vegetation community occurring in the northwestern Great Plains. This shrub prairie association generally occurred in small patches (less than 1 hectare). Sites occurred on various parent materials, but mostly well-drained, often sandy, glacial drift and sandy alluvium. *Artemisia cana* was the dominant shrub with canopy coverages to 50 %, but averaged around 25 %.

3.4 Assignment of a Preliminary Provincial Ranking and Identification of Knowledge Gaps

The amount (i.e. proposed plant communities with only one plot) and quality of available data used to describe the proposed sand dune and sand plain community types and assign provincial rankings differed from community to community. Furthermore, mapping of community types was not a component of this project. As such, there is no spatial context to provide an estimate of how much area each community type covers. Consequently, some community types were difficult to rank due to deficient or incomplete data and a lack of spatial context. For those communities that are ranked, more information is required to confirm the proposed rank. The recommended provincial ranks for each of the proposed community types is presented below, in association with an explanation of information gaps and recommended strategies to help address these gaps.

3.4.1 *Populus deltoides / Glycyrrhiza lepidota - Juncus balticus* Association
Western cottonwood / Wild licorice – wire rush

Preliminary Rank: ***S2S3***

A review of floristically similar plant communities throughout the Great Plains region revealed that this community type had been documented only in fluvial zones within Alberta, but in a similar sand dune/plain habitat in the Great Sand Hills of Saskatchewan. A somewhat similar community has been reported in numerous states, although restricted primarily to a fluvial-dominated habitat. *Populus deltoides* is currently ranked S3 by the province and Natureserve ranks a somewhat similar community type as G3G4. A preliminary rank of S2S3 is suggested for Alberta, due to the limited number of reports of this community type in a non-fluvial environment and also due to the current ranking of *P. deltoides* as S3.

This community was found in localized depressions between sand dunes and in more open sand plain areas. It was observed in a number of locations in the Pakowki Sandhill area and in certain locales, it appeared to be co-dominated by *Populus tremuloides*. One plot indicated that *Populus tremuloides* was a co-dominant species, although it shared a high prominence of understorey species that were also found in the *Populus deltoides* dominated plots. With limited plot data, it was difficult to assign a new community type based solely on one plot. As such it was included with this community type, but may indeed represent a different community type. Additional surveys of the Pakowki and other mixedgrass sandhill areas would be advantageous to identify this potential type.

3.4.2 Rosa woodsii / Sporobolus cryptandrus Association

Common wild rose / sand dropseed

Preliminary Rank: ***S3?***

Despite *Rosa woodsii* being a widely distributed and often abundant species, little information could be found documenting *Rosa woodsii* dominated plant community types. A prior survey of the Pakowki Sandhills (Komex 1993) noted its presence and a survey of the Great Sand Dunes mentioned that *Rosa woodsii* dominated communities could be dominant in leeward areas where sand accumulation was occurring (Epp and Townley-Smith 1980). It was also listed as a community type in two locations for the state of Montana, where it is ranked G5/S5 and is a reported plant community type for Idaho. Unfortunately no floristic or habitat descriptions accompany these records.

Considering that *Sporobolus cryptandrus* is currently ranked S3 by the province of Alberta and its limited documentation as a mixedgrass or sand hill community in the literature, a preliminary rank of S3? is recommended until additional information regarding this potential community type becomes available.

3.4.3 Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus Association

Peach-leaf willow – common wild rose / wire rush – sand dropseed

Preliminary Rank: ***S3?***

Little information could be found documenting *Salix amygdaloides* dominated plant community types within Alberta. A prior survey of the Pakowki Sandhills (Komex 1993) noted its presence as both a shrub and a tree, in low-lying areas and a survey of CFB – Suffield noted a general *Salix* spp. / *Stipa comata* association along the floodplains and terraces of the South Saskatchewan River (Jaques 1977). Macdonald (1996) noted that *Salix amygdaloides* was an infrequent component in these wetter habitat types. Documentation of *Salix amygdaloides* or *Salix amygdaloides* / *Salix exigua* Woodlands along riparian zones exists for a number of Great Plains and Northern Rocky Mountain states. However, the habitat of these communities differs somewhat, in that periodic flooding or soil saturation is considered to be a natural factor in the riparian-type *Salix amygdaloides*-dominated communities.

Considering that *Salix amygdaloides* and *Sporobolus cryptandrus* are currently ranked S3 by the province of Alberta and its limited documentation as a mixedgrass or sandhill community in the literature, a preliminary rank of S3? is recommended until additional information regarding this potential community type becomes available.

3.4.4 *Elaeagnus commutata / Glycyrrhiza lepidota* Association

Silverberry / wild licorice

Preliminary Rank: ***S2***

A survey of Dillberry Provincial Park reported a meadow *Elaeagnus commutata* community with *Glycyrrhiza lepidota* and *Juncus balticus* and *Calamovilfa longifolia*. Wheatley and Bentz (2002) suggested a preliminary ranking of S2 for this community type. An *Elaeagnus commutata / Symphoricarpos occidentalis – Rosa woodsii / Poa palustris* was also described from the Central Parkland occurring near Wainwright on subxeric to submesic dune sites with good internal soil drainage (Fehr 1984), which was ranked SU (Wheatley and Bentz 2002). Currently, ANHIC lists an *Elaeagnus commutata / Pascopyrum smithii* Shrubland community for the Grassland Natural Region and it is ranked S3 (Allen 2002).

A preliminary rank of S2 is suggested for this community type, as it shares a similar floristic composition as the community type reported for Dillberry Provincial Park. Although it was not found in the immediate vicinity of a lake, it was found in depressional, moisture-receiving locations between sand dunes.

3.4.5 *Elaeagnus commutata / Artemisia ludoviciana - Calamovilfa longifolia* Association

Silverberry / Prairie sagewort – sand grass

Preliminary Rank: ***S2?***

A survey of Dillberry Provincial Park reported a meadow *Elaeagnus commutata* community with *Glycyrrhiza lepidota* and *Juncus balticus* and *Calamovilfa longifolia*. Wheatley and Bentz (2002) suggested a preliminary ranking of S2 for this community type. An *Elaeagnus commutata / Symphoricarpos occidentalis – Rosa woodsii / Poa palustris* community was also described from Central Parkland occurring near Wainwright on subxeric to submesic dune sites with good internal soil drainage (Fehr 1984), which was ranked SU (Wheatley and Bentz 2002). Currently, ANHIC lists an *Elaeagnus commutata / Pascopyrum smithii* Shrubland community for the Grassland Natural Region and it is ranked S3 (Allen 2002).

A preliminary rank of S2? is suggested for this community type, as there is only one sample plot from the Pakowki Sandhills area and it shares some floristic and environmental characteristics with the community type described above. Further sampling in the Pakowki Sandhills and other sandhill and sand plains areas could help to clarify the status of this community type.

3.4.6 *Prunus virginiana / Calamovilfa longifolia* Association
Choke cherry – sand grass

Preliminary Rank: ***S4***

A prior survey of the Pakowki Sandhills (Komex 1993) noted dense *Prunus virginiana* thickets along low dune ridges and slopes, but did not provide a further description of this type. In Montana, a *Prunus virginiana* Shrubland was found as a small patch community within the Medicine Lake Sandhills (Heidel *et al.* 2000) although elsewhere in the state it is considered a riparian community. Montana and Natureserve (MNHP 2002; Natureserve 2002) currently rank this community type as G4Q/S4. In Alberta, *Prunus virginiana* is currently ranked as S5 while *Calamovilfa longifolia* is ranked S4. As such, a preliminary rank of S4 is recommended for the *Prunus virginiana / Calamovilfa longifolia* community type.

3.4.7 *Eurotia lanata / Stipa comata – Calamovilfa longifolia* Association
Winter fat / needle and thread – sand grass

Preliminary Rank: ***S4?***

Little information could be found documenting *Eurotia lanata* dominated plant community types within Alberta or Saskatchewan. A prior survey of the Pakowki Sandhills (Komex 1993) noted its presence in association with *Bouteloua gracilis – Stipa comata* on relatively level sites. Looman (1980) also noted that is a component of a *Stipa comata* grassland association. Several descriptions of a *Eurotia lanata* dominated plant community type exist for the Great Plains and Midwestern regions of the United States. Both Montana (MNHP 2002) and Natureserve (2002) report a *Krascheninnikovia lanata / Hesperostipa comata* dwarf shrubland association, which is ranked as G3/S3. Currently ANHIC ranks *Eurotia lanata* and *Calamovilfa longifolia* as S4, while *Stipa comata* is ranked S5. Therefore, due to the lack of information regarding this community type in Alberta and the individual rankings for each of the component species, a preliminary rank of S4? is recommended for this community type.

3.4.8 *Salix exigua / Glycyrrhiza lepidota - Juncus balticus* Association
Sandbar willow / wild licorice – wire rush

Preliminary Rank: ***SU***

No information related to a *Salix exigua* dominated shrubland could be found from within Canada. Several *Salix exigua* dominated community types from the Great Plains and Midwestern regions of the United States were found, but in most instances the community types were associated with riparian habitats and experienced seasonally or temporary flooding. ANHIC currently ranks *Salix exigua* and *Juncus balticus* as S5 while

Glycyrrhiza lepidota is ranked as S4. Despite the relative widespread distribution of the dominant species, little is recorded relating this community type to sandhill and sand plain habitats. As such a preliminary rank of SU is recommended while further studies are conducted to clarify the status of this community type.

3.4.9 Glycyrrhiza lepidota - Calamovilfa longifolia Association
Wild licorice – sand grass

Preliminary Rank: ***SU***

Very little information exists in either Canada or the United States regarding *Glycyrrhiza lepidota* dominated community types. A prior survey of the Pakowki Sandhills (Komex 1993) noted *Glycyrrhiza lepidota* occurring with *Calamovilfa longifolia* and *Artemisia ludoviciana*. The Montana Natural Heritage Program (2002) notes a *Glycyrrhiza lepidota* herbaceous vegetation association as a natural plant community for the state, but provides a ranking of S?. Consequently, a preliminary rank of SU is recommended while further studies are conducted to clarify the status of this community type.

3.4.10 Glycyrrhiza lepidota – Artemisia spp. - Stipa comata Association
Wild licorice – sage – needle and thread

Preliminary Rank: ***SU***

Very little information exists in either Canada or the United States regarding *Glycyrrhiza lepidota* dominated community types. A prior survey of the Pakowki Sandhills (Komex 1993) noted *Glycyrrhiza lepidota* occurring with *Calamovilfa longifolia* and *Artemisia ludoviciana*. The Montana Natural Heritage Program (2002) notes a *Glycyrrhiza lepidota* herbaceous vegetation association as a natural plant community for the state, but provides a ranking of S?. Consequently, a preliminary rank of SU is recommended while further studies are conducted to clarify the status of this community type.

3.4.11 Rumex venosus Association
Wild begonia

Preliminary Rank: ***SU***

Very little information exists in either Canada or the United States regarding *Rumex venosus* dominated community types. No references to any community types could be found in Alberta, although Looman (1980) notes a *Rumex venosus* Alliance for the Canadian Prairie Provinces, where it tends to occur on highly mobile sand dunes. Epp and Townley-Smith (1980) also noted that *Rumex venosus* could be prominent on active sand dunes in Saskatchewan, though it is not described as a community type per-se. Consequently, a preliminary rank of SU is recommended while further studies are conducted to clarify the status of this community type.

3.4.12 Oryzopsis hymenoides – Sporobolus cryptandrus Association
Indian rice grass – sand dropseed Association

Preliminary Rank: ***S3***

Very little information exists in Alberta or other prairie provinces regarding *Oryzopsis hymenoides – Sporobolus cryptandrus* communities. One report exists of a *Carex foenea – Calamovilfa longifolia – Elymus Canadensis – Oryzopsis hymenoides* community from an active blowout in the Wainwright sand dune area. However, the species present in this dune community are rather different than those found in the Pakowki Sandhills. Several surveys from Saskatchewan report a *Psoralea lanceolata – Oryzopsis hymenoides* community type in active sand dunes, but not an *Achnatherum hymenoides – Sporobolus cryptandrus* community type. In the United States, the *Oryzopsis hymenoides – Psoralidium lanceolata* community type has been described for Montana (Heidel *et al.* 2000) and is ranked G3Q / S? by the Montana Natural Heritage Program (2002). Natureserve (2002) also reports an *Achnatherum hymenoides* Herbaceous Alliance that is found on active sand dunes throughout the Great Plains and upland plateaus, but alliances are not given conservation ratings.

ANHIC currently ranks *Oryzopsis hymenoides* as S3S4 and *Sporobolus cryptandrus* as S3. Therefore, due to the limited area in which this community type was found, limited reports of similar community types and the component species current rankings, a preliminary ranking of S3 is recommended for this community type.

3.4.13 Stipa comata – Oryzopsis hymenoides Association
Needle and thread – Indian rice grass

Preliminary Rank: ***S2S3***

Very little information exists in Alberta or other prairie provinces regarding *Stipa comata – Oryzopsis hymenoides* communities. One report exists of a *Carex foenea – Calamovilfa longifolia – Elymus Canadensis – Oryzopsis hymenoides* community from an active blowout in the Wainwright sand dune area. However, the species present in this dune community are rather different than those found in the Pakowki Sandhills. Several surveys in Saskatchewan report *Stipa comata* dominated communities on both upland prairie and sand dune habitats, but not in association with *Oryzopsis hymenoides*. Natureserve (2002) reports two potentially related community types. One is an *Hesperostipa comata – Achnatherum hymenoides* association that is ranked G2 but has not been found outside the Great Divide Basin in Wyoming. The other similar type listed is an *Hesperostipa comata* Bunch Herbaceous Vegetation Alliance, from the Wyoming Basin, Colorado Plateau, Great Basin and Columbia Plateau. However, this alliance is not rated and it is also noted to not occur on dunes.

ANHIC currently ranks *Oryzopsis hymenoides* as S3S4 and *Stipa comata* S5. However, based on its similarities with the similar reported association in Natureserve (2002) and

the ANHIC ranking for *Oryzopsis hymenoides*, a preliminary ranking of S2S3 is suggested for this community type.

