A Floristic and Landscape Survey

of the Ft. Assiniboine Sandhills Wildland Park

by

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TABLE OF CONTENTS

ACKNOWLEDGMENTS 1

Lists of...
...TABLES 2

...MAPS 2

...FIGURES 2

...APPENDICES 3

ABSTRACT 4

COLOR PLATES 5

1. INTRODUCTION 8

2. STUDY AREA 8

3. METHODS 10
- **3.1 Pre-field** 10
- **3.2 Field** 10
- **3.3 Analytical** 11

4. RESULTS 12
- **4.1 Species Richness at the Study Area Scale** 12
- **4.2 Species Richness at the Plot Scale** 12
- **4.3 Rare Plant Occurrences (see Map 2, in pocket)** 14
- **4.4 Other Noteworthy Plant Occurrences** 20
- **4.5 Ordination** 21
- **4.6 Classification** 22
- **4.7 Noteworthy Landscape and Natural History Themes** 26
- **4.8 Other Special Features** 28

5. MANAGEMENT CONCERNS 29
- **5.1 Oil and Gas Activities** 29
- **5.2 OHV Use** 30
- **5.3 Fire Management** 30
- **5.4 Non-Conforming Uses** 30
- **5.5 Trail Development** 30

6. LITERATURE CITED 33

7. APPENDICES 36

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TABLES

Table 1. Provincially rare (S1-S3 rank) species of the Ft. Assiniboine Sandhills Wildland Park.

Table 2. Summary statistics for number of provincially rare plant species and total species per 0.03 ha plot (n=48) at Ft. Assiniboine Sandhills Wildland Park.

Table 3. Summary statistics for rare plant and total species diversity by vegetation type. Vegetation type codes are keyed to those of Figures 1-3.

Table 4. TWINSPAN classification of 48 plots and 84 common/dominant species at the Ft. Assiniboine Wildlands Provincial Park.

MAPS

Map 1. Location of the Ft. Assiniboine Sandhills Wildland Park.

Map 2. Provincially Rare Plants of the Ft. Assiniboine Sandhills Wildland Park (in map pocket).

FIGURES

Figure 1. Total species (mean +/- standard error) per 0.03 ha plot by vegetation type. Grassland = 0, Pj,Savannah = 1, Wheatgrass = 2, Sw Forest = 3, Mixed Deciduous Forest = 4, Aw Forest = 5, Mixedwood Forest = 6, Sw-Pj Forest = 7, Willow-Alder = 9, Seepage Meadow = 10, Riparian Meadow, Backswamp = 11, Marsh = 12, Poor Fen, Bog = 13, Meso Fen = 14, Rich Fen = 15.

Figure 2. Rare species (mean +/- standard error) per 0.03 ha plot by vegetation type. Grassland = 0, Pj,Savannah = 1, Wheatgrass = 2, Sw Forest = 3, Mixed Deciduous Forest = 4, Aw Forest = 5, Mixedwood Forest = 6, Sw-Pj Forest = 7, Willow-Alder = 9, Seepage Meadow = 10, Riparian Meadow, Backswamp = 11, Marsh = 12, Poor Fen, Bog = 13, Meso Fen = 14, Rich Fen = 15.

Figure 3. Fort Assiniboine Sandhills Wildland Park DCA stand ordination. For species richness information of vegetation types see Table 3.

Figure 4. Wetland crossings along the in-progress New Cache Petroleum Ltd. gas pipeline development and zone of degraded habitat (a 1.6 km (800 m each side) hatched buffer strip borders the pipeline and its access road). Base map after New Cache Petroleum Ltd (1997: Figure 1).

APPENDICES

Appendix 1. Annotated list of 434 vascular and non-vascular plant taxa found in the Ft. Assiniboine Sandhills Wildland Park during summer 1997. Noteworthy species are in **bold** font. Species classified as provincially rare are followed by a bold asterisk *. By taxonomic group, there were 258 vascular species, 90 mosses, 14 hepatics, and 74 lichens.

Appendix 2. Detrended Correspondence Analysis (DCA) of plots at FA. 84 species; 48 plots. Rares species downweighted; number of non-zero data items: 403; axes rescaled; segments = 30. Eigenvalues: Axis 1=0.904; Axis 2= 0.688; Axis 3= 0.519.

Appendix 3. Detrended Correspondence Analysis (DCA) of common and dominant species at FA. 84 species; 48 plots. Rare species downweighted; number of non-zero data items: 403; axes rescaled; segments = 30. Eigenvalues: Axis 1=0.904; Axis 2= 0.688; Axis 3= 0.519.

Appendix 4. TWINSPAN results. Length of raw data array: 854 non-zero items; cut levels: 0, 1, 2, 5, 10, 15, 20, 40, and 60 %;Minimum group size for division = 2; Maximum number of indicators per division = 5; Maximum number of species in final table = 84; 4 divisions; Length of data array after defining pseudospecies: 1876; Total number of species and pseudospecies: 501.

ABSTRACT

This study reports a floristic and landscape survey of Ft. Assiniboine Sandhills Wildland Park. The park spans about 6,600 ha and is located along the north side of the Athabasca River northeast of the hamlet of Ft. Assiniboine. Thirty person-days of fieldwork were conducted in June and August 1997; 48 0.03 ha plots were established and described; miscellaneous observations were made outside the plots. A total of 434 species of plants were found in the study area, of which 20 species (4.59%) are classified as provincially rare. Of the 20 rare species, 6 were vascular plants, 7 were mosses, and 7 were lichens. By taxonomic group, there were 258 vascular taxa, 90 mosses, 14 hepatics, and 74 lichens. The typical 0.03 ha plot contained 50.2 species (s.d. 18.9, median 49.5), with a maximum of 97 species and a minimum of 9 species/plot. Mean number of rare species/plot was 0.771 (s.d. 1.372, median 0). White spruce forests, typically represented by riparian old-growth forests along the Athabasca River, had the highest species richness/plot (mean 75.7 species vs. an overall mean of 50.2 species)--about 50% more species than the average plot in the study area. Mixedwood forests, typically old-growth riparian white spruce - balsam poplar +/- aspen +/- birch forests along the Athabasca River, stood out from all the others in supporting the most rare plant species (a mean of 3.0 species/plot vs. 0.771 species/plot overall). Pemmican Island is a hotspot for plant species richness and rare species richness. Conservation of plant species biodiversity requires that old-growth forests be protected from logging. The occurrence of provincially rare and otherwise noteworthy plant species is described. DCA ordination and TWINSPAN classification were used to differentiate plant communities and species groups. Five landscape types were found: eolian sand dunes; organic terrain; riparian complex; loess plain; and colluviating slopes. The most significant plant communities are riparian and non-riparian old-growth forests of white spruce and mixedwood; three types of grasslands (northern ricegrass, slender wheatgrass, western porcupine grass); and a diverse assemblage of wetlands ranging from marshes and rich fens to bogs. Management concerns relating to gas development, fire management, ORVs, non-conforming uses, and suggestions for trail development are offered.

Color Plates. (**a**) calcareous iron seep dominated by common horsetail, white spruce, variegated horsetail, false mountain willow, and *Ditrichum flexicaule* (near plot fa48, 25 Aug 97), habitat of rayless aster and bristle-leaved sedge; plot surrounded by old-growth white spruce forest (nearby Sw aged 139 years at base, dbh=57.5 cm; largest diam Sw seen nearby =76.4 cm); (**b**) old-growth riparian hygric white spruce / Alaska birch - aspen / raspberry - dogwood / meadow horsetail forest on Pemmican Island (plot fa39, 23 Aug 97), habitat of *Entodon schleicheri*, white adder's mouth, *Peltigera evansiana, P. horizontalis,* and *Physcia dimidiata*; note the four moss-covered aspen logs in foreground; (**c**) western porcupine grass - snowberry / *Tortula ruralis* grassland on steep SE-facing eolian sand slope (plot fa20, 19 Aug 97), habitat of low sedge, thread-leaved sedge, sand grass, wild morning glory, narrow-leaved puccoon, and Drummond's cockle; (**d**) riparian old-growth balsam poplar - white spruce / dogwood / common horsetail on sand Orthic Regosol with abundant buried wood; location on upstream point of island results in sand and driftwood deposition, not silt (plot fa35, 22 Aug 97); balsam poplar too large for tree corer (one of largest Bp was 100.5 cm dbh; Sw cored at 40 cm ht. was minimum 142 years (rotten heart)); habitat of *Physcia dimidiata* and *Campylium radicale*; (**e**) old-growth hygric white spruce / meadow horsetail / *Hylocomium - Ptilium* forest on organically-enriched silt loess (plot fa27, 21 Aug 97), habitat of *Physconia enteroxantha, Heterodermia speciosa,* and *Peltigera horizontalis*; (**f**) *Peltigera evansiana* on an aspen log in an old-growth riparian hygric white spruce / Alaska birch - aspen / raspberry - dogwood / meadow horsetail forest on Pemmican Island (plot fa39, 23 Aug 97); (**g**) hairy-fruited sedge / *Drepanocladus revolvens* rich fen (plot fa 41, 23 Aug 97), habitat of lakeshore sedge; (**h**) unstable, colluviating slope break sands and silts with seepage and diverse microhabitats (from xeric to hygric) as seen from Athabasca River; plot fa47 is on photo right, 22 Aug 97; (**i**) part of bole and canopy of giant balsam poplar (dbh 100.5 cm) in plot fa35, 22 Aug 97, in riparian old-growth balsam poplar - white spruce / dogwood / common horsetail forest on sand Orthic Regosol with abundant buried wood; (**j**) white adder's mouth fruiting stalk in mature/old-growth transition riparian white spruce - aspen / river alder - Alaska birch / dogwood / *Rhytidiadelphus triquetrus* forest on Pemmican Island (plot fa32, 22 Aug 97), habitat of *Zygodon viridissimus, Physcia dimidiata, Campylium polygamum, Brachythecium albicans, B. rutabulum*, and *Heterodermia speciosa*; (**k**) slender wheatgrass / bearberry grassland on steep S-facing eolian sand Brunisol (plot fa26, 20 Aug 97), habitat of low milkweed, rock little club-moss, sand grass, narrow-leaved puccoon, and Drummond's cockle.

1. INTRODUCTION

The purpose of this project was to conduct a floristic and landscape survey of the Ft. Assiniboine Sandhills Wildland Park. We documented rare or otherwise significant plants and community types as information for the management of the park.

The area was first proposed in 1971 as a provincial park by the residents of Ft. Assiniboine and the surrounding area. The original proposal for the park encompassed most of the area in the Sandhills Access and Protection Planning area that lies NE of Ft. Assiniboine. The present smaller boundaries of the park area result from a decision by Alberta Environmental Protection to accommodate off-road-vehicle recreation in the sandhills (Alberta Environmental Protection 1997). The term "Wildland Park" was chosen over "Provincial Park" "to reflect the minimal recreation and tourism development planned for the area. This park will be maintained primarily in a pristine condition with very little development" (Alberta Environmental Protection 1997).

Management guidelines for the park stipulate that an ecosystem management approach should be used. This study provides some of the information needed to implement such an approach.

2. STUDY AREA

The study area is located in the SW part of Central Mixedwood subregion of the Boreal Forest Natural Region (Map 1). The following brief description of the subregion is modified after Achuff (1994), supplemented with reference to Johnson et al. (1995), Smith (1993), and personal observations..

Surficial materials are predominantly ground and hummocky moraine with areas of eolian dunes. Topography is level to undulating. The climate is subhumid continental with short, cool summers and long, cold winters. Mean May-September temperature is about 12 C; the frost-free period is about 85 days; annual precipitation totals about 380 mm; June and July are the wettest months. Gray Luvisols predominate on well-drained upland moraine with Eutric Brunisols on the sandy uplands. Organics and Gleysolics predominate in wetlands.

Aspen forests are characteristic of the uplands, especially in the south, while balsam poplar forests are typical of moister sites and in riparian zones. Mixedwood forests of aspen, white spruce, and balsam poplar are typical, especially in areas which have not burned for some time. Alaska birch is found, typically, with aspen or white spruce on moister soils; paper birch is less common and is sometimes found on sandy soils. Characteristic understories in deciduous and mixedwood forests include prickly rose, beaked hazel, low-bush cranberry, red-osier dogwood, marsh reedgrass, wild sarsaparilla, dewberry, cream-colored vetchling, pink wintergreen, and twinflower. Old-growth forests, especially of pure white spruce and white spruce - balsam poplar, are found preferentially on sites with low fire frequencies, such as on islands, in river valleys, around lakes, and areas surrounded by wetlands. With increasing spruce cover, feather mosses become prominent in the understory. Dry forests on sands are typified by jack pine with bearberry, low bilberry, bog cranberry, and *Cladonia mitis*. Fens have a characteristic cover of larch, dwarf birch, willows, sedges, and brown mosses, and bogs are typified by black spruce, labrador tea, and *Sphagnum*. Shrub carrs are dominated by willows (many species, including sandbar, shining, yellow, little-tree, and flat-leaved willows along streams, and flat-leaved, Bebb's, and pussy willows in flat to depressional shrub wetlands, with bog, myrtle-leaved, and hoary willows typical of peatlands).