*3.4.14 Artemisia spp. - Stipa comata – Calamovilfa longifolia A*ssociation

Sage – needle and thread – sand grass

Preliminary Rank: ***S3S4***

Several similar community types have been reported for Alberta and Saskatchewan, although they vary somewhat in species composition and habitat. Smoliak (1984) reports two related community types, one on sandy upland prairie and the other on moist, coulee bottoms in the Manyberries region. Adams *et al.* (1997) reported a similar community type, though lacking the *Artemisia* spp. on coarse textured fluvial and glaciofluvial deposits in CFB-Suffield. Hulett *et al.* (1966) also report a community on partially stabilized dunes with a similar floristic composition.

Natureserve (2002) reports a related association, however this community type places *Calamovilfa longifolia* as the dominant grass. Furthermore, although *Artemisia* spp. are noted to be present in certain habitats, they are not considered to be a diagnostic species in the association. This association is ranked as G3. ANHIC ranks *Hesperostipa comata* as S5 and *Calamovilfa longifolia* as S4. Based on the documentation of this community type and similar reported types, a preliminary ranking of S3S4 is suggested for the *Artemisia spp. - Hesperostipa comata – Calamovilfa longifolia* community type.

3.4.15 Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia Association

Needle and thread – sand nut-grass – sand grass

Preliminary Rank: ***S2?***

Several similar community types have been reported for Alberta and Saskatchewan, although they vary somewhat in species composition and habitat. Smoliak (1984) reports two related community types, one on sandy upland prairie and the other on moist, coulee bottoms in the Manyberries region. Adams *et al.* (1997) reported a similar community type, on coarse textured fluvial and glaciofluvial deposits in CFB-Suffield. Hulett *et al.* (1966) also report a community on partially stabilized dunes with a similar floristic composition.

Natureserve (2002) reports a related association, however this community type places *Calamovilfa longifolia* as the dominant grass and does not mention the presence of *Cyperus schweinitzii*. This association is ranked as G3. ANHIC ranks *Stipa comata* as S5, *Cyperus schweinitzii* as S2 and *Calamovilfa longifolia* as S4. Based on the documentation of this community type and similar reported types, a preliminary ranking of S2? is suggested for the *Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* community type.

3.4.16 Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides Association

Sand dropseed – sand grass – Indian rice grass

Preliminary Rank: ***S2S3***

Several similar community types have been reported for Alberta and Saskatchewan, although they vary somewhat in species composition and habitat. Wheatley and Bentz (2002) and Meijer and Karpuk (1999) report a related *Sporobolus cryptandrus – Calamovilfa longifolia – Koeleria macrantha – Carex obtusata* community type from the Central Parkland and it was assigned a preliminary rank of S3. Reports of similar community types by Looman (1980) and Thorpe and Godwin (1993) also exist from Saskatchewan. Natureserve (2002) also reports several related *Sporobolus cryptandrus* dominated Herbaceous Alliances, although the habitat varies somewhat. Unfortunately, the alliances are not provided with a conservation ranking.

Based on previous reported rankings for similar communities (ANHIC S2 for a *Sporobolus cryptandrus* active dune community) and ANHIC's S3 ranking of *Sporobolus cryptandrus*, a preliminary ranking of S2S3 is suggested for the *Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides* community type.

3.4.17 Artemisia cana / Stipa comata Association

Silver sagebrush / needle and thread

Preliminary Rank: ***S2S3***

This community is currently tracked by ANHIC for the Grassland Natural Region and is ranked S2S3. The distribution and area of the *Artemisia cana / Stipa comata* community in the Pakowki Sandhills was rather limited and thus does not justify altering the ranking based on an increase in reported area.

4.0 Conclusion

The preliminary classification of the Pakowki Sandhills communities based on the analysis of plot data and a comparison with community types described in existing literature, revealed 17 community types. Community types included all classes, except Non-Vascular and Sparse. All proposed community types were described and assigned a suggested preliminary ranking. Cross-reference tables were created to present similar communities described in the literature, rate their similarity with the Pakowki Sandhills communities and explain their relation to the proposed community types. Knowledge gaps were identified and strategies to address these gaps were provided where possible.

Several difficulties were encountered which should be noted. In the literature, community type descriptions vary from a single sentence to extremely detailed descriptions and in most instances, there is insufficient information to adequately describe community structure and assign a conservation rank (i.e. based on distribution and abundance). No quantification of area for community types could be found in the literature, aside from qualitative notes such as 'widely distributed' or 'abundant.' Furthermore, no quantification of the area of community types was required for this project. As such, determining the areal coverage of community types was done through observation and estimation. Mapping of community types at a relatively detailed scale would provide a greater confidence behind the estimation of conservation ranks for this project and provide a means to track impacts on community types in the future.

The information in this report can be used to update the community-tracking list by including new community types. Finally, this report can also be used to decide which community types require further studies and to prioritize these studies.

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Appendix 1. Glossary of Scientific and Common Plant Species Names

Scientific Name	Common Name
Acer negundo	Manitoba maple
Achillea millefolium	common yarrow
Achnatherum hymenoides	Indian rice grass
Agropyron dasystachyum	northern wheat grass
Agropyron fragile	Siberian wheat grass
Agropyron sibiricum	Siberian wheat grass
Agropyron smithii	western wheat grass
Agropyron trachycaulum	slender wheat grass
Agrostis stolonifera	creeping bentgrass
Ambrosia acanthicarpa	bur ragweed
Ambrosia psilostachya	perennial ragweed
Antennaria microphylla	little-leaf pussytoes
Antennaria parvifolia	small-leave pussytoes
Aristida purpurea var. longiseta	Fendler threeawn
Artemisia campestris	field sagewort
Artemisia cana	silver sagebrush
Artemisia frigida	pasture sagewort
Artemisia ludoviciana	prairie sagewort
Artemisia tridentata ssp. wyomingensis	Wyoming big sagebrush
Artemisia spp.	sage
Bouteloua gracilis	blue grama
Bromus tectorum	cheatgrass
Calamovilfa longifolia	sand grass
Carex emoryi	Emory's sedge
Carex foenea	dryspike sedge
Carex lanuginosa	wooly sedge
Carex obtusata	blunt sedge
Carex pellita	wooly sedge
Carex pensylvanica	sunloving sedge
Cenchrus longispinus	mat sandbur
Cerastium arvense	field chickweed
Chamaesyce serpyllifolia	thymeleaf sandmat
Chenopodium fremontii	Fremont's goosefoot
Chenopodium pratericola	desert goosefoot
Chenopodium subglabrum	smooth narrow-leaved goosefoot
Cirsium arvense	Canada thistle
Cleome serrulata	bee plant
Cornus sericea	redosier dogwood
Coryphantha vivipara	cushion cactus
Cryptantha fendleri	Fendler's cryptanth
Cyperus schweinitzii	sand nut-grass
Descurainia sophia	flixweed
Echinacea angustifolia	blacksamson echinacea
Elaeagnus angustifolia	Russian olive
Elaeagnus commutata	silver-berry
Elymus canadensis	Canada wild rye
Elymus lanceolatus ssp. lanceolatus	northern wheat grass
Equisetum arvense	common horsetail
Equisetum hyemale	scouring rush
Erigeron caespitosus	tufted fleabane
Escobaria vivipara	cushion cactus
Euphorbia esula	leafy spurge
Eurotia lanata	winter fat

Scientific Name	Common Name
Franseria acanthicarpa	bur ragweed
Fraxinus pennsylvanica	green ash
Glycyrrhiza lepidota	wild licorice
Grindelia squarrosa	curlycup gumweed
Helianthus annuus	common annual sunflower
Helianthus couplandii	annual sunflower
Helianthus pauciflorus ssp. subrhomboideus	rhombic-leaved sunflower
Helianthus petiolaris	prairie sunflower
Helianthus subrhomboideus	rhombic-leaved sunflower
Hesperostipa comata	needle-and-thread grass
Heterotheca villosa	golden aster
Juncus balticus	wire rush
Kochia scoparia	Mexican-fireweed
Koeleria macrantha	June grass
Krascheninnikovia lanata	winter fat
Lactuca pulchella	common blue lettuce
Lactuca tartarica var. pulchella	common blue lettuce
Lepidium densiflorum	common peppergrass
Leymus canadensis	Canada wild rye
Liatris punctata	dotted blazingstar
Lygodesmia rostrata	annual skeleton-weed
Maianthemum stellata	star-flowered Solomon's seal
Melilotus spp.	sweet-clover
Mentha arvensis	wild mint
Oenothera nuttallii	white evening primrose
Opuntia macrorhiza	twistspine pricklypear
Opuntia polyacantha	prickly pear
Oryzopsis hymenoides	Indian rice grass
Pascopyrum smithii	western wheat grass
Phalaris arundinacaea	reed canarygrass
Phyla lanceolata	lanceleaf fogfruit
Plantago patagonica	wooly plantain
Poa palustris	fowl bluegrass
Poa pratensis	Kentucky bluegrass
Poa secunda	Sandberg bluegrass
Populus angustifolia	narrow-leaf cottonwood
Populus deltoides	western cottonwood
Populus fremontii	Fremont cottonwood
Populus tremuloides	aspen
Potentilla pensylvanica	Pennsylvania cinquefoil
Prunus americana	American plum
Prunus virginiana	chokecherry
Psoralea lanceolata	lemon scurfpea
Psoralidium lanceolatum	lemon scurfpea
Ribes oxyacanthoides	wild gooseberry
Rosa acicularis	prickly rose
Rosa woodsii	common wild rose
Rumex venosus	wild begonia / veined dock
Salix amygdaloides	peachleaf willow
Salix bebbiana	Bebb's willow
Salix exigua	sandbar willow
Salix interior	sandbar willow
Salix lutea	yellow willow

Scientific Name	Common Name
Salix spp.	willow
Salsola kali	Russian thistle
Schizachyrium scoparium	little bluestem
Shinnersoseris rostrata	annual skeleton-weed
Smilacina stellata	star-flowered Solomon's seal
Solidago canadensis	Canada goldenrod
Solidago missouriensis	Missouri goldenrod
Spartina pectinata	prairie cord grass
Sporobolus cryptandrus	sand dropseed
Stipa comata	needle-and thread grass
Symphoricarpos occidentalis	buckbrush
Taraxacum officinale	common dandelion
Thermopsis rhombifolia	golden bean
Tragopogon dubius	goat's beard

Common Name	Scientific Name
American plum	*Prunus americana*
annual skeleton-weed	*Lygodesmia rostrata*
annual skeleton-weed	*Shinnersoseris rostrata*
annual sunflower	*Helianthus couplandii*
aspen	*Populus tremuloides*
Bebb's willow	*Salix bebbiana*
bee plant	*Cleome serrulata*
blacksamson echinacea	*Echinacea angustifolia*
blue grama	*Bouteloua gracilis*
blunt sedge	*Carex obtusata*
buckbrush	*Symphoricarpos occidentalis*
bur ragweed	*Ambrosia acanthicarpa*
bur ragweed	*Franseria acanthicarpa*
Canada goldenrod	*Solidago canadensis*
Canada thistle	*Cirsium arvense*
Canada wild rye	*Elymus canadensis*
Canada wild rye	*Leymus canadensis*
cheatgrass	*Bromus tectorum*
chokecherry	*Prunus virginiana*
common annual sunflower	*Helianthus annuus*
common blue lettuce	*Lactuca pulchella*
common blue lettuce	*Lactuca tartarica var. pulchella*
common dandelion	*Taraxacum officinale*
common horsetail	*Equisetum arvense*
common peppergrass	*Lepidium densiflorum*
common wild rose	*Rosa woodsii*
common yarrow	*Achillea millefolium*
creeping bentgrass	*Agrostis stolonifera*
curlycup gumweed	*Grindelia squarrosa*
cushion cactus	*Coryphantha vivipara*
cushion cactus	*Escobaria vivipara*
desert goosefoot	*Chenopodium pratericola*
dotted blazingstar	*Liatris punctata*
dryspike sedge	*Carex foenea*
Emory's sedge	*Carex emoryi*
Fendler threeawn	*Aristida purpurea var. longiseta*
Fendler's cryptanth	*Cryptantha fendleri*
field chickweed	*Cerastium arvense*
field sagewort	*Artemisia campestris*
flixweed	*Descurainia sophia*
fowl bluegrass	*Poa palustris*
Fremont cottonwood	*Populus fremontii*
Fremont's goosefoot	*Chenopodium fremontii*
goat's beard	*Tragopogon dubius*
golden aster	*Heterotheca villosa*
golden bean	*Thermopsis rhombifolia*
green ash	*Fraxinus pennsylvanica*
Indian rice grass	*Achnatherum hymenoides*
Indian rice grass	*Oryzopsis hymenoides*
June grass	*Koeleria macrantha*
Kentucky bluegrass	*Poa pratensis*
lanceleaf fogfruit	*Phyla lanceolata*