Map 1. Location of the Ft. Assiniboine Sandhills Wildland Park.

Birds typical of deciduous forests include least flycatcher, house wren, ovenbird, red-eyed vireos, Baltimore oriole, and rose-breasted grosbeak. Mixedwood forest birds include yellow-bellied sapsucker, Swainson's thrush, solitary vireo, magnolia warbler, and northern goshawk. Spruce forest birds include gray jays, red-breasted nuthatch, ruby-crowned kinglet, yellow-rumped warbler, white-winged crossbills, dark-eyed junco, and boreal chickadee. Old-growth spruce and mixedwood forest birds include winter wren, black throated green warbler, brown creeper, and barred owl. Birds of moist mixedwoods and shrub carrs are typified by yellow and black-and-white warblers, song sparrow, northern water thrush, fox sparrow, and Philadelphia vireo. Common mammals include beaver, muskrat, moose, snowshoe hare, black bear, boreal red-backed vole, deer mouse, meadow vole, masked shrew, red squirrel, and ermine. Less common mammals are wolf, fisher, wolverine, river otter, lynx, and woodland caribou.

Wallis and Knapik (1990) have classified the stretch of the Athabasca River valley within and upstream of the study area as provincially significant. They noted the presence of some of the most diverse and extensive floodplain and terraces in the Mixedwood Region of Alberta. Other features they noted were: steep valley walls; diverse breeding bird habitats; mature riparian with large white spruce and balsam poplar trees; large bank swallow colonies; key moose and deer habitat; and a productive fishery supporting arctic grayling, goldeye, burbot, northern pike, walleye, and mountain whitefish.

Within the study area proper (after field observations and Hay et al. 1988), predominant surficial materials are moderately- to strongly-rolling, rapidly- to well-drained eolian sands and very poorly-drained organic terrain above the Athabasca River valley and level to undulating, imperfectly-drained sandy loam to silt loam alluvium within the valley. Eolian deposits take many forms in the study area, from transverse to parabolic, sinuous, and unoriented. Alluvial deposits are in the form of floodplain, levee, terrace, and abandoned channel. Silty and sandy colluvium and loess are also locally important. Soils are Eluviated Eutric Brunisols on the sands, Orthic and Cumulic Resosols in the river valley, Typic Mesisols in the peatlands. Various types of Gleysols are found in poorly-drained areas associated with the peatlands; colluviating areas are typified by Orthic Regosols. Typical vegetation includes jack pine forests, grasslands, and aspen forests on the drier sites; open, shrub, and treed fens, and treed bogs on the organic terrain; jack pine-white spruce forests on the moister sands; white spruce, balsam poplar, and mixedwood forests in the river valley; and shrub carrs in the river valley and in closed depressions.

3. METHODS

3.1 Pre-field

Prior to fieldwork, a literature search was conducted. A selection of rare plants likely to occur in the study area was examined at the Northern Forestry Centre herbarium. Airphotos of the park were analysed. Significant landscape features and sites likely to contain rare plants were highlighted on the airphotos. These features included riparian and upland old-growth forests, slope break grasslands, dry sand dunes, various peatland types, colluviating slopes, and springs. A fieldwork plan was then prepared.

3.2 Field

Thirty person-days of fieldwork were conducted in the park in the periods 16-23 June and

19-25 August 1997. Sites pre-plotted on airphotos were visited on foot, by mountain bike, or by canoe. Areas between plotted sites were also inspected en route. At each site, we tallied the presence and estimated the cover, by stratum, of all plants found within a 0.03 ha plot. Voucher collections were made as needed. Standard Alberta Environmental Protection site description (LISD 15B, revised 1/97) and vegetation description (LISD 14B, revised 1/97) forms were completed following the procedures specified in Alberta Environmental Protection (1994).

At each site, a three foot long metal pigtail stake was placed and left at plot centre. The top of the pigtail is painted red, labelled with an aluminum tag with the plot number (e.g., “FA01"), and flagged with pink flagging. The geographic location of each plot was determined by GPS. Once near the site, the route to the site is pink flagged on trees and tall shrubs. A site diagram showing landmarks, directions, and distances from known points is provided on the site description sheet. The location of each plot is pinpointed on an airphoto (supplied to the department), and on the enclosed map (Map 2, in pocket).

Nomenclature for vascular plants follows Moss (1983); for mosses see Ireland et al. (1987); for lichens see Egan (1987); and for hepatics see Schuster (1977). Among the vascular plants there are two exceptions: *Carex utriculata* (=*C. rostrata* in Moss 1983) and *Danthonia intermedia* (a common species subsumed under the rare *D. californica* in Moss 1983). Common names follow Alberta Environmental Protection (1993). Authorities on rarity are ANHIC (Alberta Natural Heritage Information Centre) (1996, 1997). An S1 status plant has </= 5 occurrences in Alberta. An S2 status plant has 6-20 known occurrences in Alberta.

Voucher specimens were identified in the laboratory. Difficult or otherwise problematic specimens were shown to Drs. Derek Johnson (Northern Forestry Centre) and Dale Vitt (Univ. of Alberta). Some lichens were sent to Dr. Ted Esslinger (North Dakota State University).

3.3 Analytical

Due to the high species (n=434) and landscape diversity, and the relatively high number of plots (n=48), a subjective approach to defining communities, and detecting patterns in rare species occurrences was insufficient. We felt that DCA (Detrended Correspondence Analysis) ordination and TWINSPAN (Two-Way Indicator Species Analysis) classification were needed to provide an acceptable overview. Both techniques are useful in arranging species or plots on the basis of similarities in occurrence (species) or composition (plots).

While rare species are a focus of this study, their inclusion in an ordination/classification can cause misleading results. A common result is for rare species/unusual communities to define the boundaries of the ordination, causing the majority of the plots and species to be congested in ordination centre with consequent loss of information. It was therefore necessary to filter the dataset to include only the more common <u>and</u> dominant species. The patterns observed would then be interpreted in the context of the rare species and community occurrences. The following filter was used: (a) the 10 species with the highest cover in each plot were entered into the data matrix; (b) only species with cover > trace were tallied; (c) in the event of a tie in cover values for the last species in a plot, the more common, larger species was tallied; if these were tied, then the first tied species seen in scanning the dataset was tallied. In this way the total number of species was reduced to 146, and to a maximum of 10/plot.

The species by stand matrix was then imported into PC-ORD (version 2.0; McCune and Mefford 1995). The dataset was then filtered to include only those species that occurred more than once as a dominant in the 48 plots (n=84 species).

Total species richness and rare species richness were tallied for each plot. A "rare" species of a vascular plant or of a moss was based on ANHIC (1996) and for lichens, ANHIC (1997). There were two exceptions: *Brachythecium campestre* is classified as rare in ANHIC (1996), but that designation is due to undercollection and identification to genus only. *B. campestre* is actually common, and we ignored it in the richness estimate. Conversely, *Selaginella rupestris* is classified as S3 (21-100 occurrences in AB), but it is mapped in Moss (1983) as having only 5 occurrences; we tallied it as rare. Average richness and rare species richness were then tabulated for overall plots and for plots by vegetation type.

4. RESULTS

4.1 Species Richness at the Study Area Scale

A total of 434 species of plants were found in the study area (Appendix 1), of which 20 species (4.59%) are classified as provincially rare (Table 1; note that *Brachythecium campestre* is ignored as a rare plant in the tabulation and in Map 2). Of the 20 rare species, 6 were vascular plants, 7 were mosses, and 7 were lichens. By taxonomic group, there were 258 vascular species, 90 mosses, 14 hepatics, and 74 lichens. The typical 0.03 ha plot contained 50.2 species (s.d. 18.9; median 49.5), with a maximum of 97 species and a minimum of 9 species/plot. Mean number of rare species/plot was 0.771 (s.d. 1.372; median 0) (Table 2).

It is difficult to place these species figures in context because species richness, especially that of rare species, is strongly influenced by non-ecological factors such as observer effort. Upstream of the study area, in the present Holmes Crossing Sandhills Ecological Reserve (Nelson et al. 1989; ~4900 ha), a total of 195 species have been tallied, composed of 157 vascular plants, 22 mosses, 16 lichens, and no hepatics. Bradley and Fairbarns (1984) documented the flora of the 5780 ha candidate Goose Mountain Ecological Reserve located ~90 km northwest of our study area in the Swan Hills (a physiographically distinct Cordilleran outlier) (our study area spans 6,600 ha). They found a total 369 species composed of 279 vascular plants, 45 mosses, 6 liverworts, and 39 lichens. The Pine Sands Natural Area (1,341 ha) is located along the south margin of the Athabasca River ~40 km NE of Athabasca, AB in the Dry Mixedwood subregion of the Boreal Forest Natural Region. There Timoney and Robinson (1992) found 370 taxa composed of 247 vascular plants, 72 mosses, 8 hepatics, and 43 lichens. Bakshi and Holmberg (1986), in an intensive study of 240 ha of Athabasca University lands within the town of Athabasca, found 271 species of vascular plants, 10 mosses, 2 liverworts, and reported no lichens. In comparison to other areas, the Ft. Assiniboine study area appears to have high richness of mosses, lichens, and liverworts (the latter are undersampled), and comparable numbers of vascular plants.

4.2 Species Richness at the Plot Scale

In order to determine if any vegetation types have higher species richness or support more rare species than the average, plot richness data were tabulated by vegetation type. White spruce forests, typically represented by riparian old-growth forests along the Athabasca River, had the highest species richness/plot (mean 75.7 species vs. an overall mean of 50.2 species)-- about 50%

more species than the average observed in the study area (Tables 2 and 3, Figure 1). Mixedwood forests, typically old-growth riparian white spruce - balsam poplar +/- aspen +/- birch forests along the Athabasca River, stood out from all the others in supporting the most rare plant species

Table 1. Provincially rare (S1-S3 rank) species of the Ft. Assiniboine Sandhills Wildland Park.

Provincially Rare Species	Plots and Comments	Common Name	Plant Group
Asclepias ovalifolia	plots fa03,26,18,24; regionally rare	Low Milkweed	Vascular
Aster x maccallae	fa42; no specimens in herb.	MacCalla's Aster	Vascular
Brachythecium albicans	fa32; on forest floor	-------	Moss
Brachythecium campestre	fa27,30,32,34,37,40,45,47; not rare	-------	Moss
Brachythecium rutabulum	fa32; on forest floor	-------	Moss
Campylium polygamum	fa05,14,32,34	-------	Moss
Campylium radicale	fa34,35,37	-------	Moss
Carex lacustris	fa41	Lakeshore Sedge	Vascular
Entodon schleicheri	near fa32; fa39; 4th, 5th AB record	-------	Moss
Heterodermia speciosa	fa09,27	-------	Lichen
Malaxis monophylla	fa32,39	White Adder's Mouth	Vascular
Melanelia olivacea	fa01,16,17,28	-------	Lichen
Peltigera collina	near fa38; on old poplar	-------	Lichen
Peltigera evansiana	near fa38; fa39	-------	Lichen
Peltigera horizontalis	fa27,39	-------	Lichen
Physcia dimidiata	fa32,35,39	-------	Lichen
Physconia enteroxantha	fa27	-------	Lichen
Selaginella rupestris	fa01,24,26	Rock Little Club-Moss	Vascular
Sphenopholis obtusata	fa37	Prairie Wedge Grass	Vascular
Zygodon viridissimus	fa32; 2nd record for AB	-------	Moss

(Tables 2 and 3, Figure 2)-- a mean of 3.0 species vs. 0.771 species. Pemmican Island is characterized by high plant species richness (vegetation types 3 and 6 in Table 3, Figure 2), and by high richness of rare plants (Map 2). Conservation of plant species biodiversity requires that old-growth forests be protected from logging.

4.3 Rare Plant Occurrences (see Map 2, in pocket)

Asclepias ovalifolia (low milkweed, Alberta ANHIC S2 status) was found four times in the study area (plots fa03, fa26 (color plate k), fa18, fa24). Within the park it is found sporadically in subxeric to submesic grasslands and savannahs dominated by slender wheatgrass, western wheatgrass, western porcupine grass, and bearberry. Each occurrence had a secure population.

Aster x maccallae (MacCalla's aster; status uncertain) was found once (fa42) in a jack pine/bearberry - northern ricegrass savannah; there were approximately 10 individuals. Its conservation status is uncertain, as it is shown to have only 4 occurrences in Moss (1983), but is not listed in ANHIC (1996). It is, according to Moss (1983), a hybrid between *A. ciliolatus* and *A. subspicatus*.

Brachythecium albicans ("S2?" status uncertain) was found once (fa32, color plate j). It was found on the forest floor of white spruce - aspen / river alder - Alaska birch / dogwood / *Rhytidiadelphus triquetrus* mature riparian forest undergoing the transition to old-growth condition. There were a few patches or clumps. This species is common in eastern Canada and should be more common in Alberta (R. Belland, pers. comm. 1997). The genus *Brachythecium* needs a complete revision.

Brachythecium campestre (S2 status) was found eight times in the study area (fa27,fa30,fa32,fa34,fa37,fa40,fa45,fa47). While classified as "rare" it is actually quite common and should be removed from the ANHIC tracking list. The moss is characteristic of mixedwood forests on tree bases, on soil, and on logs. It was not tallied as part of the analysis of rare species (Tables 2,3, Figure 2), nor is its occurrence noted on Map 2.

Brachythecium rutabulum ("S2?" status uncertain) was found once (in fa32; see *Brachythecium albicans*, and color plate j) on forest floor. There were a few patches or clumps.

Campylium polygamum (S3 status) was found in four plots (fa05,fa14,fa32 (color plate j), fa34) in riparian meadow, riparian mixedwood forest (2 times), and riparian balsam poplar. There were sporadic clumps. This species is probably not rare in Alberta.

Campylium radicale (S1 status) was found 3 times (fa34,fa35 (color plates d and i),fa37) in riparian old-growth mixedwood, riparian balsam poplar, and riparian river alder - willow / *Equisetum hyemale*. Its abundance varied from a single to several patches.

Carex lacustris (lakeshore sedge, S2 status) was found once (fa41, color plate g) in a *Carex lasiocarpa / Drepanocladus revolvens* rich fen. There were a few sporadic individuals.

Entodon schleicheri (S1 status) was found twice (near fa32 (color plate j); fa39, color plate b), both times in riparian forests (for fa32, see *B. albicans* and color plate j). Plot fa39 is an old-growth white spruce / paper birch - aspen / *Equisetum pratense* forest. Near fa32 there was at least one patch; in fa39 there were several robust patches. These occurrences are 4th and 5th records for this species in Alberta. The species is described in Buck and Crum (1978).

Heterodermia speciosa (rare, ANHIC status undetermined) was found twice: in an old-growth riparian white spruce / dogwood - highbush cranberry / *Equisetum pratense* / feather moss forest (fa09) and in an old-growth white spruce / *Equisetum pratense* / feather moss forest on loess with lateral seepage (fa27, color plate e). Abundance varied from a single clump to several clumps. The species is common in eastern North America (Hale 1979) and rare on deciduous or coniferous trees in western North America (Goward et al. 1994).

Malaxis monophylla (white adder's mouth, S2 status) was found twice (fa32 (color plate j),fa39), both times in mature to old-growth riparian mixedwood forests (see *Brachythecium albicans* and *Entodon schleicheri*, above). In both cases a single individual was observed.

Melanelia olivacea (rare, ANHIC status undetermined) was found four times (fa01,fa16,fa17,fa28): in a jack pine / bearberry - northern rice grass savannah; in a subxeric former slender wheatgrass - northern ricegrass grassland undergoing encroachment to aspen - balsam poplar - prickly rose shrubs with slender wheatgrass and bearberry; in an aspen / *Lonicera involucrata - Salix prolixa - S. myrtillifolia* forest; and in an encroaching shrubland (former grassland) of bearberry - chokecherry - aspen - slender wheatgrass. A few patches of the species were observed at each site. It is fairly common in southeastern Canada and the NE United States (Thomson 1984; Hale 1979; where cited as *Parmelia olivacea*).

Peltigera collina (rare, ANHIC status undetermined) was found once (near fa38) on a large old balsam poplar log in riparian balsam poplar - white spruce mixedwood. In Europe Peltigera collina is considered characteristic of "old woodlands"; it is considered "extremely rare" in Alberta (Goffinet and Hastings 1994). Figure 28 in Goffinet and Hastings (1994) indicates that 3 of the 4 collection localities for this species in Alberta were on or near major river valleys; our collection would support the notion that *P. collina* may be characteristic of old-growth riparian forests. There was only a single patch found.

Peltigera evansiana (rare, ANHIC status undetermined) was found twice (near fa38, and in fa39, color plates b and f) in old-growth white spruce and mixedwood. Near fa38 it was found on the same large balsam poplar log on which *P. collina* was found. For fa39, see *Entodon schleicheri* (above). In Alberta this species is apparently locally common around Edmonton and rare elsewhere (Goffinet and Hastings 1994) who report that it grows on rotten wood or tree roots in aspen, balsam poplar, or mixedwood forests. There were a few patches found near fa38 and a few sporadic individuals in fa39.

Peltigera horizontalis (rare, ANHIC status undetermined) was found twice (for fa27 see *Heterodermia speciosa* above and color plate e, and for fa39 see *Entodon schleicheri*, and color plates b and f) in old-growth spruce and mixedwood. In Alberta, the distribution of this species is not well known. In the lowlands of Great Britain, it appears to be a "faithful species to old hardwood forest" (Goffinet and Hastings 1994). At both sites a single patch was found.

Physcia dimidiata (rare, ANHIC status undetermined) was found at three sites (fa32 (see *Brachythecium albicans* and color plate j), fa35 (color plates d and i, balsam poplar - white spruce / dogwood / horsetail), fa39 (see *Entodon*): twice in riparian old-growth forest and once in riparian mature/old growth transition. At the three sites it occurred as a few clumps.

Physconia enteroxantha (rare, ANHIC status undetermined) was found once (fa27; see *Heterodermia speciosa*, and color plate e). A few clumps were found.

Selaginella rupestris (rock little clubmoss, S3 status) was found at three sites: in a jack pine/bearberry - northern ricegrass savannah (fa01); in a western porcupine grass - sand grass / bearberry grassland (fa24); and in slender wheatgrass / bearberry grassland (fa26, color plate k). It is characteristic of subxeric grassy sand dunes. Its abundance varied from a few individuals to widely-scattered clumps.

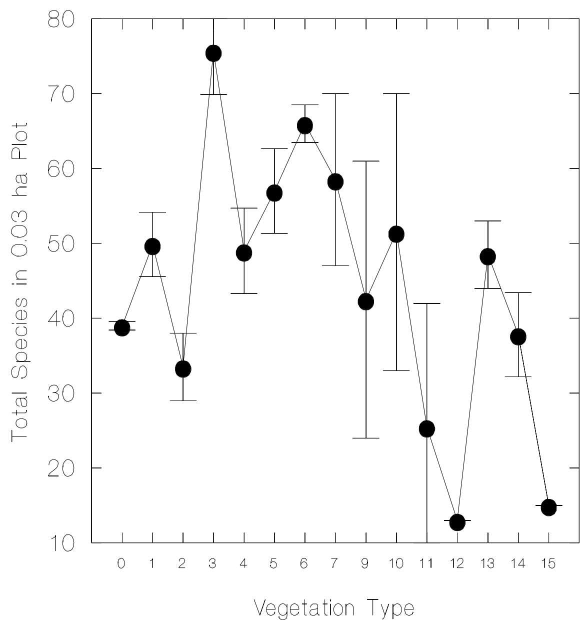
Sphenopholis obtusata (prairie wedge grass, S2 status) was found once in a river alder - shining willow - yellow willow - sandbar willow / *Equisetum hyemale* riparian point bar thicket on

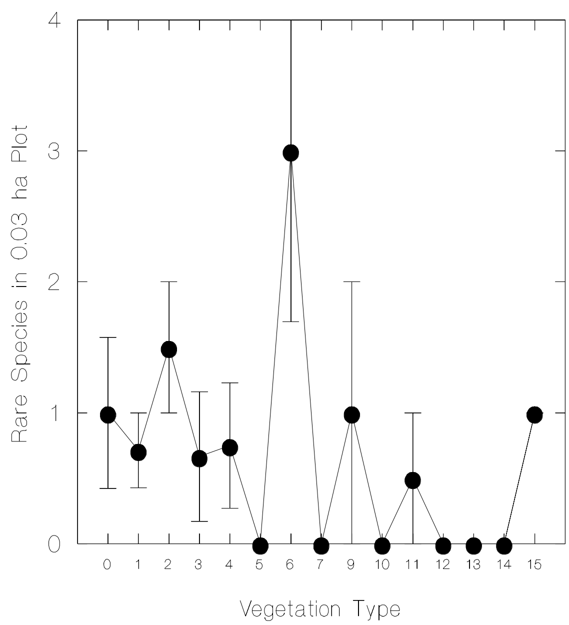
Table 2. Summary statistics for number of provincially rare plant species and total species per 0.03 ha plot (n=48) at Ft. Assiniboine Sandhills Wildland Park.

STATISTICS	RARES/PLOT	TOTAL SPP./PLOT
MINIMUM	0.000	9.000
MAXIMUM	7.000	97.000
RANGE	7.000	88.000
MEAN	0.771	50.229
VARIANCE	1.883	355.585
STANDARD DEV	1.372	18.857
STD. ERROR	0.198	2.722
SKEWNESS(G1)	2.717	-0.034
KURTOSIS(G2)	8.491	-0.233
SUM	37.000	2411.000
C.V.	1.780	0.375
MEDIAN	0.000	49.500

Table 3. Summary statistics for rare plant and total species diversity by vegetation type. Vegetation type codes are keyed to those of Figures 1-3.

	Rare Plant Species			Total Plant Species			
Vegetation Type / Code	Mean	S.D.	Median	Mean	S.D.	Median	Plot (n)
Grassland / 0	1.000	1.000	1	39.0	1.0	39.0	3
Pj,Savannah / 1	0.714	0.756	1	49.9	11.4	55.0	7
Wheatgrass / 2	1.500	0.707	1.5	33.5	6.4	33.5	2
Sw Forest / 3	0.667	1.211	0	75.7	14.1	78.0	6
Mixed Deciduous/4	0.750	0.957	0.500	49.0	11.4	46.0	4
Aw Forest / 5	0	0	0	57.0	11.3	57.0	4
Mixedwood / 6	3.000	2.915	2	66.0	5.6	63.0	5
Sw-Pj Forest / 7	0	0	0	58.5	16.3	58.5	2
Willow-Alder / 9	1.000	1.414	1.000	42.5	26.1	42.5	2
Seepage Meadow/ 10	0	0	0	51.5	26.2	51.5	2
Riparian Meadow, Backswamp / 11	0.500	0.707	0.500	25.5	23.3	25.5	2
Marsh / 12	0	---	0	13	---	13	1
Poor Fen, Bog / 13	0	0	0	48.5	6.4	48.5	2
Meso Fen / 14	0	0	0	37.8	12.6	40.0	5
Rich Fen / 15	1	---	1	15	---	15	1


80
70
60
50
40
30
20
10
Total Species in 0.03 ha Plot
0
1
2
3
4
5
6
7
9
10
11
12
13
14
15
Vegetation Type



Rare Species in 0.03 ha Plot
0
1
2
3
4
0 1 2 3 4 5 6 7 9 10 11 12 13 14 15
Vegetation Type

silt and fine sand (fa37). There were a few individuals. Prairie wedge grass is a species of "moist areas, shrubbery, coulee bottoms, creek banks, and lakeshores" (Looman and Best 1979).

Zygodon viridissimus (S1 status) has apparently been found once before in Alberta -- in the N. Saskatchewan River valley in Edmonton (D. Vitt, pers. comm. 1997). We found it once (in fa32 (color plate j), see *Brachythecium albicans*, above). This is a second record for Alberta. There were a few clumps.

4.4 Other Noteworthy Plant Occurrences

There were many occurrences of plants that are non-provincially rare but whose occurrence was otherwise significant. The significance of the plants (all vasculars with the exception of *Cladonia botrytes*) was assessed by relating their occurrences to both range maps (from Moss 1983) and to our experience with the vegetation of Alberta.