Common Name	Scientific Name
leafy spurge	*Euphorbia esula*
lemon scurfpea	*Psoralea lanceolata*
lemon scurfpea	*Psoralidium lanceolatum*
little bluestem	*Schizachyrium scoparium*
little-leaf pussytoes	*Antennaria microphylla*
Manitoba maple	*Acer negundo*
mat sandbur	*Cenchrus longispinus*
Mexican-fireweed	*Kochia scoparia*
Missouri goldenrod	*Solidago missouriensis*
narrow-leaf cottonwood	*Populus angustifolia*
needle-and thread grass	*Stipa comata*
needle-and-thread grass	*Hesperostipa comata*
northern wheat grass	*Agropyron dasystachyum*
northern wheat grass	*Elymus lanceolatus ssp. lanceolatus*
pasture sagewort	*Artemisia frigida*
peachleaf willow	*Salix amygdaloides*
Pennsylvania cinquefoil	*Potentilla pensylvanica*
perennial ragweed	*Ambrosia psilostachya*
prairie cord grass	*Spartina pectinata*
prairie sagewort	*Artemisia ludoviciana*
prairie sunflower	*Helianthus petiolaris*
prickly pear	*Opuntia polyacantha*
prickly rose	*Rosa acicularis*
redosier dogwood	*Cornus sericea*
reed canarygrass	*Phalaris arundinacaea*
rhombic-leaved sunflower	*Helianthus pauciflorus ssp. subrhomboideus*
rhombic-leaved sunflower	*Helianthus subrhomboideus*
Russian olive	*Elaeagnus angustifolia*
Russian thistle	*Salsola kali*
sage	*Artemisia spp.*
sand dropseed	*Sporobolus cryptandrus*
sand grass	*Calamovilfa longifolia*
sand nut-grass	*Cyperus schweinitzii*
sandbar willow	*Salix exigua*
sandbar willow	*Salix interior*
Sandberg bluegrass	*Poa secunda*
scouring rush	*Equisetum hyemale*
Siberian wheat grass	*Agropyron fragile*
Siberian wheat grass	*Agropyron sibiricum*
silver sagebrush	*Artemisia cana*
silver-berry	*Elaeagnus commutata*
slender wheat grass	*Agropyron trachycaulum*
small-leave pussytoes	*Antennaria parvifolia*
smooth narrow-leaved goosefoot	*Chenopodium subglabrum*
star-flowered Solomon's seal	*Maianthemum stellata*
star-flowered Solomon's seal	*Smilacina stellata*
sunloving sedge	*Carex pensylvanica*
sweet-clover	*Melilotus spp.*
thymeleaf sandmat	*Chamaesyce serpyllifolia*
tufted fleabane	*Erigeron caespitosus*
twistspine pricklypear	*Opuntia macrorhiza*
western cottonwood	*Populus deltoides*
western wheat grass	*Agropyron smithii*

Common Name	**Scientific Name**
western wheat grass	*Pascopyrum smithii*
white evening primrose	*Oenothera nuttallii*
wild begonia / veined dock	*Rumex venosus*
wild gooseberry	*Ribes oxyacanthoides*
wild licorice	*Glycyrrhiza lepidota*
wild mint	*Mentha arvensis*
willow	*Salix spp.*
winter fat	*Eurotia lanata*
winter fat	*Krascheninnikovia lanata*
wire rush	*Juncus balticus*
wooly plantain	*Plantago patagonica*
wooly sedge	*Carex lanuginosa*
wooly sedge	*Carex pellita*
Wyoming big sagebrush	*Artemisia tridentata ssp. wyomingensis*
yellow willow	*Salix lutea*

Appendix 2. PC-ORD Output from Detrended Correspondence Analysis of Plot Data

```
****************** Detrended Correspondence Analysis (DCA) ******************
PC-ORD, Version 4.20
25 Nov 2002, 13:01

SAND DUNE COMMUNITIES
Number of non-zero data items:      497

Downweighting selected.  Weights applied to columns, in sequential order:
 0.615 0.300 0.300 0.300 0.300 0.565 0.565 0.300 0.300 0.300
 1.000 0.916 0.913 0.559 1.000 1.000 0.300 0.392 0.300 0.300
 0.300 0.900 0.900 0.600 1.000 0.600 0.300 1.000 1.000 1.000
 0.600 1.000 1.000 1.000 1.000 1.000 0.600 1.000 0.540 1.000
 1.000 1.000 0.300 0.663 0.700 1.000 1.000 0.300 0.800 1.000
 0.600 0.300 0.426 1.000 1.000 1.000 1.000 0.300 0.900 0.833
 1.000 1.000 1.000 1.000 1.000

Axes are rescaled

Number of segments: 30

Threshold:  0.00

Total variance ("inertia") in the species data:   6.2854

                    ---------- Axis 1 ----------
 0.2684242427 = residual at iteration   0
 0.0854052529 = residual at iteration   1
 0.0140371500 = residual at iteration   2
 0.0061698658 = residual at iteration   3
 0.0013625850 = residual at iteration   4
 0.0006173362 = residual at iteration   5
 0.0001402497 = residual at iteration   6
 0.0000646825 = residual at iteration   7
 0.0000148964 = residual at iteration   8
 0.0000069913 = residual at iteration   9
 0.0000016124 = residual at iteration  10
 0.0000008443 = residual at iteration  11
 0.1639871597 = residual at iteration  12
 0.0244774297 = residual at iteration  13
 0.0513806567 = residual at iteration  14
 0.0032606893 = residual at iteration  15
 0.0015779877 = residual at iteration  16
 0.0002858440 = residual at iteration  17
 0.0001657879 = residual at iteration  18
 0.0000303903 = residual at iteration  19
 0.0000178559 = residual at iteration  20
 0.0000032664 = residual at iteration  21
 0.0000019687 = residual at iteration  22
 0.0000005150 = residual at iteration  23
 0.1456906796 = residual at iteration  24
 0.0234203395 = residual at iteration  25
 0.0480892435 = residual at iteration  26
 0.0030493103 = residual at iteration  27
 0.0017713277 = residual at iteration  28
 0.0002687894 = residual at iteration  29
 0.0001558407 = residual at iteration  30
 0.0000304978 = residual at iteration  31
 0.0000175863 = residual at iteration  32
 0.0000037236 = residual at iteration  33
 0.0000022105 = residual at iteration  34
 0.0000005672 = residual at iteration  35
 0.0000004183 = residual at iteration  36
 0.0000003501 = residual at iteration  37
 0.2779901028 = residual at iteration  38
 0.0074540768 = residual at iteration  39
 0.0021347259 = residual at iteration  40
 0.0006754500 = residual at iteration  41
 0.0002074938 = residual at iteration  42
 0.0000793746 = residual at iteration  43
 0.0000260332 = residual at iteration  44
 0.0000105902 = residual at iteration  45
```

```
0.0000036683 = residual at iteration  46
0.0000015326 = residual at iteration  47
0.0000005304 = residual at iteration  48
0.0119315125 = residual at iteration  49
0.0029634687 = residual at iteration  50
0.0000002078 = residual at iteration  60
0.0000211076 = residual at iteration  70
0.0018477291 = residual at iteration  80
0.0139812361 = residual at iteration  90
0.0000005091 = residual at iteration 100
0.0000062506 = residual at iteration 110
0.0000461937 = residual at iteration 120
0.0222807173 = residual at iteration 130
0.1710713655 = residual at iteration 140
0.0000009847 = residual at iteration 150
0.0000099311 = residual at iteration 160
0.0002753049 = residual at iteration 170
0.0028829316 = residual at iteration 180
0.0192794092 = residual at iteration 190
0.0000006532 = residual at iteration 200
0.0000043344 = residual at iteration 210
0.0000274861 = residual at iteration 220
0.0097351270 = residual at iteration 230
0.0000010114 = residual at iteration 240
0.0000127912 = residual at iteration 250
0.0001706528 = residual at iteration 260
0.0005976434 = residual at iteration 270
0.0020370230 = residual at iteration 280
0.1597174108 = residual at iteration 290
0.0000015046 = residual at iteration 300
0.0000147340 = residual at iteration 310
0.0000765337 = residual at iteration 320
0.0011597162 = residual at iteration 330
0.0019860768 = residual at iteration 340
0.2260046750 = residual at iteration 350
0.0954641625 = residual at iteration 360
0.0000008501 = residual at iteration 370
0.0003140370 = residual at iteration 380
0.0263471641 = residual at iteration 390
0.1734091938 = residual at iteration 400
0.0000005903 = residual at iteration 410
0.0000467348 = residual at iteration 420
0.0000296704 = residual at iteration 430
0.0007561108 = residual at iteration 440
0.0360311270 = residual at iteration 450
0.0000008192 = residual at iteration 460
0.0002691617 = residual at iteration 470
0.0133251371 = residual at iteration 480
0.0000009775 = residual at iteration 490
0.0000034115 = residual at iteration 500
0.0019896838 = residual at iteration 510
0.0212083757 = residual at iteration 520
0.0000005526 = residual at iteration 530
0.0000056518 = residual at iteration 540
0.0001769213 = residual at iteration 550
0.0478879064 = residual at iteration 560
0.0000007582 = residual at iteration 570
0.0000120228 = residual at iteration 580
0.0004150117 = residual at iteration 590
0.0002466936 = residual at iteration 600
0.0018837127 = residual at iteration 610
0.2045992166 = residual at iteration 620
0.0000096100 = residual at iteration 630
0.0000455938 = residual at iteration 640
0.0055995947 = residual at iteration 650
0.1489204913 = residual at iteration 660
0.1107899100 = residual at iteration 670
0.0000003468 = residual at iteration 680
0.0000078266 = residual at iteration 690
0.0004097962 = residual at iteration 700
0.0000001005 = residual at iteration 710
```

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 0.0000026737 = residual at iteration 720
 0.0000636807 = residual at iteration 730
 0.0006091066 = residual at iteration 740
 0.0165218879 = residual at iteration 750
 0.0000096641 = residual at iteration 760
 0.0000374746 = residual at iteration 770
 0.0000017238 = residual at iteration 780
 0.0000040091 = residual at iteration 790
 0.0000317458 = residual at iteration 800
 0.0000037804 = residual at iteration 810
 0.0003344046 = residual at iteration 820
 0.0202178955 = residual at iteration 830
 0.0000006557 = residual at iteration 840
 0.0001674164 = residual at iteration 850
 0.0006750197 = residual at iteration 860
 0.0000157669 = residual at iteration 870
 0.0001539329 = residual at iteration 880
 0.0045301383 = residual at iteration 890
 0.1807350367 = residual at iteration 900
 0.0000009182 = residual at iteration 910
 0.0000329651 = residual at iteration 920
 0.0000177802 = residual at iteration 930
 0.0006978700 = residual at iteration 940
 0.0364268906 = residual at iteration 950
 0.0009799623 = residual at iteration 960
 0.0008513225 = residual at iteration 970
 0.1945322305 = residual at iteration 980
 0.0000022841 = residual at iteration 990
 0.0534050353 = residual at iteration 999
 0.7860396504 = eigenvalue
*** BEWARE *** RESIDUAL BIGGER THAN TOLERANCE, WHICH IS 0.0000001000

Length of gradient:     2.995
Length of segments:  0.32  0.32  0.31  0.30  0.29  0.29  0.26  0.19  0.13  0.11
Length of segments:  0.10  0.10  0.09  0.09  0.09
Length of gradient:     3.567

Length of gradient:     4.127
Length of segments:  0.24  0.24  0.22  0.20  0.19  0.20  0.21  0.21  0.21  0.19
Length of segments:  0.19  0.19  0.20  0.22  0.22  0.21  0.17  0.15  0.15  0.16
Length of segments:  0.17
Length of gradient:     4.129

                   ---------- Axis 2 ----------
 0.2091501057 = residual at iteration   0
 0.0765530691 = residual at iteration   1
 0.0229611807 = residual at iteration   2
 0.0032644884 = residual at iteration   3
 0.0007385664 = residual at iteration   4
 0.0001094733 = residual at iteration   5
 0.0000250289 = residual at iteration   6
 0.0000037378 = residual at iteration   7
 0.0000008669 = residual at iteration   8
 0.0000001618 = residual at iteration   9
 0.0000001470 = residual at iteration  10
 0.0000001581 = residual at iteration  11
 0.1715056002 = residual at iteration  12
 0.0267237853 = residual at iteration  13
 0.0032643846 = residual at iteration  14
 0.0005265863 = residual at iteration  15
 0.0000775312 = residual at iteration  16
 0.0000147603 = residual at iteration  17
 0.0000022521 = residual at iteration  18
 0.0000004430 = residual at iteration  19
 0.0000004798 = residual at iteration  20
 0.0000002632 = residual at iteration  21
 0.0000001324 = residual at iteration  22
 0.2258998752 = residual at iteration  23
 0.0052952184 = residual at iteration  24
 0.0007295895 = residual at iteration  25
 0.0000719962 = residual at iteration  26
```

```
 0.0000153151 = residual at iteration  27
 0.0000024945 = residual at iteration  28
 0.0000005695 = residual at iteration  29
 0.0000002555 = residual at iteration  30
 0.0000001209 = residual at iteration  31
 0.1649405807 = residual at iteration  32
 0.0030498444 = residual at iteration  33
 0.0001900764 = residual at iteration  34
 0.0000162592 = residual at iteration  35
 0.0000029595 = residual at iteration  36
 0.0000004602 = residual at iteration  37
 0.0000002008 = residual at iteration  38
 0.1445547491 = residual at iteration  39
 0.0134180319 = residual at iteration  40
 0.0013512193 = residual at iteration  41
 0.0001006165 = residual at iteration  42
 0.0000235098 = residual at iteration  43
 0.0000029193 = residual at iteration  44
 0.0000007032 = residual at iteration  45
 0.0000002582 = residual at iteration  46
 0.1190573350 = residual at iteration  47
 0.0200145710 = residual at iteration  48
 0.0045830240 = residual at iteration  49
 0.0006001128 = residual at iteration  50
 0.0000569950 = residual at iteration  60
 0.0000140514 = residual at iteration  70
 0.0000016084 = residual at iteration  80
 0.0000006614 = residual at iteration  90
 0.0000002011 = residual at iteration 100
 0.1686325073 = residual at iteration 110
 0.0000001987 = residual at iteration 120
 0.0245861672 = residual at iteration 130
 0.0128338402 = residual at iteration 140
 0.0009726097 = residual at iteration 150
 0.1492897719 = residual at iteration 160
 0.0230942033 = residual at iteration 170
 0.0347204730 = residual at iteration 180
 0.0006071823 = residual at iteration 190
 0.0000031297 = residual at iteration 200
 0.0000002212 = residual at iteration 210
 0.0000000478 = residual at iteration 220
 0.6630458236 = eigenvalue

Length of gradient:     2.660
Length of segments:  0.27  0.28  0.29  0.29  0.28  0.27  0.25  0.23  0.17  0.08
Length of segments:  0.06  0.06  0.06  0.06
Length of gradient:     3.499

Length of gradient:     4.663
Length of segments:  0.11  0.11  0.12  0.14  0.19  0.23  0.25  0.25  0.24  0.24
Length of segments:  0.24  0.24  0.25  0.25  0.25  0.24  0.24  0.23  0.22  0.16
Length of segments:  0.12  0.12  0.12  0.12
Length of gradient:     4.639