Anemone cylindrica (long-fruited anemone) was found in a few areas (fa26 (color plate k), near fa11, and elsewhere). It is relatively uncommon.

Arabis lyrata (lyre-leaved rock cress) was found at fa01 and elsewhere in dry open sands. It is relatively uncommon.

Aster brachyactis (rayless aster) was found once (fa48, color plate a) in a colluviating, calcareous iron seep; it is relatively uncommon.

Aster modestus (large northern aster) was found east of fa38 near the south shore of Pemmican Island in an *Aster*-willow-grass community. It is relatively uncommon.

Calamagrostis purpurascens (purple reedgrass) was found twice in subxeric sandy grasslands (fa08, fa16); it is uncommon in the region and its occurrence fills in a range gap.

Calamovilfa longifolia (sand grass) was found at fa24 in subxeric grassland. It is uncommon in the region, and its occurrence is a small range extension.

Carex eburnea (bristle-leaved sedge) was found with *Aster brachyactis* in the colluviating, calcareous iron seep (fa48); it is uncommon.

Carex filifolia (thread-leaved sedge) was found in three dry grasslands (fa18, fa20 (color plate c), near fa24); its occurrence is a range extension.

Carex lanuginosa (woolly sedge) was a dominant in the marsh/rich fen transition plot (fa07); it is uncommon north of the N. Saskatchewan River.

Carex leptalea (bristle-stalked sedge) was found twice in situations with high iron content: in an old-growth white spruce / feather moss forest along an iron brook (fa04), and in an iron seep poor fen (fa19); it is uncommon.

Carex prairea (prairie sedge) was found in a larch / *Menyanthes* / *Carex diandra* / *Tomenthypnum* string fen (fa44); it is uncommon.

Carex richardsonii (Richardson's sedge) was found at fa01, fa02, and fa10; it is an uncommon species of dry sandy grasslands and dry pine forests.

Carex rossii (Ross' sedge) was found in a dry slope break grassland above the Athabasca River (fa08); it is uncommon.

Carex stenophylla (low sedge) was found in a steep, SE-facing western porcupine grass site (fa20, color plate c); it is uncommon.

Chenopodium leptophyllum (narrow-leaved goosefoot) was found in somewhat disturbed, dry open sand at our camp on the south-central boundary of the study area. It is uncommon and a small range extension.

Circaea alpina (small enchanter's nightshade) was found in a few old-growth riparian forests (e.g., fa09); it is locally uncommon.

Cladonia botrytes was found on a log on a string in a larch / *Menyanthes* / *Carex diandra* / *Tomenthypnum* fen (fa44); it is uncommon.

Convolvulus sepium (wild morning glory) was found outside plot fa20 in a western porcupine grass - snowberry / *Tortula ruralis* grassland on a steep, SE-facing eolian sand slope.

Danthonia intermedia (oat grass) was found once in a sandy grassland along the Klondyke Trail near fa42; it is regionally uncommon.

Drosera rotundifolia (round-leaved sundew) was found once in the iron seep poor fen (fa19); it is locally uncommon.

Eriophorum viridi-carinatum (thin-leaved cotton grass) was found once in a disturbed *Equisetum variegatum / Catoscopium nigritum* calcareous seep meadow (fa02); it is locally uncommon.

Habenaria obtusata (blunt-leaved bog orchid) was found in a larch / *Menyanthes* / *Carex diandra* / *Tomenthypnum* fen (fa44); it is uncommon.

Heterotheca villosa (golden aster) was found in two dry grasslands (e.g, fa08); it is locally uncommon.

Juncus alpinoarticulatus (alpine rush) was found in the colluviating, calcareous iron seep (fa48); it is relatively uncommon.

Lithospermum incisum(narrow-leaved puccoon) was found in a steep, SE-facing western porcupine grass grassland (fa20) and in a steep south-facing slender wheatgrass grassland (fa26); it is regionally uncommon and a small range extension.

Lycopodium annotinum (stiff clubmoss) was found occasionally in riparian old-growth white spruce and mixedwood forests; it is locally uncommon..

Melampyrum lineare (cow-wheat) was found near fa28 in a bearberry dune grassland undergoing shrub encroachment. It was also found with bearberry along a trailside near our south camp (south-central boundary of park); it is regionally uncommon..

Muhlenbergia glomerata (bog muhly) was found in a larch / bog birch / brown moss fen (fa12; it is relatively uncommon.

Salix drummondiana (Drummond's willow) was found in a riparian *Scirpus microcarpus* meadow along Clearwater Creek (fa05); it is regionally uncommon.

Silene drummondii (Drummond's cockle) was found in the steep, SE- or S-facing grasslands of western porcupine grass (fa20) or of slender wheatgrass (fa26, color plate k); it is relatively uncommon.

Solidago missouriensis (low goldenrod) was found at a dry slope break grassland above the Athabasca River (fa08) and in an actively colluviating bluff along the Athabasca River (fa47, color plate h); it is regionally uncommon and a range fill-in.

Sporobolus cryptandrus (sand dropseed) was found with *Solidago missouriensis*, *Heterotheca villosa, Carex rossii,* etc. (at fa08), and in disturbed xeric sand at a well site near fa11; it is locally uncommon.

Stipa curtiseta (western porcupine grass) was found at fa20 and fa24 as a dominant in the dry grasslands; it is regionally uncommon.

4.5 Ordination

Stand ordination indicates a high degree of dissimilarity among the wetland types (Figure 3, right, Appendix 2), indicating a high community diversity of wetlands. An ordination artifact of the wetland diversity is that upland communities are clumped in ordination left-center. Both axes 1 and 2 are complex gradients, but moisture regime is clearly a predominant environmental variable on axis 1 (dry on left, wet on right; r=0.904). A prominent feature of axis 2 (r=0.688) is that peatlands (bog and fens) occupy the bottom while non-organic wetlands (e.g., marshes and meadows) occupy the top (with upland communities occupying the middle).

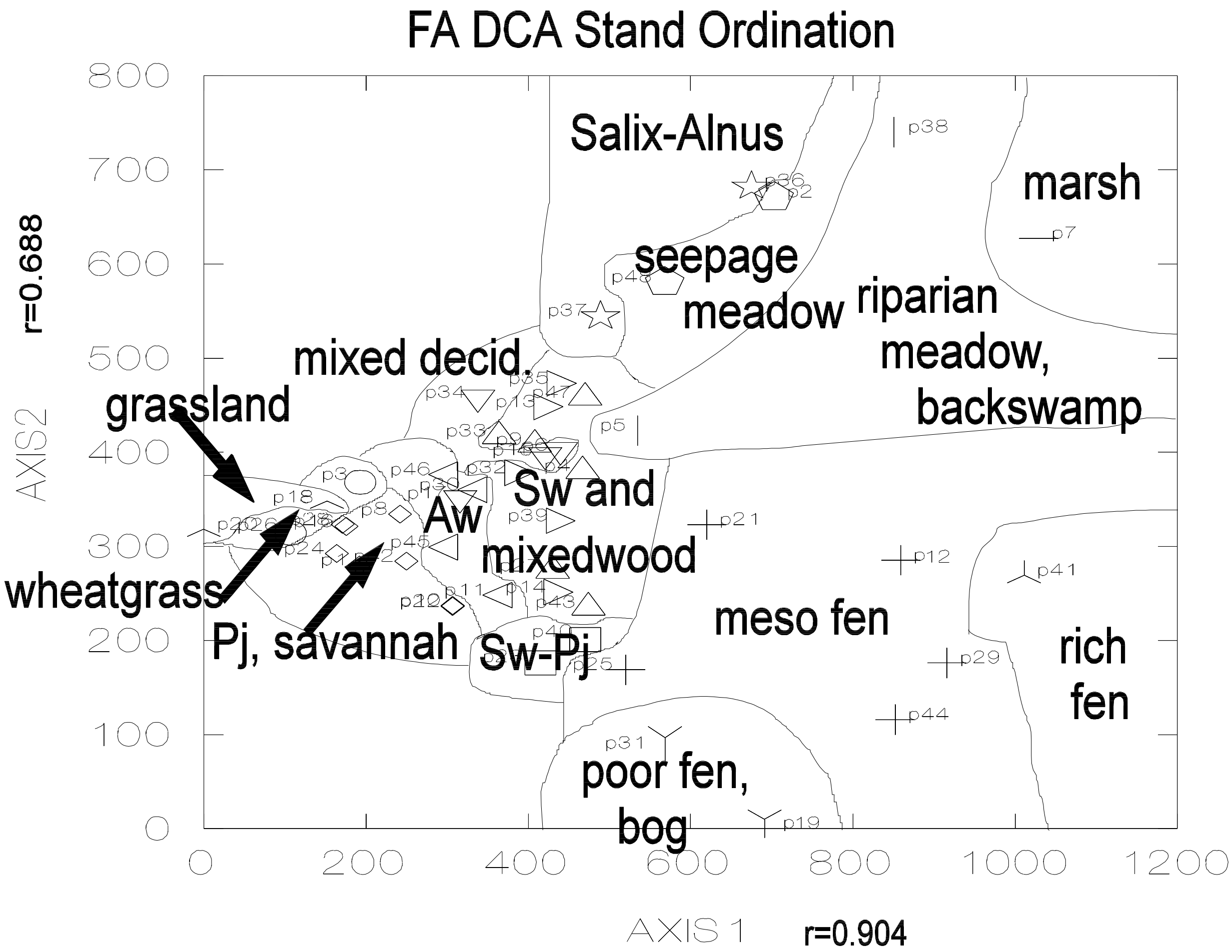
Dry grasslands occupy steep freely-drained slopes on eolian and colluviating sands (ordination far left). Grasslands dominated by slender wheatgrass occupy similar to somewhat moister sites. Dry open jack pine forests and jack pine/rice grass savannahs on rolling eolian sand dunes occupy the transition from grasslands to forests, both on the landscape and on the ordination. Aspen forests are found on yet moister sites, ranging from undulating loess to silty colluviating slopes. North-facing dunes, slope bases, and generally cooler sites on eolian sands are occupied by white spruce - jack pine forests. White spruce and white spruce mixedwood forests are best represented on the moist silty soils, either on the loess plains with seepage, or along streams, most notably on the riparian terraces of the Athabasca River. Mixed deciduous (*Populus balsamifera +/- P. tremuloides +/- Betula +/- Salix*) forests occupy moist silts (above middle-center). *Salix-Alnus* carrs occupy the silt floodplain and first terraces of the Athabasca River (ordination top, center). Riparian meadows are found on the floodplain of slow-flowing streams (e.g., Clearwater Creek), while backswamps are sedge marshes that occupy abandoned back channels of the Athabasca River. Seepage meadows (top, center) are graminoid-dominated and occupy silty soils where laterally-flowing nutrient-rich water reaches the soil surface. Marshes (top, right) occupy fine-textured depressions (usually silt-bottom) between eolian sands in which there is a clear lateral transport of water through the area; they are transitional to rich fens. Fens (lower right) occupy similar landscape positions but are differentiated from marshes by peat accumulation and species composition. Rich fens are high in mineral nutrients and usually lack strings, shrubs, and trees. Mesotrophic fens have moderate levels of nutrients and often a string or network pattern in the study area. Poor fens and bogs are marked by significant peat accumulation and a hummocky or domed surface.

Ordination of the 84 common/dominant species produced a plot that was difficult to interpret due to excessive overwriting (clustering) of species. DCA species ordination scores are provided in Appendix 3. TWINSPAN classification was employed as an alternative to DCA ordination.

4.6 Classification

An inherent disadvantage of TWINSPAN is that it is not well-suited to complex ecological gradients (McCune and Mefford 1995) (e.g., combined age/succession, water, nutrient, and disturbance gradients). The clear importance of water as a primary ecological gradient, we believed, justified the use of TWINSPAN to provide an overview of vegetation and species groups.