                    ---------- Axis 3 ----------
 0.1746972799 = residual at iteration   0
 0.0342275575 = residual at iteration   1
 0.0056336881 = residual at iteration   2
 0.0004523548 = residual at iteration   3
 0.0000723316 = residual at iteration   4
 0.0000058883 = residual at iteration   5
 0.0000009449 = residual at iteration   6
 0.0000000834 = residual at iteration   7
 0.4721443057 = eigenvalue

Length of gradient:     3.666
Length of segments:  0.13  0.14  0.15  0.19  0.23  0.28  0.31  0.32  0.30  0.28
Length of segments:  0.24  0.22  0.20  0.18  0.15  0.11  0.08  0.08  0.08
Length of gradient:     3.973

Length of gradient:     3.773
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```
Length of segments:  0.17  0.17  0.18  0.19  0.20  0.21  0.21  0.22  0.23  0.24
Length of segments:  0.23  0.22  0.20  0.18  0.18  0.18  0.18  0.18  0.19
Length of gradient:     3.695


SAND DUNE COMMUNITIES
SPECIES SCORES
```

N	NAME	AX1	AX2	AX3	RANKED 1		RANKED 2	
					EIG=0.786		EIG=0.663	
1	POPUDEL1	-37	282	387	7 PRUNVIR4	428	44 RUMEVEN6	496
2	POPUTRE2	-128	282	356	11 PRUNVIR5	424	45 FRANACA6	490
3	POPUDEL2	35	295	443	44 RUMEVEN6	405	63 ELYMCAN7	412
4	SALIAMY3	112	280	387	45 FRANACA6	402	62 ORYZHYM7	350
5	ELEACOM4	-70	149	-9	26 SALSKAL6	398	30 THERRHO6	347
6	SALIAMY4	71	330	103	28 EQUIFLU6	380	6 SALIAMY4	330
7	PRUNVIR4	428	-14	177	58 AGROSMI7	370	15 ROSAWOO5	308
8	SALIAMY5	77	239	101	41 LYGOROS6	361	27 HELISUB6	295
9	ARTECAN5	-67	87	395	62 ORYZHYM7	351	3 POPUDEL2	295
10	RIBEOXY5	14	262	26	50 HELIANN6	346	60 CARELAN7	292
11	PRUNVIR5	424	-15	180	63 ELYMCAN7	305	64 SPORCRY7	291
12	ELAECOM5	-27	91	-43	51 CERAARV6	296	31 TARAOFF6	289
13	SALIEXI5	-24	175	-13	33 CRYPFEN6	281	1 POPUDEL1	282
14	EUROLAN5	206	112	282	65 CALALON7	246	2 POPUTRE2	282
15	ROSAWOO5	116	308	38	64 SPORCRY7	236	4 SALIAMY3	280
16	SOLIMIS6	104	197	201	57 AGRODAS7	235	52 BOUTGRA7	280
17	PLANPAT6	-425	49	370	18 ARTECAM	228	59 AGROSIB7	278
18	ARTECAM	228	94	306	40 CHENFRE6	226	37 SMILSTE6	265
19	ERIGCAE6	-67	87	395	49 LATUPUL6	215	49 LATUPUL6	265
20	POTEPEN6	-67	87	395	34 CHENSUB6	211	10 RIBEOXY5	262
21	ANTEPAR6	-67	87	395	14 EUROLAN5	206	39 SOLICAN6	249
22	LEPIDEN6	-46	70	380	46 CHRYVIL6	197	54 JUNCBAL7	249
23	ACHIMIL6	-99	96	353	42 OPUNPOL6	191	50 HELIANN6	245
24	CLEOSER6	66	184	391	53 CYPESCH7	175	61 POAPRA7	241
25	CORYMIS6	-136	111	338	35 CHENPRA6	165	8 SALIAMY5	239
26	SALSKAL6	398	1	270	55 STIPCOM7	135	48 ANTIMIC6	239
27	HELISUB6	35	295	443	30 THERRHO6	134	43 OENONUT6	233
28	EQUIFLU6	380	33	364	38 ARTEFRI6	117	32 TRAGDUB6	230
29	ARTELUD6	26	137	187	15 ROSAWOO5	116	47 GLYCLEP6	213
30	THERRHO6	134	347	210	4 SALIAMY3	112	16 SOLIMIS6	197
31	TARAOFF6	110	289	406	52 BOUTGRA7	112	40 CHENFRE6	197
32	TRAGDUB6	-54	230	300	56 KOELMAC7	112	36 DESCSOP6	192
33	CRYPFEN6	281	40	261	31 TARAOFF6	110	24 CLEOSER6	184
34	CHENSUB6	211	136	250	16 SOLIMIS6	104	13 SALIEXI5	175
35	CHENPRA6	165	161	329	60 CARELAN7	81	46 CHRYVIL6	168
36	DESCSOP6	-20	192	378	8 SALIAMY5	77	35 CHENPRA6	161
37	SMILSTE6	-69	265	388	48 ANTIMIC6	77	5 ELEACOM4	149
38	ARTEFRI6	117	127	319	6 SALIAMY4	71	29 ARTELUD6	137
39	SOLICAN6	-47	249	251	24 CLEOSER6	66	34 CHENSUB6	136
40	CHENFRE6	226	197	310	59 AGROSIB7	60	56 KOELMAC7	131
41	LYGOROS6	361	37	60	3 POPUDEL2	35	38 ARTEFRI6	127
42	OPUNPOL6	191	78	290	27 HELISUB6	35	14 EUROLAN5	112
43	OENONUT6	-192	233	93	47 GLYCLEP6	30	25 CORYMIS6	111
44	RUMEVEN6	405	496	182	29 ARTELUD6	26	53 CYPESCH7	110
45	FRANACA6	402	490	216	54 JUNCBAL7	17	23 ACHIMIL6	96
46	CHRYVIL6	197	168	254	10 RIBEOXY5	14	55 STIPCOM7	96
47	GLYCLEP6	30	213	189	36 DESCSOP6	-20	18 ARTECAM	94
48	ANTIMIC6	77	239	101	13 SALIEXI5	-24	12 ELAECOM5	91
49	LATUPUL6	215	265	16	12 ELAECOM5	-27	51 CERAARV6	89
50	HELIANN6	346	245	199	1 POPUDEL1	-37	9 ARTECAN5	87
51	CERAARV6	296	89	205	22 LEPIDEN6	-46	19 ERIGCAE6	87
52	BOUTGRA7	112	280	387	39 SOLICAN6	-47	20 POTEPEN6	87
53	CYPESCH7	175	110	290	32 TRAGDUB6	-54	21 ANTEPAR6	87
54	JUNCBAL7	17	249	227	61 POAPRA7	-55	42 OPUNPOL6	78
55	STIPCOM7	135	96	334	21 ANTEPAR6	-67	65 CALALON7	76
56	KOELMAC7	112	131	234	19 ERIGCAE6	-67	22 LEPIDEN6	70
57	AGRODAS7	235	57	76	9 ARTECAN5	-67	57 AGRODAS7	57
58	AGROSMI7	370	37	313	20 POTEPEN6	-67	17 PLANPAT6	49
59	AGROSIB7	60	278	87	37 SMILSTE6	-69	33 CRYPFEN6	40
60	CARELAN7	81	292	31	5 ELEACOM4	-70	58 AGROSMI7	37
61	POAPRA7	-55	241	291	23 ACHIMIL6	-99	41 LYGOROS6	37
62	ORYZHYM7	351	350	196	2 POPUTRE2	-128	28 EQUIFLU6	33

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    63 ELYMCAN7   305  412  128      |    25 CORYMIS6 -136 |    26 SALSKAL6    1 |
    64 SPORCRY7   236  291   73      |    43 OENONUT6 -192 |     7 PRUNVIR4  -14 |
    65 CALALON7   246   76   93      |    17 PLANPAT6 -425 |    11 PRUNVIR5  -15 |


SAND DUNE COMMUNITIES
SAMPLE SCORES - WHICH ARE WEIGHTED MEAN SPECIES SCORES
    N    NAME     AX1  AX2  AX3      |       RANKED 1       |       RANKED 2       |
                                      |      EIG=0.786       |      EIG=0.663       |
     1 1          257  248  141      |    10 10        412  |    30 30        463  |
     2 2           19  225  175      |    14 14        412  |     6 6         461  |
     3 3          239  252   87      |     6 6         390  |    29 29        314  |
     4 4          206  219  104      |    13 13        371  |    31 31        310  |
     5 5          140  293   55      |    30 30        367  |    21 21        305  |
     6 6          390  461  183      |    34 34        362  |    35 35        303  |
     7 7           42  215  195      |    21 21        324  |    28 28        303  |
     8 8          235  140  252      |    37 37        307  |    26 26        300  |
     9 9            0  254  278      |    35 35        282  |    37 37        297  |
    10 10         412   15  178      |    29 29        263  |     5 5         293  |
    11 11          33  168  132      |     1 1         257  |    27 27        279  |
    12 12          46  257  369      |    25 25        250  |    25 25        265  |
    13 13         371   72  170      |     3 3         239  |    12 12        257  |
    14 14         412    0  177      |     8 8         235  |     9 9         254  |
    15 15         230  196  186      |    15 15        230  |    17 17        253  |
    16 16         119  244  101      |    31 31        214  |     3 3         252  |
    17 17          13  253  307      |     4 4         206  |     1 1         248  |
    18 18           9  119    0      |    23 23        182  |    16 16        244  |
    19 19          46  176  218      |    33 33        176  |     2 2         225  |
    20 20          92  156  261      |    38 38        169  |     4 4         219  |
    21 21         324  305  185      |    40 40        163  |     7 7         215  |
    22 22         136  128  291      |    26 26        150  |    15 15        196  |
    23 23         182  146  105      |     5 5         140  |    19 19        176  |
    24 24         110  116  316      |    39 39        140  |    11 11        168  |
    25 25         250  265  197      |    22 22        136  |    36 36        157  |
    26 26         150  300   60      |    28 28        130  |    20 20        156  |
    27 27          99  279  133      |    16 16        119  |    23 23        146  |
    28 28         130  303  119      |    36 36        115  |     8 8         140  |
    29 29         263  314  125      |    24 24        110  |    22 22        128  |
    30 30         367  463  169      |    32 32         99  |    18 18        119  |
    31 31         214  310  135      |    27 27         99  |    24 24        116  |
    32 32          99   95   63      |    20 20         92  |    38 38        114  |
    33 33         176  102  259      |    19 19         46  |    40 40        107  |
    34 34         362   21  181      |    12 12         46  |    33 33        102  |
    35 35         282  303  131      |     7 7          42  |    39 39        101  |
    36 36         115  157  181      |    11 11         33  |    32 32         95  |
    37 37         307  297  156      |     2 2          19  |    13 13         72  |
    38 38         169  114  276      |    17 17         13  |    34 34         21  |
    39 39         140  101  284      |    18 18          9  |    10 10         15  |
    40 40         163  107  273      |     9 9           0  |    14 14          0  |
*************************** Calculations finished ***************************
```

Appendix 3. Species Code Descriptions

Code	Species	Stratum
POPUDEL1	*Populus deltoides*	Main Canopy Tree (> 5 m)
POPUTRE2	*Populus tremuloides*	Understorey Tree (> 5 m but at least 3 m shorter than overstorey trees)
POPUDEL2	*Populus deltoides*	Understorey Tree (> 5 m but at least 3 m shorter than overstorey trees)
SALIAMY3	*Salix amygdaloides*	Tall Shrub (2.5 m - 5 m)
ELEACOM4	*Elaeagnus commutata*	Medium Shrub (1 - 2.5 m)
PRUNVIR4	*Prunus virginiana*	Medium Shrub (1 - 2.5 m)
SALIAMY4	*Salix amygdaloides*	Medium Shrub (1 - 2.5 m)
ARTECAN5	*Artemisia cana*	Low Shrub (< 1 m)
ELAECOM5	*Elaeagnus commutata*	Low Shrub (< 1 m)
EUROLAN5	*Eurotia lanata*	Low Shrub (< 1 m)
PRUNVIR5	*Prunus virginiana*	Low Shrub (< 1 m)
RIBEOXY5	*Ribes oxyacanthoides*	Low Shrub (< 1 m)
ROSAWOO5	*Rosa woodsii*	Low Shrub (< 1 m)
SALIAMY5	*Salix amygdaloides*	Low Shrub (< 1 m)
SALIEXI5	*Salix exigua*	Low Shrub (< 1 m)
ACHIMIL6	*Achillea millefolium*	Forb / Herb
ANTIMIC6	*Antennaria microphylla*	Forb / Herb
ANTEPAR6	*Antennaria parvifolia*	Forb / Herb
ARTECAM6	*Artemisia campestris*	Forb / Herb
ARTEFRI6	*Artemisia frigida*	Forb / Herb
ARTELUD6	*Artemisia ludoviciana*	Forb / Herb
CERAARV6	*Cerastium arvense*	Forb / Herb
CHENFRE6	*Chenopodium fremontii*	Forb / Herb
CHENPRA6	*Chenopodium pratericola*	Forb / Herb
CHENSUB6	*Chenopodium subglabrum*	Forb / Herb
CLEOSER6	*Cleome serrulata*	Forb / Herb
CORYVIV6	*Coryphantha vivipara*	Forb / Herb
CRYPFEN6	*Cryptantha fendleri*	Forb / Herb
DESCSOP6	*Descurainia sophia*	Forb / Herb
EQUIHYE6	*Equisetum hyemale*	Forb / Herb
ERIGCAE6	*Erigeron caespitosus*	Forb / Herb
FRANACA6	*Franseria acanthicarpa*	Forb / Herb
GLYCLEP6	*Glycyrrhiza lepidota*	Forb / Herb
HELIANN6	*Helianthus annuus*	Forb / Herb
HELISUB6	*Helianthus subrhomboideus*	Forb / Herb
HETEVIL6	*Heterotheca villosa*	Forb / Herb
LATUPUL6	*Lactuca pulchella*	Forb / Herb
LEPIDEN6	*Lepidium densiflorum*	Forb / Herb
LYGOROS6	*Lygodesmia rostrata*	Forb / Herb
OENONUT6	*Oenothera nuttallii*	Forb / Herb
OPUNPOL6	*Opuntia polyacantha*	Forb / Herb
PLANPAT6	*Plantago patagonica*	Forb / Herb
POTEPEN6	*Potentilla pensylvanica*	Forb / Herb
RUMEVEN6	*Rumex venosus*	Forb / Herb
SALSKAL6	*Salsola kali*	Forb / Herb
SMILSTE6	*Smilacina stellata*	Forb / Herb
SOLICAN6	*Solidago canadensis*	Forb / Herb
SOLIMIS6	*Solidago missouriensis*	Forb / Herb
TARAOFF6	*Taraxacum officinale*	Forb / Herb
THERRHO6	*Thermopsis rhombifolia*	Forb / Herb
TRAGDUB6	*Tragopogon dubius*	Forb / Herb
AGRODAS7	*Agropyron dasystachyum*	Graminoid
AGROSIB7	*Agropyron sibiricum*	Graminoid