TWINSPAN (Table 4, Appendix 4) recognized 13 vegetation groups at the fourth level. Since TWINSPAN classification is automated, the vegetation types differ somewhat from those subjectively delimited. For that reason, we have used letters rather than numbers as a shorthand for the TWINSPAN types. The equivalent types that we recognized subjectively (Table 3) are


FA DCA Stand Ordination
Salix-Alnus
marsh
seepage
meadow
riparian
meadow,
backswamp
mixed decid.
grassland
Sw and
mixedwood
Aw
wheatgrass
Pj, savannah
Sw-Pj
meso fen
rich
fen
poor fen,
bog
AXIS 1
r=0.904
AXIS2
r=0.688

```
Table 4.  TWINSPAN classification of 48 plots and 84 common/dominant species
at the Ft. Assiniboine Wildlands Provincial Park.  Species groups are listed
on the right hand side (a,b,c...), plot groups across the bottom and top (a,b,
c...), plot numbers across the top, and seven letter species codes on left.

          aaaaaaaaaabbbcdddddeeeeeeeeeeeeffffffffghhijklmn
          2 24 112 2212134413 3 13333  14122344214 3124 43
          084236881620310565457932359467745710319826294718

pinuba    -656-3--5-777----------------------434----2-----  0000 a
agrotr    ----33-437--------------------------------------  0000 a
arctuv    368939797746------------------3-----------------  0000 a
asclov    ----2-3-----------------------------------------  0000 a
calalo    3-3------2--------------------------------------  0000 a
cladmi    --------8-43------------------------------------  0000 a
fragvi    ----4--3----------------3-----------------------  0000 a
galibo    -3-----422--------------------------------------  0000 a
oryzpu    --33---343-3------------------------------------  0000 a
smilst    -333--------------------------------------------  0000 a
stipcu    7-6---------------------------------------------  0000 a
sympal    6----53-----------------------------------------  0000 a
tortru    43----------------------------------------------  0000 a
viciam    24----4-----------------------------------------  0000 a
amelal    2233-344-32--3437-8-----7-----------------------  0000 a
apocan    -7--443----------7------------------------------  0000 a
lathoc    -----3-------3----------------------------------  0000 a
prunvi    ----2-344-------643-----3-----------------------  0000 a
sympsp    --3--------------4------------------------------  0000 a
elymin    ---3------2--7-3--------------------------------  0001 b
lathve    ---------2------3-------------------------------  0001 b
maiaca    -----------4--322-2-----------------------------  0001 b
prunpe    -------2-------34-------------------------------  0001 b
alnucr    ---3----3-443--9-----4-------------34-----------  0001 b
aralnu    --------------8384-----------3-4-4--------------  0001 b
salibe    -----------335----43-----------------3----------  0001 b
vaccmy    ----------3-25---------------------32-----------  0001 b
eleaco    -4----------------------------4--------3--------  0010 c
popuba    -----3-----------49--47--7---4------------------  0010 c
pylapo    --------------4--4-----4---44-------------------  0010 c
vibued    --------------4--------4------------------------  0010 c
poputr    ----24-3-----6888-----46--4-77-4-3-4------------  0010 c
rosaac    2-----33--3----4653--3544----3-3-3--------------  0010 c
cornca    ------------4-54-------4-------5---4------------  0011 d
pleusc    ----------459---------------3--887997-3---------  0100 e
ptilcr    ------------4------------------737--2-----------  0100 e
vaccvi    -----------3---3---------------44--32-----------  0100 e
ledugr    ------------33------------------8-863-6---------  0100 e
usnesc    ---4---------------4------------4---------------  0100 e
betune    -----------------8-6--4-----7----4-3-7----------  0100 e
linnbo    -----------32--------------33--4-8--------------  0100 e
equipr    ------------------3---563-4------8--------------  0101 f
hylosp    ---------------------------7-3-687446-----------  0101 f
parmsu    -------------------4--------------4-------------  0101 f
picegl    -2-3--------3--------76777774-7768-784-62-2-----  0101 f
plagel    -------------------3------6-----------7---------  0101 f
alnute    -------------------68-3--4-65-6-4--------3------  0101 f
bracsa    ------------------------33-4--------------------  0101 f
careau    ---------------------------------------35-------  0101 f
ditrfl    ------------------------------3--------7--------  0101 f
equiar    ------------------5--46-46-44-6--------8--------  0101 f
equiva    ---------------------------------------487------  0101 f
loniin    ----------------------------47------------------  0101 f
rhyttr    -----------------------9--4---------------------  0101 f
rubuid    -------------------------37---------------------  0101 f
saliar    -------------------4-------------------3--------  0101 f
saliex    --------------------4--------------------6------  0101 f
salips    ---------------------------------------5-7------  0101 f
vibutr    ---------------------4--32----------------------  0101 f
cornst    ----------------5-345567-75---2-----------------  0101 f
betupa    ------3------------------46---------------------  0101 f
coryco    ----------------3----4------4-------------------  0101 f
rubupu    --------------7--4---6-64-7--3------------------  0101 f
picema    -------------3------------------5-8-5-4-----3---  0110 g
careaq    --------------------------------------6-------2-  0111 h
hypoph    -------------------4----------------------2-----  0111 h
calaca    --------------4-------3--3---7-----------2-----4  100  i
calain    -----------------------------------------4-----2  1010 j
campst    ---------------------------------------4-----3--  1010 j
bryups    ----------------------------------------534--2--  1011 k
everme    ---4---------------------------------------44---  1100 l
menytr    --------------------------------------6----35---  1101 m
betupu    -------------------------------------4----844---  1101 m
drepve    --------------------------------------4----9----  1101 m
tomeni    ------------------------------------------449---  1101 m
larila    ----------------------------------3--54---778---  1101 m
carech    --------------------------------------------4-4-  1110 n
carela    ------------------------------------------48--7-  1110 n
drepad    ------------------------------------------5----4  1110 n
salica    ------------------------------------------3--2--  1110 n
careut    ----------------------------------------------47  1111 o
equifl    ---------------------------------------------3-2  1111 o
drepre    ---------------------------------------------37-  1111 o
utrimi    ---------------------------------------------84-  1111 o

          000000000000000000000000000000000000000000111111
          000000000000000000011111111111111111111111000111
          000000000000011111100000000000000000000111011001
          0000000000111011111000000000000111111110011 0101
```

aaaaaaaaaabbbcdddddeeeeeeeeeeeefffffffghhijklmn provided in parentheses after the following types. Type a (10 plots, types 0,1,2) is composed of grasslands and jack pine savannahs on dry eolian sands; characteristic species are bearberry, *Tortula ruralis*, slender wheatgrass, western porcupine grass, and northern ricegrass. Type b (3 plots, types 1,7) is composed of jack pine forests on north-facing to slightly-depressional eolian sands; characteristic species are jack pine, green alder, and big redstem moss (Schreber's moss). Type c (1 plot, type 5) is an unusual ecotonal slope base forest dominated by aspen and black spruce. Type d (5 plots, type 4) is a heterogeneous deciduous forest group dominated by aspen or Alaska birch or balsam poplar with a well-developed shrub layer, all typically on silts or very fine sands; other characteristic species are chokecherry and wild sarsaparilla. Type e (12 plots, types 3,6) is a large group of moist riparian forests on silt; characteristic species are white spruce, river alder, balsam poplar, and *Equisetum pratense*; half the plots are old-growth forests. Type f (8 plots, types 3,13,14) is a heterogeneous group of hygric conifer / feathermoss forests ranging from old-growth white spruce on a loess plain with seepage to white spruce, black spruce, and larch mesotrophic and poor fens and bogs; other characteristic species are big redstem, Knight's plume, and stairstep mosses, bog cranberry, and labrador tea. Type g (1 plot, type 10) is a species-rich, slumping, calcareous seep (color plate a); characteristic species are *Ditrichum flexicaule* and *Equisetum arvense*. Type h (2 plots, types 9,10) is composed of moist, disturbed silts (plot 2 seepage site disturbed by machinery, and plot 36 disturbed by frequent flooding) with a high willow cover; characteristic species are *Equisetum variegatum*, *Carex aurea*, and *Bryum pseudotriquetrum*; willow species vary from site to site (*Salix pseudomonticola, S. exigua, S. arbusculoides*). Types i-n are all wetlands and contain only one plot each. Type i (type 14) is a young larch/shrub mesotrophic fen with no string development. Type j (type 14) is an older example of type i showing faint string development. Type k (type 14) is a larch/sedge mesotrophic string fen. Type l (type 12) is a *Carex lanuginosa / Utricularia minor* marsh. Type m (type 15) is a *Carex lasiocarpa / Drepanocladus revolvens* extreme rich fen. Type n (type 11) is a *Carex utriculata / Drepanocladus aduncus* backswamp.

In general, the subjective and objective classifications agreed well. TWINSPAN failed to differentiate some of the white spruce forests from the white spruce mixedwood forests and mixed conifer forests, which is understandable in that the three subjective types are segments of gradients in white spruce vs. black spruce and larch vs. deciduous tree cover. Similarly, TWINSPAN failed to differentiate the subxeric grasslands and savannahs-- a difficulty that would have been avoided if a dataset including more species were used as there are many characteristic (but non-dominant) species that grow preferentially in northern ricegrass vs. porcupine grass vs. slender wheatgrass communities. Conversely, TWINSPAN split the mesotrophic fens (type 14) into four groups-- a clear indication that the organic wetlands are different in species composition (also indicated by the wide ordination spread in Figure 3).

Unlike the high eigenvalues observed for the plot groups, the species groups delineated by TWINSPAN were generally of low statistical significance (Table 4, Appendix 4). The low eigenvalues are probably a result of the method used to filter the dataset to occurrences when a particular species was dominant. Many dominant species have wide ecological amplitudes. As such, their distribution patterns tend to overlap with other dominant species, making recognition of distinct groups difficult. Little significance should be attached to the species groups identified on the right side of Table 4. The table does show, however, a clear moisture gradient with species typical of dry communities at the top, those typical of mesic to hygric mineral soils in table center, and those typical of wetlands at the bottom of the table.

4.7 Noteworthy Landscape and Natural History Themes

Five broad biophysical (landscape) units were identifiable within our study area: (1) eolian sands, typically in the form of dunes; (2) undulating loess (eolian silt) plains; (3) organic and non-organic wetlands; (4) riparian complex; and (5) colluviating slopes at the transition from the uplands to the Athabasca River valley. In comparison, in the nearby Holmes Crossing Sandhills Ecological Reserve, Nelson et al. (1989) found five landscape types: (1) eolian; (2) fluvial (=riparian complex); (3) lacustrine; (4) colluviating slopes; and (5) organic and non-organic wetlands. In the Goose Mountain Ecological Reserve (lying within the Upper Foothills subregion of the Foothills Natural Region), Bradley and Fairbarns (1984) documented four biophysical (landscape) units: (1) coniferous forest; (2) open wetlands; (3) floodplains (riparian); and (4) a seepage unit. In the Pine Sands Natural Area (Timoney and Robinson 1992), the dominant landscape units were (1) riparian complex; and (2) sand dunes; with a small number of wetlands and colluviating landforms. The Ft. Assiniboine Sandhills Wildlands Park is diverse in landscape units.

Achuff (1994) identified natural history themes for the Central Mixedwood subregion of the Boreal Forest Natural Region. Many of the Level 1 and Level 2 themes are well-represented in the study area: Level 1 Sandy Upland (both Dune Field and Sandy Plain), Valley/Ridge (both Protected Slope and Floor/Stream), and Wetland (Mineral, Organic, and Lake). The only Level 1 theme that is missing is Non-Sandy Upland (Ground Moraine and Hummocky Moraine). Additionally, other landscape units in the study area do not fit well in the natural history theme framework for the Central Mixedwood-- the loess plains and colluviating (mass wasting) slopes (there may also be glacial lake deposits present as one auger hole found sandy clay under a sand veneer (fa40)).

At Level 2, a great number of themes are present in the study area. Within Sandy Uplands there are stabilized dunes, jack pine forests, and deciduous forests. Within Valley/Ridge, there are white spruce, mixedwood, and deciduous forests, rivers, and muskeg streams. Within Wetlands, there are marshes, swamps (=broadleaf tree non-peaty wetlands), white spruce, black spruce, and tamarack forests, shrublands, bogs, patterned and non-patterned fens, graminoid communities, and eutrophic lakes. The presence of much of the Level 1 and 2 diversity is due in large part to the topographic, landform, and hydrologic diversity imparted by the Athabasca River and the sandhills.

It is difficult to place the diverse vegetation associations of the study area within a provincial context for one simple reason: there is still no adequate current overview of the vegetation of Alberta. In order to evaluate the significance of a vegetation type, four pieces of information are needed:(a) an accurate classification of the type; (b) its abundance; (c) its geographic distribution (e.g, an otherwise abundant type might be significant if found outside its documented range); and (d) its condition (undisturbed, degraded, fragmented, etc.). Such information is difficult to find given our incomplete understanding of vegetation, limited data, and hard-to-access plot information.