Code	Species	Stratum
AGROSMI7	*Agropyron smithii*	Graminoid
BOUTGRA7	*Bouteloua gracilis*	Graminoid
CALALON7	*Calamovilfa longifolia*	Graminoid
CARELAN7	*Carex lanuginosa*	Graminoid
CYPESCH7	*Cyperus schweinitzii*	Graminoid
ELYMCAN7	*Elymus canadensis*	Graminoid
JUNCBAL7	*Juncus balticus*	Graminoid
KOELMAC7	*Koeleria macrantha*	Graminoid
ORYZHYM7	*Oryzopsis hymenoides*	Graminoid
POAPRA7	*Poa pratensis*	Graminoid
SPORCRY7	*Sporobolus cryptandrus*	Graminoid
STIPCOM7	*Stipa comata*	Graminoid

Appendix 4. Correlation Table with Literature From Within Alberta

Class	Community Type	Similar Communities and Citations	Similarity Rating[1]	Comments
Forest	*Populus deltoides / Glycyrrhiza lepidota / Juncus balticus*	*Populus deltoides* moist coulee community (Smoliak 1985)	3	Found occasionally in moist coulees (Manyberries). Share dominant overstorey species, but different site conditions (i.e. coulee vs. dunes). Detailed information not provided.
		Populus tremuloides / Stipa spp.- Carex rossii (Jaques 1977)	3	Found primarily in depressional areas and coulees (CFB Suffield-Middle Sandhills) where sandy soils allow deep-water percolation. Different overstorey but somewhat similar site conditions.
		Populus deltoides association (Jaques 1977)	2	Found on floodplains and alluvial terraces of South Saskatchewan river (CFB-Suffield).). Share dominant overstorey species, but different site conditions (i.e. floodplain and terraces vs. dunes). Detailed information not provided.
		Populus X jackii (Adams *et al.* 1997)	3	Noted this community type was related to the *Populus deltoides* community reported by Jaques (1977)
		*Populus tremuloides (Populus deltoides) (*Komex 1993*)*	2	Found on dunes/plains in 1993 in another survey of the Pakowki Sandhills. Noted isolated *Populus deltoides* found in low areas, though aspen clones reported being more common.
		Populus tremuloides / Symphoricarpos occidentalis (Adams *et al.* 1997)	3	Noted this community type was related to the *Populus tremuloides / Stipa spp.- Carex rossii* community reported by Jaques (1977), found in depressional areas and coulees of CFB Suffield-Middle Sandhills, in sandy soils. Different overstorey but again similar site conditions.
Shrubland	*Rosa woodsii / Sporobolus cryptandrus*	*Rosa woodsii* (Komex 1993)	1	Found on dunes in 1993 in another survey of the Pakowki Sandhills. Reported to occur in low area between dunes, often in association with wild licorice. Similar general community type described in previous survey of study area.
Shrubland	*Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus*	*Salix spp. / Stipa comata* association (Jaques 1977)	3	Found on floodplains and alluvial terraces of South Saskatchewan river (CFB-Suffield). Community found on coarse textured materials, though site conditions vary. Dominant *Salix* species unknown, thus some important differences.

[1] Similarity Rating: 1, identical to or very similar; 2, similar in most respects; 3, several similarities but important differences (scale from Corns 1983).

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus*	*Salix amygdaloides* (Komex 1993)	1	Found on dunes in 1993 in another survey of the Pakowki Sandhills. *Salix amygdaloides* found in low areas and as both tree and shrub form. Similar general community type described in previous survey of study area, however no detailed floristic or site conditions provided.
Shrubland	*Elaeagnus commutata / Glycyrrhiza lepidota*	*Elaeagnus commutata* (Wheatley and Bentz 2002)	3	Site described based on three reports in Central Parkland, at Dillberry Lake Provincial Park, near Rumsey and in Dry Island Buffalo Jump. Is described as occurring a low shrublands and shrubby meadows along perimeter of saline lakes, adjacent to marshes and graminoid meadows. Shares dominant species but site conditions vary considerably.
		Elaeagnus commutata / Symphoricarpos occidentalis – Rosa woodsii / Poa palustris (Wheatley and Bentz 2002)	3	Described from Central Parkland occurring near Wainwright on subxeric to submesic sites with good drainage. It has a well-developed low shrub layer. Different floristic composition but occurred on sites with similar moisture and soil drainage conditions.
		Elaeagnus commutata Shrubland (Komex 1993)	1	Found on dunes in 1993 in another survey of the Pakowki Sandhills. Reported to occur as thickets on some north-facing slopes and at base of some dunes. Similar general community type described in previous survey of study area, however no detailed floristic or site conditions provided.
Shrubland	*Elaeagnus commutata / Artemisia ludoviciana / Calamovilfa longifolia*	*Elaeagnus commutata* (Wheatley and Bentz 2002)	3	Site described based on three reports in Central Parkland, at Dillberry Lake Provincial Park, near Rumsey and in Dry Island Buffalo Jump. Is described as occurring a low shrublands and shrubby meadows along perimeter of saline lakes, adjacent to marshes and graminoid meadows. Shares dominant species but site conditions vary considerably.
		Elaeagnus commutata / Symphoricarpos occidentalis – Rosa woodsii / Poa palustris (Wheatley and Bentz 2002)	3	Described from Central Parkland occurring near Wainwright on subxeric to submesic sites with good drainage. It had a well-developed low shrub layer. Different floristic composition, but occurred on sites with similar moisture and soil drainage conditions.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Prunus virginiana / Calamovilfa longifolia*	*Prunus virginiana* shrubland (Komex 1993)	1	Found on dunes in 1993 in another survey of the Pakowki Sandhills. Reported to occur along low dune ridges and slopes. Similar general community type described in previous survey of study area, however no detailed floristic or site conditions provided.
		Prunus virginiana – Amelanchier alnifolia / Agropyron trachycaulum – Poa pratensis (Wheatley and Bentz 2002)	3	Was described for the Central Parkland, described from a site in the Blackfoot Provincial Recreation Area. Soils were not described but the site was a steep, south-facing slope. Some similar species noted and located on strong slope, but limited details otherwise.
Dwarf Shrubland	*Eurotia lanata / Stipa comata – Calamovilfa longifolia*	Stipa – Bouteloua – Agropyron type (Smoliak 1985)	3	Mentioned that this type is found on upland prairie, with *Eurotia lanata* as a common shrub. Very limited floristic composition provided and few site characteristics. No mention of sand as primary substrate.
Herbaceous Vegetation	*Salix exigua / Glycyrrhiza lepidota / Juncus balticus*	None described		-
	Glycyrrhiza lepidota / Calamovilfa longifolia	*Glycyrrhiza lepidota (Calamovilfa longifolia / Artemisia ludoviciana)* (Komex 1993)	1	Found on dunes in 1993 in another survey of the Pakowki Sandhills. Also reported to occur with wire rush (*Juncus balticus*). Similar general community type described in previous survey of study area, however no detailed floristic or site conditions provided.
Herbaceous Vegetation	*Glycyrrhiza lepidota – Artemisia spp. / Stipa comata*	*Glycyrrhiza lepidota (Calamovilfa longifolia / Artemisia ludoviciana)* (Komex 1993)	2	Found on dunes in 1993 in another survey of the Pakowki Sandhills. Also reported to occur with wire rush (*Juncus balticus*). Similar general community type described in previous survey of study area, however no detailed floristic or site conditions provided. Different dominant grass noted.
	Rumex venosus	None described	-	-
	Oryzopsis hymenoides – Sporobolus cryptandrus	*Carex foenea – Calamovilfa longifolia – Elymus canadensis – Oryzopsis hymenoides* (Fehr 1984)	3	Reported for the Wainwright sand dune area, on active blowouts. Similar site conditions and several similar species, but community composition quite different.
	Stipa comata – Oryzopsis hymenoides	*Carex foenea – Calamovilfa longifolia – Elymus canadensis – Oryzopsis hymenoides* (Fehr 1984)	3	Reported for the Wainwright sand dune area, on active blowouts. Similar site conditions and several similar species, but community composition quite different.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia*	*Calamovilfa longifolia – Hesperostipa comata* (Adams *et al.* 1997)	2	Described from CFB Suffield. Site conditions differed because this site on fluvial slump features along the South Saskatchewan River, where a sand veneer was present. Texture loamy sand, with slopes 5-15 %. Also found on glaciofluvial outwash plain, with minimal eolian action, where texture is loamy sand and slope is 0-5%. Some similarities in site conditions and several grass species. No mention of *Cyperus schweinitzii* occurring however.
		Calamovilfa longifolia – Artemisia (Smoliak 1985)	2	Found on upland prairie, sandy soils (Manyberries). Somewhat similar community noted in general region, on sandy soils though only one dominant similar grass species.
		Calamovilfa longifolia – Stipa comata (Smoliak 1985)	2	Found on sandy soils, in coulee bottoms (Manyberries). Similar community noted in general region, on sandy soils though community in this report likely has more moisture available. No mention of *Cyperus schweinitzii* occurring.
	Sporobolus cryptandrus – Calamovilfa longifolia - Oryzopsis hymenoides	*Sporobolus cryptandrus – Calamovilfa longifolia – Koeleria macrantha – Carex obtusata* (Wheatley and Bentz 2002; Meijer and Karpuk 1999)	2	Described from Central Parkland on active dunes and blowouts at Dillberry Lake Provincial Park. Generally located on south to west-facing aspects and sparse vegetative cover. *Heterotheca villosa* may also be present. Two dominant species in this report same as those grass species found in Pakowki Sand Hills. Similar site conditions, both in respect to substrate and slope and aspect.
		Calamovilfa longifolia – Sporobolus cryptandrus sparsely vegetated active dunes (Komex 1993)	1	Found on active dunes in 1993 in another survey of the Pakowki Sandhills. Other species include *Helianthus couplandii,* golden aster, and golden bean. Similar general community type described in previous survey of study area, however no detailed floristic or site conditions provided.
Herbaceous Vegetation	*Artemisia cana / Stipa comata*	*Artemisia cana / Stipa comata* (Holcroft Weerstra 2001)	2	Described occurring along old river terraces, badlands, ravine side slopes and valley walls on a range of parent materials, but occurring most often on sandy glacial drift and alluvium.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Artemisia cana / Stipa comata* (cont.)	*Artemisia cana – Rosa woodsii / Calamovilfa longifolia – Hesperostipa comata – Koeleria macrantha* (Adams *et al.* 1997)	2	Described at CFB Suffield, on a morainal plain with eolian veneer and sand dunes. Texture was sand, with slopes ranging from 5-15 and well to rapid drainage. Quite similar site conditions, despite CFB Suffield being an eolian veneer over moraine. Vegetation composition also quite similar, with a few differing species.

Appendix 5. Correlation Table with Literature From Outside Alberta

Class	Community Type	Similar Communities and Citations	Similarity Rating[2]	Comments
Forest	*Populus deltoides / Glycyrrhiza lepidota / Juncus balticus*	*Populus deltoides - (Salix amygdaloides) / Salix (exigua, interior)* Woodland (Natureserve 2002)	2	This community was found widely in the central Great Plains of the United States. Stands occurred on recent alluvial materials, along rivers and streams. The soils were derived from fluvial sands, silts and clays and were poorly developed. The water table fluctuates with the level of the adjacent river or stream. *Populus deltoides* was the dominant species in this community, although *Salix exigua* and/or *Salix interior* were generally more dominant in the initial stages following a major flood event. *Salix amygdaloides* was rare to codominant. *Glycyrrhiza lepidota* may be a dominant forb where grazing and other disturbance is minimal. Community quite similar to that found at Pakowki Sandhills, although this community generally found along fluvial routes, not noted to occur in sand dune areas, although recent alluvial materials are generally coarse textured. Relatively similar floristic composition.
		Populus tremuloides sand type (Thorpe and Godwin 1993)	3	Forests of aspen found on upland, north-facing or lower slope positions and on more stabilized landforms. Was found to be most widespread occurring community type in Manito Sandhills (Sask.). Had rapidly to moderately well drained soils. Community different due to different overstory species, though site conditions are very similar.
		Populus tremuloides (Populus deltoides) low areas in sand flats (Epp and Townley-Smith 1980)	2	Found on low areas in sand flats of Great Sand Hills (Sask.) where soil salinity is not high. *Glycyrrhiza lepidota* listed as understorey forb species. Noted in similar eolian landscape, though with aspen as more common than cottonwood. Similar site conditions.
		Populus deltoides Woodland (Epp and Townley Smith 1980)	2	Located in a region of high dunes, scattered on interdune sand flats, with no understorey vegetation (Great Sand Hills). Again, similar site conditions with common leading overstory species. Lack of understorey vegetation quite different.

[2] Similarity Rating: 1, identical to or very similar; 2. similar in most respects; 3, several similarities but important differences (scale from Corns 1983).