Scott (1995) provides a recent account of the vegetation of Canada, but that work is of course too broad in scope to be useful for our purposes. While there are many excellent regional and local accounts, an excellent provincial overview is the pioneering work of Moss (1955). That work, however, is difficult to use at the association level due to the accumulation of much information in the intervening 45 years since that work was published. A more recent work by Looman (1979, and papers following in that series) provides an overview of the vegetation of the Prairie Provinces. Like Moss' work, that treatment is necessarily general. Strong (1991) has recently provided a provincial-level classification, but again the types are quite general for useful comparisons (e.g., xeric sites in the Mid-Boreal Mixedwood (synonymous with Central Mixedwood here) are typified by jack pine with bearberry and blueberries). There is little information given in that account on boreal grasslands nor on non-forested wetlands. Beckingham (1993) provided detailed information on vegetation associations of northern Alberta, but no data are provided on non-forested associations.

In the absence of a provincial-level vegetation classification, we provide a subjective assessment of the significant vegetation types of the park.

4.7.1 Grasslands

There are three fairly distinct grassland types in the area: (a) northern ricegrass, (b) slender wheatgrass, and (c) porcupine grass. They all show a preference for subxeric sites and all are to some extent fire-dependent in a boreal climatic region. Northern ricegrass grasslands are to be expected on boreal and parkland sandhills and have a close association with jack pine, typically existing as a savannah or parkland mosaic with dry jack pine forest (Timoney and Robinson 1992). These grasslands are assignable to the pine-heath faciation of the jack pine association of Moss (1955). Slender wheatgrass grassland has a sporadic widespread distribution across parkland and boreal forest, often found in association with hairy wild rye, and sometimes *Stipa* species. It is successional to aspen forest. As a disjunct, it is known as far north as the Benchmark Creek area in Wood Buffalo National Park (Schwarz et al. 1988). It is likely a variant of the Peace River Prairie *Agropyron - Stipa* association of Moss (1955). The third grassland type, dominated by western porcupine grass, is surprising in that *Stipa* grasslands more typically occur on loamy soils, not sands. It is usually found on steep dry slopes and is closely-allied, if not equivalent, to the *Stipa* faciation (=sub-association) of the Peace River Prairie association (Moss 1955).

Many of the most interesting plant occurrences are found in the grasslands (in particular the *Stipa* grasslands), such as *Arabis lyrata, Calamagrostis purpurascens, Carex filifolia, C. richardsonii, C. rossii, C. stenophylla, Danthonia intermedia, Heterotheca villosa, Lithospermum incisum, Melampyrum lineare, Silene drummondii, Solidago missouriensis,* and *Sporobolus cryptandrus*. On the other hand, some expected species were not found in the grasslands, e.g., *Agropyron dasystachyum*, *Koeleria macrantha, Stipa columbiana, S. richardsonii, Artemisia frigida*, *A. ludoviciana*, and *Carex obtusata*. The apparent absence of these species could be due to the predominantly sandy soils of the uplands. While sand grass (*Calamovilfa longifolia*) is present in a few of the grasslands, it is at low cover. The grasslands of the area have elements in common with Peace River Prairie, a pine-heath faciation, and the Calamovilfetea longifoliae order of Looman (1980).

4.7.2 Forests on Mineral Terrain

An outstanding feature of the park is its diverse forest cover. Without a doubt, the most noteworthy of the forest types are the riparian old-growth white spruce and white spruce mixedwood forests of the Athabasca River valley. These hygric forests are found on silty alluvial terraces on generally imperfectly-drained Cumulic Regosols. Here we find not only the highest species diversity, but also the greatest concentration of rare plants. Stand ages in these forests exceed 160 years, and the large girth of the trees in many areas (too large for our tree corer) indicates ages well in excess of 200 years. Recent studies indicate that both riparian balsam poplar and white spruce stand ages may exceed 300 years (Timoney and Robinson 1996). Canopy heights in the area may reach 30 m, and a maximum of about 35 meters was observed in the sites we examined. The largest concentration of these forests is on Pemmican Island and on the large island immediately downstream of Pemmican Island.

Due to their location within a riparian travel corridor, their diverse plant species, and their structural complexity (multistoried canopy, large trees, snags, large nursery logs, buried wood, etc.), these forests provide home to a wealth of other forms of life, and are characterized by high bird, mammal, bacterial, and fungal diversity (Roy et al. 1995; Schieck and Nietfeld, 1995; Timoney and Robinson 1996, among others). They provide some of the best habitat in the province for cavity-requiring bats, ducks, and many birds and mammals (Ohmann, et al. 1994, among others). The survival of these forests is endangered by logging focussed on the river valleys of boreal western Canada (Timoney and Peterson 1996; Timoney et al. 1997). The forests within the park must be given absolute protection.

Significant forests on mineral soils are not restricted to the valley of the Athabasca River. There are fine examples of old-growth white spruce and mixedwood forests scattered across the park where nearby wetlands and ponds have protected the sites from fire, and also pockets of old-growth forest along small creeks. There are also some nice examples of tall canopied aspen forest on loess (e.g., fa30). The jack pine forests and savannahs are good examples of boreal sandhills vegetation, and are the characteristic cover over much of the sandhills.

4.7.3 Wetlands

As discussed under sections 4.5 and 4.6, the wetland vegetation of the park is diverse. The distribution of peatland forms in Alberta has been tabulated by natural subregion by Vitt et al. 1996. An estimated 31% of the Central Mixedwood is covered by peatland, of which wooded, unpatterned, non-permafrost fens with no internal lawns, and open, unpatterned, non-permafrost, graminoid-dominated fens are the two most abundant types, followed by unpatterned, non-permafrost, open shrub fen and unpatterned, non-permafrost wooded bog with no internal lawns. All of these types are present in the study area.

The above peatland classification scheme based on surface form is useful in that the peatland types are identifiable on airphotos. It is important from a biodiversity standpoint to realize, however, that all peatlands of a given surface form are not alike. This is evident in the study area, e.g., among the open unpatterned fens where there were (a) *Carex lanuginosa / Utricularia minor / Campylium stellatum - Drepanocladus revolvens* (fa07) and (b) *Carex lasiocarpa - C. utriculata - C. chordorhiza / Drepanocladus revolvens* types. Among the larch string fens there were (a) larch / *Menyanthes* / *Carex diandra / Tomenthypnum* (fa44) and (b) larch / *Carex lasiocarpa / Drepanocladus vernicosus* (fa29) types. The same can be said for the bogs and other non-peatland wetlands.

Suffice to say that there is a great variety of wetlands in the park and that diversity is important.

4.8 Other Special Features

Seeps are characteristic of the area. Most commonly they are found along or at the base of the valley wall. Often they are iron-rich and may be associated with an iron-stained brook. The reddish color of the iron seeps is due to oxidation of iron by bacteria, likely by *Gallionella* (Nelson et al. 1989). Sometimes the seeps are calcareous as indicated by the calciphytic flora. Uncommon plants are often associated with these seeps such as *Aster brachyactis, Carex eburnea*, and *Tofieldia glutinosa*. The soils of the seeps are Rego Gleysols and sensitive to disturbance. Even foot traffic can cause liquefaction, ponding, erosion and damage to the plant cover.

Colluviating landforms are characteristic of the valley wall and are associated with both seepage and fluvial erosion on the outside of meanders. In both situations, bank instability may lead to mass wasting. The characteristic slope failure is topographically and hydrologically diverse with convex dry sites situated next to concave wet sites. As such, vegetation and floral diversity can be high in these areas (e.g., fa 47, color plate h). Actively colluviating areas can be dangerous. Human use in these areas should be discouraged.

5. MANAGEMENT CONCERNS

5.1 Oil and Gas Activities

The in-progress gas development by New Cache Petroleum Ltd. is of great concern and has angered Alberta conservation groups. The pipeline, the development of the three gas well sites, the upgrading of the access road south from the Hwy 661, and the continual disturbance as personnel check or service the facilities over the years will cause irreparable harm to the park. The impacts to an area characterized by extensive interconnected peatlands, dunes, an upland/lowland riparian boundary, and a major river valley are large and multi-scaled. At the landscape level, dissection and fragmentation will cause loss of interior/sensitive species and processes, boundaries to movement of materials, energy, and species. Disruptions of the wetlands due to hydrological impacts brought about by changes in surface water flow volume and direction, water chemistry, ponding/deprivation of water; extirpation of community types will occur. Populations of rare and/or sensitive species will be reduced; there may be local extirpation.

The draft environmental plan by the proponent (New Cache Petroleum 1997) does little to instill confidence. We read, e.g., that "No rare or endangered plant species were noted..." They noted the presence of 19 plant species. In this study we documented at least 21 provincially rare species, and a minimum 434 species.

Of primary concern are the landscape level impacts which include damage to the wetland complexes and fragmentation/dissection of habitat. At a 20 October 1997 Ft. Assiniboine Sandhills Wildland Park meeting in St. Albert, AB, the attendees were informed by the consultants for New Cache Petroleum Ltd. that the pipeline would "cross only one wetland." As this statement appeared dubious, we transferred the pipeline route (from Figure 2 of New Cache Petroleum 1997) onto airphotos AS4580-159,160, 181,182,183 and examined the landscape types crossed by the pipeline. Exclusive of the crossing of Clearwater Creek, there are eight wetland crossings (Figure 4). The total length of the pipeline in the park is 7.2 km, 1.2 km

(16.6%) of which is routed through wetlands. These crossings will have serious implications for lateral transport of water, nutrients, and energy through the wetland complexes. Elsewhere on the pipeline route, two significant areas of thin, sinuous dunes with native grassland and parklike white spruce and jack pine will be crossed.

The pipeline and its access road are a major concern to the spatial requirements and movements of animals through the park. Following Lyon et al. (1985), Figure 4 shows an 800 m wide buffer extending to either side of the pipeline and road corridors which delimits a zone of habitat degraded for interior/sensitive species. The figure also demonstrates the habitat fragmentation/dissection caused by the development. Such a development is inimical to the re-establishment of woodland caribou in the park (see Alberta Environmental Protection 1997).

5.2 OHV Use

In spite of changes in the park's protection status, OHV (off-highway vehicle) use remains a concern. There was abundant evidence of continued recent traffic by quads and dirt bikes, particularly on dry sandhills and peatlands. Both the sand dunes and the peatlands are sensitive to disturbance. During fieldwork we heard and saw OHVs regularly. It is important that this illegal use be stopped. There is no justification for use of the park, as OHV users already have the nearby Timeu Off-Highway Vehicle Recreation Area.

5.3 Fire Management

A critical decision needs to be made immediately by park management in regards to fire management. Many of the communities and species in the park are fire dependent, such as many of the grasslands, savannahs, and dry pine forests, the ecological processes that characterize them, and the species that inhabit them. The current fire management policy of "total suppression" must be changed to accommodate fire within the park ecosystem. If this is not done, the park will lose a large share of its biodiversity as forest succession takes place. Secondly, total fire suppression, if continued, might endanger surrounding landowners as build-up of fuel in the drier forests will take place and a severe fire weather year may precipitate a dangerous wildfire.

A proactive approach is needed. We recommend that management conduct well-planned prescribed burns in areas where encroachment is resulting in loss of biodiversity. Such a program would be on an as-needed basis as monitoring indicates. Prescribed burns would generally be indicated when encroachment by jack pine, aspen, and shrubs are reducing grassland cover. Prescribed burns would not be recommended *carte blanche* across the sandhills as there are many areas (e.g., north-facing dunes, dune slope bases, seepage areas, wetland margins, and loess deposits) where beautiful and healthy forests are found on whose sites grasslands would not form. It should also be noted at this juncture that mistletoe (*Arceuthobium americanum*) is an important natural disturbance in the study area. As it acts to retard succession to pure jack pine forests on the sand dunes, it helps to maintain a semi-open forest / grassland mosaic.

The program would help to maintain a diverse mosaic of cover types that would serve the purposes of park protection, and through maintaining a patchy forest cover on the dunes would lower the risk of fire spread.

5.4 Non-Conforming Uses

All forests in the park must be protected from logging. OHV use, auto-access camping, logging, domestic grazing, coal development, coal exploration, surface materials removal, industrial development, residential subdivisions, and cultivation are all non-conforming uses (Alberta Environmental Protection 1997). Funds and personnel must be allocated to ensure that non-conforming uses do not occur in the park.

5.5 Trail Development

There are many pre-existing trails in the area that pass significant community types and interesting or rare species. Due to the high diversity of landscapes and plant species, there is great potential for public education and appreciation. Some trails should be developed along a landscape diversity interpretation theme routing the trails through or past a variety of landscape types. A low impact method of providing the information would be via an interpretive brochure keyed to numbered posts at strategic points. Suggested topics to be covered are: biodiversity (from landscape to species scales), succession, fire, surficial geology, glacial history, how landscapes change over time, old-growth forests, woodland caribou, and riparian ecology. Many of the significant areas in the Athabasca River are boat-accessible only. Some riparian sites, however, can be reached by pre-existing trails in the far east side of the park.

Figure 4. Wetland crossings along the in-progress New Cache Petroleum Ltd. gas pipeline development and zone of degraded habitat (a 1.6 km (800 m each side) hatched buffer strip borders the pipeline and its access road). Base map after New Cache Petroleum Ltd (1997: Figure 1).

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7. APPENDICES

Appendix 1. Annotated list of 434 vascular and non-vascular plant taxa found in the Ft. Assiniboine Sandhills Wildland Park during summer 1997. Noteworthy species are in **bold** font. Species classified as provincially rare are followed by a bold asterisk *. By taxonomic group, there were 258 vascular species, 90 mosses, 14 hepatics, and 74 lichens.

Species	Notes
Achillea millefolium	
Achillea sibirica	
Actaea rubra	
Agropyron pectiniforme	well site near fa11
Agropyron repens	
Agropyron trachycaulum	typically as var. subsecundum
Agrostis stolonifera	
Alnus crispa	
Alnus tenuifolia	
Amblystegium serpens	
Amelanchier alnifolia	
Anastrophyllum michauxii	
Andromeda polifolia	
Androsace septentrionalis	
Anemone canadensis	
Anemone cylindrica	fa26, near fa11; rel. uncommon; + elsewhere
Anemone multifida	
Anemone patens	
Anemone riparia	
Aneura pinguis	
Antennaria rosea	
Apocynum androsaemifolium	
Aquilegia brevistyla	
Arabis glabra	
Arabis lyrata	fa01, elsewhere in park; rel. uncommon;
Aralia nudicaulis	
Arceuthobium americanum	
Arctostaphylos uva-ursi	
Artemisia campestris	
Asclepias ovalifolia*	fa03, fa26, fa18, fa24; regionally rare
Aster borealis	
Aster brachyactis	fa48; relatively uncommon
Aster cf. x maccallae*	fa42; no specimens in herb.; rare
Aster ciliolatus	
Aster conspicuus	

Aster hesperius	
Aster laevis	
Aster modestus	east of fa38; Aster-willow-grass; uncommon
Aster puniceus	
Astragalus aboriginum	near fa43; dry sand upslope of plot
Astragalus americanus	
Astragalus dasyglottis	near fa43; dry sand upslope of fa43
Astragalus sp.	
Astragalus striatus	
Aulacomium palustre	
Barbula convoluta	
Barbula fallax	
Betula neoalaskana	
Betula papyrifera	
Betula pumila	
Blepharostoma trichophyllum	
Botrychium virginianum	
Brachythecium albicans*	fa32; rare, of forest floor
Brachythecium campestre*	fa27,fa30,fa32,fa34,fa37,fa40,fa45,fa47; "rare"
Brachythecium mildeanum	
Brachythecium rutabulum*	fa32; rare, of forest floor
Brachythecium salebrosum	
Brachythecium sp.	
Brachythecium starkei	
Bromus cilatus	
Bromus inermis	
Bryoerythophyllum recurvirostrum	
Bryoria fuscescens	
Bryoria glabra	
Bryoria sp.	
Bryum lonchocaulon	
Bryum pseudotriquetrum	
Bryum sp.	
Calamagrostis canadensis	
Calamagrostis inexpansa	
Calamagrostis purpurascens	fa08, fa16; reg. uncommon; range fill-in
Calamagrostis stricta	
Calamovilfa longifolia	fa24; reg. uncommon; range extension
Calliergon stramineum	
Calliergon trifarium	
Calliergonella cuspidata	
Caloplaca cerina	
Caloplaca holocarpa	
Caltha palustris	

Campanula rotundifolia	
Campylium hispidulum	
Campylium polygamum*	fa05,fa14,fa32,fa34; rare
Campylium radicale*	fa34,fa35,fa37; rare
Campylium stellatum	
Candelariella vitellina	
Carex aquatilis	
Carex atherodes	
Carex aurea	
Carex cf. capillaris	
Carex cf. sartwellii	
Carex chordorhiza	
Carex concinna	
Carex diandra	
Carex disperma	
Carex eburnea	fa48; uncommon
Carex filifolia	fa18, fa20, near fa24; range extension
Carex gynocrates	
Carex lacustris*	fa41; rare
Carex lanuginosa	fa07; uncommon n. of Sask. R.
Carex lasiocarpa	
Carex leptalea	fa04, fa19; uncommon
Carex limosa	
Carex norvegica	
Carex paupercula	
Carex praegracilis	
Carex prairea	fa44; uncommon
Carex richardsonii	fa01,fa02,fa10; uncommon
Carex rossii	fa08; uncommon
Carex siccata	
Carex stenophylla	fa20; uncommon
Carex utriculata	= C. rostrata in Moss (1983)
Carex vaginata	
Catoscopium nigritum	
Cephalozia sp.	
Ceratodon purpureus	
Cetraria islandica	
Cetraria platyphylla	
Chenopodium leptophyllum	dry open sand;uncommon, range ext.
Cicuta bulbifera	
Cinna latifolia	
Circaea alpina	locally uncommon
Cirsium arvense	
Cladonia bacillaris	

Cladonia botrytes	fa44; uncommon
Cladonia chlorantha	
Cladonia chlorophaea	
Cladonia coccifera	
Cladonia coniocraea	
Cladonia cornuta	
Cladonia crispata	
Cladonia cristatella	
Cladonia fimbriata	
Cladonia furcata	
Cladonia gracilis	
Cladonia mitis	
Cladonia multiformis	
Cladonia phyllophora	
Cladonia pocillum	
Cladonia pyxidata	
Cladonia rangiferina	
Cladonia sp.	squamules only
Cladonia subulata	
Climacium dendroides	
Conocephalum conicum	
Convolvulus sepium	
Corallorhiza trifida	
Cornus canadensis	
Cornus stolonifera	
Corylus cornuta	
Cratoneuron commutatum var. falcatum	photo far03-35, submerged in iron seep
Crepis tectorum	
Danthonia intermedia	Klondyke Trail; regionally uncommon
Delphinium glaucum	
Deschampsia cespitosa	
Dicranella cf. heteromalla	
Dicranella sp.	
Dicranella varia	
Dicranum acutifolium	
Dicranum flagellare	
Dicranum fragilifolium	
Dicranum fuscescens	
Dicranum polysetum	
Dicranum scoparium	
Dicranum undulatum	
Didymodon acutus	
Didymodon rigidulus	
Diploschistes scruposus	

Disporum trachycarpum	
Ditrichum flexicaule	
Drepanocladus aduncus	
Drepanocladus revolvens	
Drepanocladus uncinatus	
Drepanocladus vernicosus	
Drosera rotundifolia	fa19; locally uncommon
Eleagnus commutata	
Elymus canadensis	
Elymus innovatus	
Entodon schleicheri*	near fa32,in fa39; rare; 4th record for AB
Epilobium sp.	
Epilobium angustifolium	
Equisetum arvense	
Equisetum fluviatile	
Equisetum hyemale	
Equisetum pratense	
Equisetum scirpoides	
Equisetum sylvaticum	
Equisetum variegatum	
Erigeron glabellus	
Erigeron philadelphicus	
Erigeron sp.	
Eriophorum gracile	
Eriophorum polystachion	
Eriophorum viridi-carinatum	fa02; locally uncommon
Eurhynchium pulchellum	
Evernia mesomorpha	
Festuca saximontana	
Flavopunctelia flaventior	
Fragaria vesca	
Fragaria virginiana	
Galium boreale	
Galium labradoricum	
Galium trifidum	
Galium triflorum	
Gentianella amarella	
Geocalyx graveolans	
Geocaulon lividum	
Geum aleppicum	
Glyceria sp.	immature specimen
Glyceria striata	
Goodyera repens	
Habenaria dilatata	

Habenaria hyperborea	
Habenaria obtusata	uncommon
Haplocladium microphyllum	
Helodium blandowii	
Heterodermia speciosa*	fa09; fa27; rare
Heterotheca villosa	locally uncommon
Hieracium umbellatum	
Hylocomium splendens	
Hypnum lindbergii	
Hypnum pallescens	
Hypogymnia physodes	
Impatiens sp.	
Imshaugia aleurites	
Jamesoniella autumnalis	
Juncus alpinoarticulatus	fa48; relatively uncommon
Juncus balticus	
Juncus tenuis	
Juniperis communis	
Larix laricina	
Lathyrus ochroleucus	
Lathyrus venosus	
Lecanora sp.	
Lecidea sp.	
Ledum groenlandicum	
Lepidozia reptans	
Leptobryum pyriforme	
Leptogium saturninum	
Lilium philadelphicum	
Linnaea borealis	
Lithospermum incisum	fa20, 26; reg. uncommon; range extension
Lonicera dioica	
Lonicera involucrata	
Lophocolea heterophylla	
Lycopodium annotinum	locally uncommon
Lycopodium complanatum	
Lycopodium obscurum	
Maianthemum canadense	
Malaxis monophylla*	fa32,fa39; rare
Marchantia polymorpha	
Medicago sativa	well site near fa11
Meesia triquetra	
Meesia uliginosa	
Melampyrum lineare	near fa28; regionally uncommon
Melanelia albertana	

Melanelia exasperatula	
Melanelia olivacea*	fa01,fa16,fa17,fa28; rare
Melanelia subaurifera	
Melanelia subolivacea	
Melilotus alba	well site near fa11
Mentha arvensis	
Menyanthes trifoliata	
Mertensia paniculata	
Mitella nuda	
Moneses uniflora	
Muhlenbergia glomerata	fa12; uncommon
Nuphar variegatum	
Ochrolechia arborea	
Oenothera biennis	
Oncophorus wahlenbergii	
Orthilia secunda	
Orthotrichum obtusifolium	
Orthotrichum speciosum	
Oryzopsis asperifolia	
Oryzopsis pungens	
Oxycoccus microcarpus	
Oxytropis deflexa	
Oxytropis sericea	
Parmelia sulcata	
Parmeliopsis ambigua	
Parmeliopsis hyperopta	
Parnassia palustris	
Pedicularis parviflora	
Pellia sp.	
Peltigera aphthosa	
Peltigera canina	
Peltigera collina*	near fa38; rare; on old poplar
Peltigera didactyla var. extenuata	
Peltigera didactyla	
Peltigera elisabethae	
Peltigera evansiana*	fa38; nearby; rare
Peltigera horizontalis*	fa27,fa39; rare
Peltigera malacea	
Peltigera neckeri	
Peltigera neopolydactyla	
Peltigera polydactyla	
Petasites palmatus	
Petasites sagitatus	
Petasites vitifolius	

Phaeophyscia orbicularis	
Physcia adscendens	
Physcia aipolia	
Physcia dimidiata*	fa32; rare
Physcia millegrana	
Physconia detersa	
Physconia enteroxantha*	fa27; rare
Picea glauca	
Picea mariana	
Pinus banksiana	
Plagiomnium cuspidatum	
Plagiomnium drummondii	
Plagiomnium ellipticum	
Plagiomnium medium	
Platismatia glauca	
Platydictya jungermannioides	
Platygyrium repens	
Pleurozium schreberi	
Poa interior	
Poa palustris	
Poa pratensis	
Pohlia nutans	
Pohlia sp.	
Pohlia wahlenbergii	
Polygonum convolvulus	
Polytrichum juniperinum	
Polytrichum piliferum	
Populus balsamifera	
Populus tremuloides	
Potamogeton gramineus	
Potentilla norvegica	
Potentilla palustris	
Prunus pensylvanica	
Prunus virginiana	
Ptilidium pulcherrimum	
Ptilium cristra-castrensis	
Pylaisiella polyantha	
Pyrola asarifolia	
Pyrola chlorantha	
Ramalina dilacerata	
Ramalina pollinaria	
Ranunculus macounii	
Rhizomnium pseudopunctatum	
Rhytiadelphus triquetrus	