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Forest	*Populus deltoides / Glycyrrhiza lepidota / Juncus balticus*	*Populus deltoides / Symphoricarpos occidentalis* Woodland (MNHP 2002)	?	Listed as G2G3/S2S3 for Montana. No information provided. Cannot assess similarity.
		*Populus tremuloides (Populus balsamifera) (*Coupland 1950)	3	Often dominant on leeward (east side) of dunes, as they are adapted to withstand burial of the trunk by sand (Saskatchewan). Similar eolian conditions, however dominant species different than those observed at Pakowki Sandhills.
		Populus tremuloides / Symphoricarpos alba Forest (Heidel *et al.* 2000)	3	Small, young stands found in Medicine Lake Sandhills (Montana) but did not have native understorey and growth and expansion was affected by grazing. Similar eolian conditions; however, dominant species different than those observed at Pakowki Sandhills and trees were quite mature.
		Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland (USGS 2002a)	3	At Scotts Bluff NM (Nebraska) community was found on level to gently sloping locations, at the base of low, north-facing slopes. Soil was silty. Contained more eastern species such as *Fraxinus pennsylvanica* and *Acer negundo*. Similar leading species, but different overall floristic composition. Soil conditions also quite different.
		Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland (USGS 2002d)	3	At Badlands National Park, in South Dakota. Was found along river and creek floodplains, pond and reservoir margins, seeps and springs in mesic draws and seeps and springs that occurred along the edge of sandhill complexes. Same leading tree species, but floristic composition and site conditions varied from those observed at Pakowki Sandhills.
		Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland (USGS 2002b)	3	At Devil's Tower NM (Wyoming) community was found on floodplain of river. Soil was sandy. At this location community was very small and had a high cover of invasive, exotic species. Same leading tree species, but somewhat different soil conditions (i.e. fluvial vs. eolian), although still coarse textured materials.
		Populus deltoides / Pascopyrum smithii Woodland (Jones 1998a)	3	Located in Thunder Basin National Grassland, Wyoming along Cheyenne River. Formed linear groves of trees, parallel to stream channel on alluvial materials. Same leading tree species, different understorey, and somewhat different soil conditions (i.e. fluvial vs. eolian).

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Forest	*Populus deltoides / Glycyrrhiza lepidota / Juncus balticus*	*Populus deltoides / Calamovilfa longifolia* Woodland (Jones 1998b)	3	Located in Thunder Basin National Grassland, Wyoming along Antelope Creek. Formed linear groves of trees, parallel to stream channel on coarse textured soils. Same leading tree species, different understorey, and somewhat different soil conditions (i.e. fluvial vs. eolian)), although still coarse textured materials.
		Populus deltoides / Symphoricarpos occidentalis Woodland (Cooper *et al.* 2001)	3	Found along rivers on unstabilized floodplains where colonized alluvial deposits on meanders of streams and rivers. A well-developed shrub layer was typically present. Same leading tree species, but with different understorey, and somewhat different soil conditions (i.e. fluvial vs. eolian) although still coarse textured materials.
		Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland (Faber-Langendoen , D. editor 2001)	2	Typically found along banks of streams and rivers where it developed on newly deposited alluvium. Soils were predominantly sand, though some silt, clay or loam may be present. Noted that *Glycyrrhiza lepidota* was a common forb where disturbance was low. Also noted that because of high permeability of sandy floodplain, species typical of upland prairie may invade, including *Artemisia spp., Calamovilfa longifolia, Heterotheca villosa, Poa pratensis* and *Sporobolus cryptandrus.* Community quite similar to that found at Pakowki Sandhills, although this community generally found along fluvial routes, not noted to occur in sand dune areas, although recent alluvial materials are generally coarse textured. Relatively similar floristic composition.
		Populus deltoides – (Salix amygdaloides) / Salix exigua Woodland (USGS 2002c)	3	At Agate Fossil Beds NM (Nebraska) community was found on floodplain of Niobara river. Located on level or sloping ground on banks or in old channels in the primary floodplain. Soils were fine sands and sandy loams that were somewhat poorly drained. Same leading tree species, but with different understorey, and different soil conditions (i.e. fluvial vs. eolian, poor drainage) although still coarse textured materials.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Rosa woodsii / Sporobolus cryptandrus*	*Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* (Epp and Townley-Smith 1980)	2	Form closed shrublands found on stabilized slip faces, typically north-facing. Shrub composition varied location to location and each shrub species may be dominant at specific sites, where at others may be co-dominant. Variable floristic composition though very similar eolian landscape and site/soil conditions.
		Rosa woodsii (Epp and Townley-Smith 1980)	1	Community dominant in areas where sand has been whipped off dune by strong winds, creating areas of slow sand accumulation. Very similar (general) floristic composition and very similar site conditions, being located on active sand dunes.
		Rosa woodsii (Artemisia cana / Elaeagnus commutata) (Coupland 1950)	2	Found in undulating to gently rolling areas between stabilized dunes. Water table typically within 8 to 12 feet of soil surface in these locations. Variable floristic composition and generally similar eolian landscape and site/soil conditions. Community occurred in Pakowki Sandhills on partially stabilized to active dunes, on leeward slopes.
		Rosa woodsii Temporarily Flooded Shrubland Alliance (Natureserve 2002)	3	These shrublands occurred in the foothills and plains of Montana and Idaho. Elevations ranged from 650-1700 m. Stands occurred in floodplains and on alluvial terraces along rivers and streams, on hillsides below springs and in ravines and swales where overland flow from snowmelt and summer thunderstorms provides additional moisture. Sites were flat to moderately steep. Although sites were temporarily flooded, they were well drained and did not have a shallow water table. Soils ranged from sandy loams to silt loams. Same dominant shrub species, but with different soil conditions (i.e. fluvial vs. eolian, temporary flooding) although still coarse textured materials.
		Rosa woodsii Shrubland (Cooper *et al.* 1999)	?	A community type listed in Beaverhead Mountain region (Montana) though it is not described with an abstract. Due to lack of information, cannot assess similarity.
		Rosa woodsii Shrubland (MNHP 2002)	?	Listed as G5/S5 in Montana. No description of community type given. Due to lack of information, cannot assess similarity.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Rosa woodsii / Sporobolus cryptandrus*	Grass and shrub / Sand type (Thorpe and Godwin 1993)	3	*Symphoricarpos occidentalis* was dominant shrub, as far as percent cover goes, but *Rosa* spp. and *Prunus virginiana* were present in 50% of plots in this type. Located on stabilized dunes, with rapidly drained, sandy soils. *Sporobolus cryptandrus* not listed as a prevalent species. Similar site conditions, and eolian landscape. Floristic composition variable in literature, while Pakowki *Rosa woodsii* communities quite repetitive pattern.
		Rosa woodsii Shrubland (Rust 1997)	?	Listed as a natural plant community in Idaho. No description of community type given, thus cannot assess similarity.
Shrubland	*Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus*	*Salix amygdaloides* Woodland (MNHP 2002)	?	Listed as G3/S3 for Montana but no description given. No description of community type given, thus cannot assess similarity.
		Salix amygdaloides / Salix exigua Woodland (Natureserve 2002)	3	This vegetation association occurred in riparian habitats on the Columbian Plateau in the interior Northwest and in northeastern Utah. Elevation ranges from 100-1600 m. Stands were located in overflow channels of large rivers, on narrow floodplains of small creeks and soil textures cover a wide range, with the exception of clay. This community had a moderately open overstorey canopy dominated by the small tree *Salix amygdaloides* with *Salix exigua* dominating the tall-shrub layer near the shore. Other tree species included scattered *Populus fremontii, Acer negundo, Populus angustifolia, Populus deltoides* and the introduced *Elaeagnus angustifolia*. Community described here found only in riparian habitats, and not eolian landscapes. Likely different moisture regime versus Pakowki region.
		Salix amygdaloides Woodland (Natureserve 2002)	3	The *Salix amygdaloides* woodland type was found in the Northern Rocky Mountains and potentially into parts of the western Great Plains. Stands occurred in riparian areas. The vegetation was dominated by *Salix amygdaloides*. Community described here found only in riparian habitats, and not eolian landscapes. Likely different moisture regime versus Pakowki region.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Salix amygdaloides – Rosa woodsii / Juncus balticus – Sporobolus cryptandrus* (cont.)	*Salix amygdaloides* Woodland (Faber-Langendoen , D. editor 2001; Marriott and Faber-Langendoen 2000)	3	Found in the Northern Rocky Mountains and possibly into parts of the western Great Plains. Stands occurred in riparian areas. Was documented in Black Hills at confluence of two creeks. It formed a tall-shrub stratum with *Salix bebbiana* and *Cornus sericea* and was more shrubland than woodland. Community described here found only in riparian habitats, and not eolian landscapes. Likely different moisture regime versus Pakowki region. Species composition also quite different.
Shrubland	*Elaeagnus commutata / Glycyrrhiza lepidota*	*Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* (Epp and Townley-Smith 1980)	2	Formed closed shrublands found on stabilized slip faces, typically north-facing. Shrub composition varied location to location and each shrub species may be dominant at specific sites, where at others may be co-dominant. Species composition more variable than that found at Pakowki Sandhills region, but site conditions quite similar, being stabilized eolian features.
		Elaeagnus commutata Shrubland (MNHP 2002)	?	Listed as G2Q/S2? For Montana. No description given thus no assessment of similarity could be made.
		Rosa woodsii (Artemisia cana / Elaeagnus commutata) (Coupland 1950)	2	Found in undulating to gently rolling areas between stabilized dunes. Water table typically within 8 to 12 feet of soil surface in these locations. Species composition different, though quite general, than that found at Pakowki Sandhills region, but site conditions quite similar. Depth to water table at study area was not known.
		Elaeagnus commutata shrubland (Epp and Townley Smith 1980)	2	Often found inhabiting blowouts away from bare sand. Pakowki Sandhills community not found in blowouts, but was found on partially stabilized sand dunes, away from active sand. Detailed description of floristic composition unfortunately not provided.
		Elaeagnus commutata Shrubland (Heidel *et al.* 2000)	2	Reported in northern Montana, east of Continental divide. Generally classified as temporarily flooded. In Medicine Lake sandhills, sites had shrub cover of 10% and grass cover of 70%. Sites were not flooded but the water table was within the rooting zone. Community described here as temporarily flooded, whereas Pakowki not likely experiencing flooding.. Likely different moisture regime versus Pakowki region.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Elaeagnus commutata / Glycyrrhiza lepidota* (cont.)	Elaeagnus commutata Shrubland Alliance (Natureserve 2002)	2	This shrub alliance was found in the northern Great Plains in a mixedgrass prairie matrix. It was dominated by mid to tall shrubs, especially *Elaeagnus commutata*. *Pascopyrum smithii* was dominant in the herbaceous layer, typically accompanied by *Koeleria macrantha, Schizachyrium scoparium* and *Hesperostipa comata (= Stipa comata)*. *Elaeagnus commutata* was most abundant on flat sandy sites in southern Saskatchewan. Species composition more variable than that observed at Pakowki, though dominant species is the same. Site conditions, being somewhat more level, sandy substrates, are similar.
		Elaeagnus commutata / Pascopyrum smithii Shrubland (Natureserve 2002)	3	This association occurred in the northwestern portion of the Great Plains of the United States and Canada. Stands occurred on a variety of glacial landforms including kames, eskers and areas of till and outwash. Common on north facing slopes and sites where moisture was more abundant, including along river valley slopes. The vegetation formed open thickets within the mixed-grass prairie landscape. *Elaeagnus commutata* was generally a short to medium height shrub, although it can grow up to 5 m. *Pascopyrum smithii* not a dominant species at Pakowki Sandhills. Although substrates described in this report are coarse, they are different than eolian landforms.
Shrubland	*Elaeagnus commutata / Artemisia ludoviciana / Calamovilfa longifolia*	*Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* (Epp and Townley-Smith 1980)	2	Formed closed shrublands found on stabilized slip faces, typically north-facing. Shrub composition varied location to location and each shrub species may be dominant at specific sites, where at others may be co-dominant. Species composition more variable than at Pakowki Sandhills, although no mention of *Artemisia* spp. or sand grass. Site conditions quite similar however.
		Elaeagnus commutata Shrubland (MNHP 2002)	?	Listed as G2Q/S2? for Montana. No description given thus no similarity assessment could be made.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Elaeagnus commutata / Artemisia ludoviciana / Calamovilfa longifolia* (cont.)	*Rosa woodsii (Artemisia cana / Elaeagnus commutata*) (Coupland 1950)	2	Found in undulating to gently rolling areas between stabilized dunes. Water table typically within 8 to 12 feet of soil surface in these locations. Species composition different, though quite general, than that found at Pakowki Sandhills region, but site conditions quite similar. Depth to water table at Pakowki study area was not known.
		Elaeagnus commutata shrubland (Epp and Townley Smith 1980)	2	Often found inhabiting blowouts away from bare sand. Pakowki Sandhills community not found in blowouts, but was found on partially stabilized sand dunes, away from active sand. Detailed description of floristic composition unfortunately not provided.
		Elaeagnus commutata Shrubland (Heidel *et al.* 2000)	2	Reported in northern Montana, east of Continental divide. Generally classified as temporarily flooded. In Medicine Lake Sandhills, sites had shrub cover of 10% and grass cover of 70%. Sites are not flooded but the water table was within the rooting zone. Community described here as temporarily flooded, whereas Pakowki not likely experiencing flooding. Likely different moisture regime versus Pakowki region.
		Elaeagnus commutata Shrubland Alliance (Natureserve 2002)	2	This shrub alliance was found in the northern Great Plains in a mixedgrass prairie matrix. It was dominated by mid to tall shrubs, especially *Elaeagnus commutata*. *Pascopyrum smithii* was dominant in the herbaceous layer, typically accompanied by *Koeleria macrantha, Schizachyrium scoparium* and *Hesperostipa comata (= Stipa comata)*. *Elaeagnus commutata* was most abundant on flat sandy sites in southern Saskatchewan. Species composition more variable than that observed at Pakowki, though dominant species is the same. Site conditions, being somewhat more level, sandy substrates, are similar.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Elaeagnus commutata / Artemisia ludoviciana / Calamovilfa longifolia* (cont.)	*Elaeagnus commutata / Pascopyrum smithii* Shrubland (Natureserve 2002)	3	This association occurred in the northwestern portion of the Great Plains of the United States and Canada. Stands occurred on a variety of glacial landforms including kames, eskers and areas of till and outwash. Common on north-facing slopes and sites where moisture was more abundant, including along river valley slopes. The vegetation formed open thickets within the mixed-grass prairie landscape. *Elaeagnus commutata* was generally a short to medium height shrub, although it can grow up to 5 m. *Pascopyrum smithii* not a dominant species at Pakowki Sandhills. Although substrates described in this report are coarse, they are different than eolian landforms.
Shrubland	*Prunus virginiana / Calamovilfa longifolia*	*Elaeagnus commutata – Rosa woodsii – Symphoricarpos occidentalis – Prunus virginiana* (Epp and Townley-Smith 1980)	2	Formed closed shrublands found on stabilized slip faces, typically north-facing. Shrub composition varied location to location and each shrub species may be dominant at specific sites, where at others may be co-dominant. Species composition more variable than that observed at Pakowki Sandhills, however site conditions are very similar.
		Prunus virginiana Shrubland (MNHP 2002)	?	Listed as G4Q/S4 in Montana. No description given thus no similarity assessment could be made.
		Prunus virginiana Shrubland (Heidel *et al.* 2000)	2	Noted to occur in small patches in Medicine Lake Sandhills, Montana. Had high shrub cover and low understorey cover, though *Stipa comata* was common understorey species. *Prunus virginiana* has a deep root system that can reach the water table in the Medicine Lake Sandhills. Elsewhere in Montana was considered a riparian community. Dominant grass different, but density of shrubs comparable to that found in Pakowki Sandhills. Site conditions very similar

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Shrubland	*Prunus virginiana / Calamovilfa longifolia* (cont.)	*Prunus virginiana* Shrubland Alliance (Natureserve 2002)	3	This community was typically found along streams, rivers, lakes and ponds and on terraces, or in canyons or steep gullies. Elevations ranged from 716 m to about 1600 m in Montana, Wyoming and Colorado and up to 2440 m in Nevada. In some places, the alliance occurred on side slopes of hillsides, immediately below a seep or spring. Some examples of this alliance have been placed into an intermittently or temporarily flooded hydrologic regime. Soils were usually well-developed, older and well-drained, formed in shallow to deep alluvial deposits. Community described here found only in riparian habitats, and not eolian landscapes. Very different soil conditions and different moisture regime versus Pakowki region.
		Prunus virginiana – (Prunus americana) Shrubland (Cooper *et al.* 1999)	3	Community reported in Montana at Bitter Creek Badlands, at heads of coulees feeding into badlands. Community occurred as very small, dense, linear patches. Few other species found, due to density of *Prunus*. Different species composition, as only one *Prunus* species found at Pakowki Sandhills. Site conditions also somewhat different, though likely drier than average. Density and shape of community similar.
		Prunus virginiana – (Prunus americana) Shrubland (USGS 2002d)	3	Dominantly *Prunus americana*, with some *P. virginiana.* Generally found in sloping to nearly level mesic draws and nearly level oxbows. A few stands also found at seep zone on edge of sandhills. Different species composition, as only one *Prunus* species found at Pakowki Sandhills. Site conditions also somewhat different, as dominantly a riparian community.
		Grass and shrub / Sand type (Thorpe and Godwin 1993)	3	*Symphoricarpos occidentalis* was dominant shrub, as far as percent cover goes, but *Rosa* spp. and *Prunus virginiana* were present in 50% of plots in this type. Located on stabilized dunes, with rapidly drained, sandy soils. *Calamovilfa longifolia* also listed as occurring. Species composition more variable than that observed at Pakowki Sandhills, though site conditions are quite similar.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Dwarf Shrubland	*Eurotia lanata / Stipa comata – Calamovilfa longifolia*	*Stipa comata* ASSOCIATION (Looman 1980)	3	Found to be common (with *Bouteloua gracilis*) on dry prairie. Cover of *Bouteloua gracilis* increases, gradually replacing *Stipa comata* as grazing increases. A variation of the community includes *Calamovilfa longifolia* and occurred on sandy loam or loamy sand soils. Species composition quite different, and no mention of winterfat as a shrub. Coarser textured soils, which are similar to Pakowki Sandhills.
		Krascheninnikovia lanata / Stipa comata Dwarf-Shrubland (MNHP 2002)	?	Listed as G3/S3 for Montana. No description given thus no assessment of similarity could be made.
		Krascheninnikovia lanata / Hesperostipa comata Dwarf-Shrubland (Natureserve 2002)	2	Reported in DeVelice, R. L., J. Lichthardt and P. S. Bourgeron. 1991. A preliminary classification of the plant communities of northeastern Montana. Prepared for the Montana Natural Heritage Program. Helena, MT. 144 pp. No description given thus difficult to assess, but based on community name dominant species are the same as those found in Pakowki.
		Krascheninnikovia lanata / Bouteloua gracilis Dwarf Shrub Herbaceous Vegetation (Faber-Langendoen , D. editor 2001)	3	Vegetation contained open shrub and graminoid layer. Short herbaceous layer is dominated by *Bouteloua gracilis, Echinacea angustifolia* and *Liatris punctata.* Found in southwestern Great Plains and Semi-desert mountains, from Colorado south to New Mexico and Arizona. Also found in Kansas. Species composition quite different, and no mention of needle-and-thread or sand grass. Located in a much more southerly region, with desert conditions.
		Eurotia lanata / Poa secunda Extremely xeromorphic dwarf-shrubland (Rust 1997)	?	Listed as natural plant community type for Idaho. No description given thus no similarity assessment could be made.
Herbaceous Vegetation	*Salix exigua / Glycyrrhiza lepidota / Juncus balticus*	*Salix exigua* Shrubland (USGS 2002a)	3	Community found along margins of North Platte River (Scotts Bluff NM) and locations on lower floodplain terrace. Occurred on recent alluvial sands with little soil development. Understorey species composition quite different, also note occasional *Populus deltoides*, thus quite different than community type found in Pakowki Sandhills.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Salix exigua / Glycyrrhiza lepidota / Juncus balticus* (cont.)	*Salix exigua* / Mesic Graminoids Shrubland (Faber-Langendoen , D. editor 2001)	3	Vegetation dominated by shrubs with a fairly dense ground cover (at least 30%) of mesic graminoids and forbs. *Juncus* spp. noted as a common herbaceous species. Community found on sandbars, islands and shorelines of stream channels and braided rivers. Soils are poorly developed. Primarily found in Great Plains but also parts of Rocky Mountains and Intermountain Semi-desert regions. Wyoming west to possibly Idaho, south to Utah and east to Oklahoma. Species composition comparable, but site conditions quite different. This community described mainly from riparian areas, and although they have poorly developed, coarse textured soils, they would have a greater moisture availability than sand dune region.
		Salix exigua Temporarily Flooded Shrubland (Faber-Langendoen , D. editor 2001)	3	Dominated by 2-4m *Salix exigua* with a moderate to high stem density. Found on recently deposited or disturbed alluvial materials, dominantly sands. Found at lower elevations throughout northwestern US and Great Plains and into Manitoba. Species composition comparable, but site conditions quite different. This community described mainly from riparian areas, and although they have coarse textured soils, they would have a greater moisture availability than sand dune region.
		Salix exigua Temporarily Flooded Shrubland (USGS 2002d)	3	Found along banks of several creeks. Occurred adjacent to creeks and rivers where moist sediments accumulate and adjacent to some wetland communities. Sites were nearly all level with presence of ground-water. This community described mainly from riparian areas, and was noted to have ground water present.
		Salix exigua Shrubland [Provisional] (USGS 2002c)	2	Found along Niobara River, Agate Fossil Beds NM in Nebraska. Found along lower floodplain terraces, with sandy loam soils that are poorly to somewhat poorly drained. *Juncus balticus* listed as an abundant species. Noted species diversity quite high. Species composition comparable, but site conditions quite different. This community described mainly from riparian areas, with somewhat poorly drained soils.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Salix exigua / Glycyrrhiza lepidota / Juncus balticus* (cont.)	*Salix exigua* Temporarily Flooded Shrubland (Cooper *et al.* 1999)	3	Found in Beaverhead Mountains, Montana, where it occurred on gravelly alluvial materials on floodplains and river terraces in river bottoms. Understorey species minimal due to high disturbance rate, but most common are *Cirsium arvense, Mentha arvensis* and *Phalaris arundinacaea.* Species composition somewhat similar, but site conditions quite different. This community described mainly from riparian areas, with temporarily flooded soils.
		Salix exigua / Barren Seasonally flooded cold-deciduous Shrubland (Rust 1997)	?	Listed as a natural plant community for Idaho, but no description given thus no assessment of similarity could be done.
		Salix exigua / Equisetum arvense Seasonally flooded cold-deciduous Shrubland (Rust 1997)	?	Listed as a natural plant community for Idaho, but no description given thus no assessment of similarity could be done.
		Salix exigua / Mesic Forb Seasonally flooded cold-deciduous Shrubland (Rust 1997)	?	Listed as a natural plant community for Idaho, but no description given thus no assessment of similarity could be done.
		Salix exigua / Mesic Graminoid Seasonally flooded cold-deciduous Shrubland (Rust 1997)	?	Listed as a natural plant community for Idaho, but no description given thus no assessment of similarity could be done.
		Salix exigua / Rosa woodsii Seasonally flooded cold-deciduous Shrubland (Rust 1997)	?	Listed as a natural plant community for Idaho, but no description given thus no assessment of similarity could be done.
		Salix exigua / Barren Shrubland (MNHP 2002)	?	Listed as a natural plant community for Montana, but no description given thus no assessment of similarity could be done.
		Salix exigua / Mesic Graminoid Shrubland (MNHP 2002)	?	Listed as a natural plant community for Montana, but no description given thus no assessment of similarity could be done.
		Salix exigua Temporarily Flooded Shrubland (MNHP 2002)	?	Listed as a natural plant community for Montana, but no description given thus no assessment of similarity could be done.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Glycyrrhiza lepidota / Calamovilfa longifolia*	*Glycyrrhiza lepidota* Herbaceous Vegetation (MNHP 2002)	?	Listed as S? for Montana. No description provided thus no assessment of similarity could be done.
Herbaceous Vegetation	*Glycyrrhiza lepidota – Artemisia spp. / Stipa comata*	*Stipa comata* Association (Looman 1980)	3	Found to be common (with *Bouteloua gracilis*) on dry prairie. Cover of *Bouteloua gracilis* increases, gradually replacing *Stipa comata* as grazing increases. A variation of the community includes *Calamovilfa longifolia* and occurred on sandy loam or loamy sand soils. Very different species composition though occurs on coarse textured soils.
		Stipa comata – Artemisia frigida (Hulett *et al.* 1966)	2	Dominant community in Great Sand Hills (Sask.) on stabilized dunes. *Calamovilfa longifolia* is present in reported community. Species composition varies somewhat, though site conditions are quite similar. No mention of wild licorice.
		Glycyrrhiza lepidota Herbaceous Vegetation (MNHP 2002)	?	Listed as S? for Montana. No description provided thus no assessment of similarity could be done.
Herbaceous Vegetation	*Rumex venosus*	*Rumex venosus* Alliance (Looman 1980)	1	May be dominant on highly mobile dunes/ during early stages of development. Very limited description, although dominant species coincides, and community found in Pakowki was on active sand dune areas.
		Active Sand Dune Complex (Epp and Townley-Smith 1980)	3	*Rumex venosus* noted as occurring on active sand dune complexes, typically towards the edge of the deflation zone and on sides of dunes. No *Rumex venosus* community type noted however. Occurs under similar conditions, but authors did not describe this particular community.
Herbaceous Vegetation	*Oryzopsis hymenoides – Sporobolus cryptandrus*	*Oryzopsis hymenoides* Order (Looman 1980)	3	Reported as an order within the Calamovilfetea class. Very limited description, though noted to occur on coarse textured soils.
		Psoralea lanceolata – Oryzopsis hymenoides (Hulett *et al.* 1966)	2	Dominant community in Great Sand Hills (Sask.) on active sand dune complexes. Dominant grass similar to that found at Pakowki Sandhills, although *Psoralea lanceolata* was not found in association. Site conditions very similar.
		Psoralea lanceolata – Oryzopsis hymenoides (Epp and Townley-Smith 1980)	2	Formed a sparse cover located on edge of deflation zone away from dune. Vegetative cover found to increase as distance from deflation zone increases. Dominant grass similar to that found at Pakowki Sandhills, although *Psoralea lanceolata* was not found in association. Site conditions very similar.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Oryzopsis hymenoides – Sporobolus cryptandrus* (cont.)	*Oryzopsis hymenoides – Psoralidium lanceolatum (*Heidel *et al.* 2000)	*2*	In Montana, found to be restricted to slopes and crests of sand dunes recently disturbed by soil erosion. Sand dropseed was also present, often forming up to 10% cover. Found in blow-outs and is driest and earliest stage of succession (Medicine Lake Sandhills, Montana). Dominant grass similar to that found at Pakowki Sandhills, although *Psoralea lanceolata* was not found in association. Site conditions very similar.
		Achnatherum hymenoides Herbaceous Alliance (Natureserve 2002)	2	Stands of this alliance occurred in two distinctively different habitats (sandy areas and shale barrens) in different geographic areas. Sandy areas included 'blowouts' in the Great Plains and in arid and semi-arid dune systems in the Chihuahuan Desert, San Luis Valley, Colorado Plateau and Great Basin. Substrates are sand or shale. This alliance was characterized by a sparse to moderately dense herbaceous layer that is dominated by *Achnatherum hymenoides (= Oryzopsis hymenoides)*. Dominant grass the same, though no mention of sand dropseed. Similar site conditions, excluding shale barrens.
		Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation (Natureserve 2002)	?	No description given thus no assessment of similarity could be made.
		Oryzopsis hymenoides – Psoralidium lanceolatum Herbaceous vegetation (MNHP 2002)	?	No description given thus no assessment of similarity could be made.
		Calamovilfa longifolia - Achnatherum hymenoides Herbaceous Vegetation (Natureserve 2002)	?	No description given thus no assessment of similarity could be made.
Herbaceous Vegetation	*Stipa comata – Oryzopsis hymenoides*	*Stipa comata* Association (Looman 1980)	3	Found to be common (with *Bouteloua gracilis*) on dry prairie. Cover of *Bouteloua gracilis* increases, gradually replacing *Stipa comata* as grazing increases. Occurred on sandy loam or loamy sand soils. Site conditions similar in that it occurred on coarser textured sandy soils, although not eolian particularily. Floristic composition quite different.
		Psoralea lanceolata - Stipa comata (Hulett *et al.* 1966)	3	Dominant community in Dundurn Sand Hills (Sask.) on stabilized dunes. Site conditions would be quite similar, but no *Psoralea lanceolata* found in Pakowki communities.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Stipa comata – Oryzopsis hymenoides* (cont.)	*Psoralea lanceolata – Oryzopsis hymenoides* (Epp and Townley-Smith 1980)	3	Forms a sparse cover located on edge of deflation zone away from dune. Vegetative cover found to increase as distance from deflation zone increases. Site conditions would be quite similar, but no *Psoralea lanceolata* found in Pakowki communities.
		Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation (Natureserve 2002)	2	This grass type has been described from the Great Divide Basin in south-central Wyoming. *Hesperostipa comata* and *Achnatherum hymenoides* codominatedthe vegetation and *Pascopyrum smithii* was seccndary species. Scattered shrubs present, primarily *Artemisia tridentata ssp. wyomingensis.* This type apparently has not been described outside the Great Divide Basin of south-central Wyoming. Other basins in south-central and southwestern Wyoming and the northwestern quarter of Colorado are similar in climate and geology and this association may well extend over a wide area of the two states. Species composition quite similar, though with some variation. No description of site conditions however.
		Hesperostipa comata Bunch Herbaceous Alliance (Natureserve 2002)	3	This grassland alliance was found on sandy soils in the intermountain steppe, Wyoming Basin, Colorado Plateau, Great Basin and Columbia Plateau. Stands typically occurred on upland sites with coarse-textured soils such as sandstone outcrop ridges in the plains, dry-sandy sites in the Columbia Basin and on dissected alluvial fans below sandstone plateaus, but not dunes. Noted to occur on coarse textured soils. However authors state that community does not occur on sand dunes, thus quite different from type found at Pakowki.
		Stipa comata / Psoralidium lanceolatum Herbaceous Vegetation (Heidel *et al.* 2000)	2	Found in Medicine Lake sandhills. Restricted to wind-blown sand deposits with undeveloped soils and is found on choppy dunes to rolling plains. Was thought to be a seral stage between *Oryzopsis hymenoides / Psoralidium lanceolatum* and *Pascopyrum smithii - Stipa comata* association. Grass cover was 20-40% and most was *Stipa comata*. Occurred on stabilized to partially stabilized sand dunes. Site conditions quite similar, but no *Psoralea lanceolata* found in Pakowki communities.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Stipa comata – Oryzopsis hymenoides* (cont.)	*Oryzopsis hymenoides – Psoralidium lanceolatum* Herbaceous vegetation (MNHP 2002)	?	No description given thus no similarity assessment could be made.
Herbaceous Vegetation	*Artemisia spp. / Stipa comata – Calamovilfa longifolia*	*Stipa comata* Association (Looman 1980)	3	Found to be common on dry prairie. Cover of *Bouteloua gracilis* increased, gradually replacing *Stipa comata* as grazing increased. A variation of the community includes *Calamovilfa longifolia* and occurred on sandy loam or loamy sand soils. Somewhat similar species composition, and also occurring on more coarse textured soils. Species composition could be quite variable however.
Herbaceous Vegetation		*Stipa comata – Artemisia frigida* (Hulett *et al.* 1966)	1	Dominant community in Great Sand Hills (Sask.) on stabilized dunes. *Calamovilfa longifolia* is present in reported community. Virtually identical site conditions, and floristic composition.
Herbaceous Vegetation	*Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia*	*Stipa comata* Association (Looman 1980)	2	Found to be common (with *Bouteloua gracilis*) on dry prairie. Cover of *Bouteloua gracilis* increased, gradually replacing *Stipa comata* as grazing increased. A variation of the community includes *Calamovilfa longifolia* and occurred on sandy loam or loamy sand soils. Somewhat similar species composition, and also occurring on more coarse textured soils. Species composition more variable however at Pakowki Sandhills.
		Stipa comata – Artemisia frigida (Hulett *et al.* 1966)	2	Dominant community in Great Sand Hills (Sask.) on stabilized dunes. *Calamovilfa longifolia* is present in reported community. Virtually identical site conditions, and similar floristic composition.
		Psoralea lanceolata - Stipa comata (Hulett *et al.* 1966)	3	Dominant community in Dundurn Sand Hills (Sask.) on stabilized dunes. *Calamovilfa longifolia* is present in reported community. Site conditions quite similar, but no *Psoralea lanceolata* found in Pakowki communities.
		Stipa comata – Calamovilfa longifolia – Agropyron spp. (Hulett *et al.* 1966)	1	Dominant community in Dundurn Sand Hills (Sask) in dune depressions and appears to be intermediate between stabilized blowouts and stabilized dunes. Virtually identical site conditions, and similar floristic composition.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* (cont.)	*Calamovilfa longifolia - Hesperostipa comata* Herbaceous Vegetation (Natureserve 2002)	2	This prairie sandreed grassland community type occurred in the central and northern Great Plains region of the United States. Stands occur on stabilized sand dunes, as well as in interdunal valleys, colluvial sands and, less commonly, silty terraces of intermittent streams. Soils were medium to fine sands formed either from eolian or colluvial processes. The vegetation had an open canopy, dominated by mid to tall grasses. *Calamovilfa longifolia* and *Hesperostipa comata (= Stipa comata)* were the most conspicuous and dominant grasses. Virtually identical site conditions, and similar floristic composition although no mention of *Cyperus schweinitzii.*
		Calamovilfa longifolia - Hesperostipa comata Grassland (Jones 1998a)	3	Found on sandy soils at an intermediate height above the river channel (Wyoming). Major species are *Calamovilfa longifolia, Stipa comata* and *Psoralea lanceolata*. Site conditions somewhat similar, but found dominantly along fluvial channels. No *Psoralea lanceolata* found in Pakowki communities.
		Calamovilfa longifolia – Hesperostipa comata Grassland (Jones 1998b)	3	Found on sandy soils at an intermediate height above the river channel (Wyoming). Major species were *Calamovilfa longifolia*, *Stipa comata* and *Psoralea lanceolata*. Also found on sand dunes and higher fluvial surfaces with sandy soils. Was a major community type in the area. Site conditions somewhat similar, but found dominantly along fluvial channels. No *Psoralea lanceolata* found in Pakowki communities.
		Calamovilfa longifolia – Hesperostipa comata Herbaceous Vegetation (Faber-Langendoen , D. editor 2001)	2	Vegetation had open canopy dominated by *Calamovilfa longifolia*. Stands occurred on stabilized sand dunes as well as in interdunal valleys or draws, colluvial sands and less commonly on silty terraces of intermittent streams. Soils were medium to fine sands formed from either eolian or colluvial processes. Noted occurring in central and northern Great Plains, ranging from Colorado to Nebraska and north to Wyoming and South Dakota. Site conditions very similar and floristic composition also quite similar. No mention of *Cyperus scheweinitzii* however.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Stipa comata – Cyperus schweinitzii – Calamovilfa longifolia* (cont.)	*Calamovilfa longifolia – Hesperostipa comata* Herbaceous Vegetation (Cooper *et al.* 2001)	2	Occurred most abundantly where sandy substrates dominant, on stabilized dunes, interdunal swales and colluvial sands. Was found in Rock Creek Canyon and a few sandy outcrops in Bitter Creek Badlands area, Montana. Was highly restricted in area, occurring on mainly colluvial sands. Site conditions very similar and floristic composition also quite similar. No mention of *Cyperus scheweinitzii* however.
		Calamovilfa longifolia – Stipa comata Herbaceous Vegetation (Heidel *et al.* 2000)	2	Found at Medicine Lake Sandhills, Montana, as a minor type. Did not appear to be a wide-spread community, occurring in small patches on low ridges and in mosaic patterns on gentle plains of Medicine Lake. Site conditions very similar and floristic composition also quite similar. No mention of *Cyperus scheweinitzii* however.
Herbaceous Vegetation	*Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides*	*Calamovilfa longifolia* CLASS (Looman 1980)	2	Sand grass reported to be dominant in well developed sandhill prairie. Other characteristic species included *Elymus canadensis, Helianthus couplandii and Sporobolus cryptandrus.* Floristic composition somewhat similar, though with some variation. Site conditions not described in detail, though are expected to be quite similar.
		Carex pennsylvanica – Sporobolus cryptandrus – Cyperus schwentzeii – Calamovilfa longifolia on active sand (Thorpe and Godwin 1993)	3	Found on sparsely vegetated, active east/west oriented sand dunes that were rapidly drained. Soils were coarse-textured and had little to no organic matter to retain moisture. Site conditions very similar, almost identical. However floristic composition much more variable than that found at Pakowki Sandhills.
		Sporobolus cryptandrus – Poa secunda Medium-tall bunch temperate or sub-polar grassland (Rust 1997)	?	Listed as community type for Idaho but no description given. No similarity assessment could be made.
		Sporobolus cryptandrus medium-tall temperate or subpolar grassland with a needle-leaved or microphyllous evergreen shrub layer (Rust 1997)	?	Listed as community type for Idaho but no description given. No similarity assessment could be made.
		Heterotheca villosa / Sporobolus cryptandrus Low temperate or subpolar forb vegetation (Rust 1997)	?	Listed as community type for Idaho but no description given. No similarity assessment could be made.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides*	*Sporobolus cryptandrus* Shrub Herbaceous Vegetation (MNHP 2002)	?	Listed as G2/S2 for Montana but no description given. No similarity assessment could be made
		Sporobolus cryptandrus Herbaceous Alliance (Natureserve 2002)	3	This grassland alliance was found in the lower Salmon and Snake river canyons of Idaho, Oregon and Washington, the Columbia River in central Washington and the Green and Virgin rivers in Utah. Stands occurred on river terraces, footslopes of benches and alluvial fans. The elevation ranged from 240-1460 m. Sites are flat to gently sloping (to 30%) and occurred on all aspects. Soils were moderately deep and derived from loess and alluvium-colluvium. Surface soil texture varied from sandy loam to silt loam. Limited floristic description provided, although site conditions quite similar except for method of deposition.
		Sporobolus cryptandrus Shrub Herbaceous Alliance (Natureserve 2002)	3	Grasslands in this alliance were described from Montana, Idaho and New Mexico. In New Mexico, the alliance occurred in the northwestern part of the state on alluvial flats at an elevation of approximately 2140 m. Climate was semi-arid with most of the highly variable annual precipitation falling during the summer as high-intensity convectional storms. Sites were nearly level. Soils are calcareous, loamy and shallow (less than 25 cm deep). Limited floristic description provided and site and climatic conditions quite different.
Herbaceous Vegetation	*Sporobolus cryptandrus – Calamovilfa longifolia – Oryzopsis hymenoides*	*Sporobolus cryptandrus - Poa secunda* Herbaceous Vegetation (Natureserve 2002)	3	This plant association was described for the Columbia Basin and lower Snake River, where it occurred on gentle, lower slope and river terrace positions in the valleys of the Snake and Clearwater rivers. Stands were dominated by *Sporobolus cryptandrus*. *Poa secunda* was common but varied in abundance. *Aristida purpurea var. longiseta (= Aristida longiseta)* and *Hesperostipa comata (= Stipa comata)* were frequently present in low abundance. Differences in site and floristic composition than what is found at Pakowki Sandhills.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Artemisia cana / Stipa comata*	*Rosa woodsii (Artemisia cana / Elaeagnus commutata*) (Coupland 1950)	2	Found in undulating to gently rolling areas between stabilized dunes. Water table typically within 8 to 12 feet of soil surface in these locations. Species composition more variable than that found at Pakowki Sandhills, but site conditions quite similar. Depth to water table not known at Pakowki Sandhills.
		Artemisia cana / Hesperostipa comata Shrub Herbaceous Vegetation (Natureserve 2002)	1	This shrub prairie association, which generally occurred in small patches (less than 1 hectare), occurred in the northwestern Great Plains. In Montana, it was found on benches to gently inclined slopes (30% maximum recorded) in the vicinity of breaklands. Sites occurred on various parent materials, but mostly well-drained, often sandy, glacial drift and sandy alluvium. *Artemisia cana* was dominant shrub with canopy coverages to 50%, but averaging around 25%, which placed it on the cusp of being a true shrub type. Virtually identical site and floristic composition.
		Artemisia cana / Hesperostipa comata Shrub Herbaceous Vegetation (Faber-Langendoen, D. editor 2001)	1	This small patch type currently had a narrow geographic distribution, though it may be expected to occur in Saskatchewan and North Dakota. This type's affinity for well drained benches and gently inclined landforms in a primarily agricultural landscape puts it at a moderate risk for agriculture conversion. Fortunately this landform also occurred in breakland and badland environments less desirable for agriculture, thus lessening the chances of this uncommon type being converted to agriculture. Virtually identical floristic composition, though somewhat different site conditions.
		Artemisia cana / Hesperostipa comata Shrub Herbaceous Vegetation (Cooper *et al.* 2001)	1	In Montana, was found on benches to gently inclined slopes (30% maximum recorded) in the vicinity of breaklands. Sites occurred on various parent materials but mostly well-drained, often sandy glacial drift and sandy alluvium. Considered to be a minor type in the Bitter Creek / Frenchman Creek area in Montana, due to limited distribution of coarse textured materials. Virtually identical floristic composition, though somewhat different site conditions.

Class	Community Type	Similar Communities and Citations	Similarity Rating	Comments
Herbaceous Vegetation	*Artemisia cana / Stipa comata* (cont.)	*Artemisia cana / Stipa comata* Shrub Herbaceous Vegetation (MNHP 2002)	?	Listed as natural plant community for Montana, but no description given. Rated S3 for Montana. No similarity assessment could be made.