Rhytidium rugosum	
Ribes hudsonianum	
Ribes lacustre	
Ribes oxyacanthoides	
Ribes triste	
Riccardia latifrons	
Riccardia sp.	
Rosa acicularis	
Rosa woodsii	
Rubus arcticus	
Rubus idaeus	
Rubus pubescens	
Salix arbusculoides	
Salix bebbiana	
Salix candida	
Salix drummondiana	fa05; regionally uncommon
Salix exigua	
Salix lucida	
Salix lutea	
Salix myrtillifolia	
Salix pedicellaris	
Salix petiolaris	
Salix prolixa	
Salix pseudomonticola	
Salix serissima	
Scapania sp.	
Schizachne purpurascens	
Scirpus microcarpus	
Scorpidium scorpioides	
Selaginella rupestris*	fa01,fa24, fa26; rare; KT + elsewhere
Senecio pauperculus	
Shepherdia canadensis	
Silene drummondii	fa20; relatively uncommon
Sisyrinchium montanum	
Sium suave	
Smilacina stellata	
Smilacina trifolia	
Solidago canadensis	
Solidago gigantea	
Solidago graminifolia	
Solidago missouriensis	fa08, fa47; reg. uncommon; range fill-in
Sonchus arvensis	
Sonchus uliginosus	
Sparganium cf. minimum	

Sphagnum angustifolium	
Sphagnum fuscum	
Sphagnum magellanicum	
Sphagnum nemoreum	photo far04-12
Sphagnum russowii	
Sphagnum teres	
Sphagnum warnstorfii	
Sphenopholis obtusata*	fa37; rare
Spiranthes romanzoffiana	
Splachnum ampullaceum	
Sporobolus cryptandrus	fa08; well site near fa11; locally uncommon
Stellaria longipes	
Stipa curtiseta	fa20; fa24; regionally uncommon
Streptopus sp.	vegetative only
Symphoricarpos albus	
Taraxacum officinale	
Tetraphis pellucida	
Tetraplodon mnioides	
Thalictrum sp.	
Thalictrum venulosum	
Thuidium abietinum	
Thuidium recognitum	
Timmia megapolitana	
Tofieldia glutinosa	fa02; regionally uncommon
Tomenthypnum nitens	
Tortella fragilis	
Tortula ruralis	
Trifolium sp.	
Triglochin maritima	
Triglochin palustris	
Tuckermannopsis americana	
Typha latifolia	
Usnea cavernosa	
Usnea hirta	
Usnea scabrata	
Usnea subfloridana	
Utricularia minor	
Vaccinium myrtilloides	
Vaccinium vitis-idaea	
Viburnum edule	
Viburnum trilobum	
Vicia americana	
Viola canadensis	
Viola cf. adunca	

Viola sp.	
Vulpicida pinastri	
Zygodon viridissimus*	fa32; very rare; this second record for AB

Appendix 2.Detrended Correspondence Analysis (DCA) of plots at FA. 84 species; 48 plots. Rares species downweighted; number of non-zero data items: 403; axes rescaled; segments = 30. Eigenvalues: Axis 1=0.904; Axis 2= 0.688; Axis 3= 0.519.

SAMPLE SCORES - WHICH ARE WEIGHTED MEAN SPECIES SCORES

N	NAME	AX1	AX2	AX3	RANKED 1 EIG= .904			RANKED 2 EIG= .688		
1	p1	192	280	169	7	p7	1029	38	p38	740
2	p2	703	671	14	41	p41	1011	36	p36	683
3	p3	193	371	135	29	p29	916	2	p2	671
4	p4	467	380	142	12	p12	855	7	p7	627
5	p5	536	423	208	38	p38	852	48	p48	581
6	p6	440	402	157	44	p44	852	37	p37	545
7	p7	1029	627	389	2	p2	703	35	p35	473
8	p8	242	334	157	19	p19	694	34	p34	458
9	p9	408	408	118	36	p36	675	47	p47	458
10	p10	307	237	177	21	p21	620	13	p13	448
11	p11	362	248	192	31	p31	576	5	p5	423
12	p12	855	283	192	48	p48	568	33	p33	417
13	p13	425	448	125	5	p5	536	9	p9	408
14	p14	437	251	149	25	p25	520	6	p6	402
15	p15	421	397	183	37	p37	489	15	p15	397
16	p16	176	321	146	43	p43	474	4	p4	380
17	p17	316	351	125	40	p40	470	32	p32	378
18	p18	191	339	139	47	p47	470	46	p46	376
19	p19	694	0	244	4	p4	467	3	p3	371
20	p20	0	318	142	35	p35	441	30	p30	360
21	p21	620	323	210	6	p6	440	17	p17	351
22	p22	307	236	183	39	p39	440	18	p18	339
23	p23	432	185	178	14	p14	437	8	p8	334
24	p24	164	292	156	23	p23	432	39	p39	327
25	p25	520	169	174	27	p27	430	21	p21	323
26	p26	107	317	141	13	p13	425	28	p28	323
27	p27	430	274	152	15	p15	421	16	p16	321
28	p28	171	323	141	9	p9	408	20	p20	318
29	p29	916	176	92	32	p32	389	26	p26	317
30	p30	331	360	121	33	p33	364	45	p45	299
31	p31	576	83	189	11	p11	362	24	p24	292
32	p32	389	378	121	34	p34	338	42	p42	284
33	p33	364	417	113	30	p30	331	12	p12	283
34	p34	338	458	125	17	p17	316	1	p1	280
35	p35	441	473	117	10	p10	307	27	p27	274
36	p36	675	683	61	22	p22	307	41	p41	269
37	p37	489	545	172	45	p45	295	14	p14	251
38	p38	852	740	75	46	p46	295	11	p11	248
39	p39	440	327	140	42	p42	250	10	p10	237
40	p40	470	204	166	8	p8	242	22	p22	236
41	p41	1011	269	0	3	p3	193	43	p43	235
42	p42	250	284	157	1	p1	192	40	p40	204
43	p43	474	235	154	18	p18	191	23	p23	185
44	p44	852	116	158	16	p16	176	29	p29	176
45	p45	295	299	143	28	p28	171	25	p25	169
46	p46	295	376	121	24	p24	164	44	p44	116
47	p47	470	458	116	26	p26	107	31	p31	83
48	p48	568	581	68	20	p20	0	19	p19	0

Appendix 3. Detrended Correspondence Analysis (DCA) of common and dominant species at FA. 84 species; 48 plots. Rare speciess downweighted; number of non-zero data items: 403;axes rescaled; segments = 30. Eigenvalues: Axis 1=0.904; Axis 2= 0.688; Axis 3= 0.519.

SPECIES SCORES

N	NAME	AX1	AX2	AX3	RANKED 1 EIG= .904			RANKED 2 EIG= .688		
1	agrotr	42	322	137	79	utrimi	1070	22	careut	798
2	alnucr	278	258	161	29	drepre	1051	34	equifl	769
3	alnute	501	554	184	34	equifl	1026	15	calain	754
4	amelal	264	432	121	21	carela	1008	71	salips	698
5	apocan	246	376	159	20	carech	973	36	equiva	694
6	aralnu	296	358	111	69	salica	957	17	campst	686
7	arctuv	159	303	146	30	drepve	915	19	careau	680
8	asclov	129	379	113	22	careut	902	70	saliex	654
9	betune	607	399	246	76	tomeni	883	27	ditrfl	652
10	betupa	411	396	113	28	drepad	881	79	utrimi	642
11	betupu	872	282	230	11	betupu	872	14	calaca	617
12	bracsa	404	477	105	42	larila	846	28	drepad	615
13	bryups	792	614	54	49	menytr	804	13	bryups	614
14	calaca	652	617	120	37	everme	796	33	equiar	593
15	calain	717	754	163	13	bryups	792	67	saliar	587
16	calalo	11	300	149	17	campst	778	3	alnute	554
17	campst	778	686	426	15	calain	717	31	eleaco	528
18	careaq	714	-184	332	18	careaq	714	69	salica	501
19	careau	686	680	-12	36	equiva	690	41	hypoph	495
20	carech	973	115	-16	19	careau	686	57	popuba	491
21	carela	1008	216	-19	70	saliex	659	25	cornst	488
22	careut	902	798	18	71	salips	656	12	bracsa	477
23	cladmi	159	255	197	14	calaca	652	83	vibutr	459
24	cornca	363	245	139	55	plagel	650	26	coryco	446
25	cornst	408	488	126	41	hypoph	643	4	amelal	432
26	coryco	367	446	117	53	picema	629	62	pylapo	417
27	ditrfl	623	652	9	27	ditrfl	623	64	rosaac	404
28	drepad	881	615	225	45	ledugr	620	38	fragvi	403
29	drepre	1051	239	-37	9	betune	607	9	betune	399
30	drepve	915	155	93	67	saliar	601	10	betupa	396
31	eleaco	400	528	86	51	parmsu	600	75	sympsp	394
32	elymin	325	214	237	33	equiar	547	60	prunvi	388
33	equiar	547	593	48	3	alnute	501	44	lathve	387
34	equifl	1026	769	428	56	pleusc	497	63	rhyttr	380
35	equipr	392	295	145	65	rubuid	478	8	asclov	379
36	equiva	690	694	4	78	usnesc	477	47	loniin	379
37	everme	796	194	110	40	hylosp	470	66	rubupu	378
38	fragvi	157	403	108	52	picegl	461	5	apocan	376
39	galibo	115	328	134	68	salibe	421	82	vibued	374
40	hylosp	470	225	157	81	vaccvi	414	52	picegl	360
41	hypoph	643	495	273	10	betupa	411	6	aralnu	358
42	larila	846	172	185	61	ptilcr	409	59	prunpe	355
43	lathoc	232	260	186	25	cornst	408	84	viciam	348
44	lathve	216	387	108	12	bracsa	404	58	poputr	330
45	ledugr	620	29	206	31	eleaco	400	39	galibo	328
46	linnbo	392	253	163	35	equipr	392	74	sympal	328
47	loniin	291	379	110	46	linnbo	392	1	agrotr	322
48	maiaca	276	273	158	62	pylapo	388	77	tortru	319
49	menytr	804	-70	263	66	rubupu	381	65	rubuid	317
50	oryzpu	172	273	172	26	coryco	367	73	stipcu	305
51	parmsu	600	257	220	24	cornca	363	7	arctuv	303
52	picegl	461	360	120	83	vibutr	363	16	calalo	300
53	picema	629	29	191	63	rhyttr	358	35	equipr	295
54	pinuba	321	219	196	80	vaccmy	356	72	smilst	294
55	plagel	650	-42	319	75	sympsp	350	78	usnesc	294
56	pleusc	497	145	174	57	popuba	339	68	salibe	284

57	popuba	339	491	128	82	vibued	335	11	betupu	282	
58	poputr	301	330	128	32	elymin	325	48	maiaca	273	
59	prunpe	235	355	115	54	pinuba	321	50	oryzpu	273	
60	prunvi	228	388	131	64	rosaac	314	43	lathoc	260	
61	ptilcr	409	215	162	58	poputr	301	2	alnucr	258	
62	pylapo	388	417	134	6	aralnu	296	51	parmsu	257	
63	rhyttr	358	380	106	47	loniin	291	23	cladmi	255	
64	rosaac	314	404	128	2	alnucr	278	46	linnbo	253	
65	rubuid	478	317	116	48	maiaca	276	24	cornca	245	
66	rubupu	381	378	110	4	amelal	264	29	drepre	239	
67	saliar	601	587	148	5	apocan	246	40	hylosp	225	
68	salibe	421	284	223	59	prunpe	235	54	pinuba	219	
69	salica	957	501	425	43	lathoc	232	21	carela	216	
70	saliex	659	654	183	60	prunvi	228	61	ptilcr	215	
71	salips	656	698	67	44	lathve	216	32	elymin	214	
72	smilst	206	294	160	72	smilst	206	81	vaccvi	195	
73	stipcu	-39	305	147	50	oryzpu	172	37	everme	194	
74	sympal	-8	328	134	7	arctuv	159	80	vaccmy	190	
75	sympsp	350	394	196	23	cladmi	159	42	larila	172	
76	tomeni	883	87	114	38	fragvi	157	30	drepve	155	
77	tortru	-44	319	144	84	viciam	142	56	pleusc	145	
78	usnesc	477	294	210	8	asclov	129	20	carech	115	
79	utrimi	1070	642	428	39	galibo	115	76	tomeni	87	
80	vaccmy	356	190	222	1	agrotr	42	45	ledugr	29	
81	vaccvi	414	195	168	16	calalo	11	53	picema	29	
82	vibued	335	374	104	74	sympal	-8	55	plagel	-42	
83	vibutr	363	459	96	73	stipcu	-39	49	menytr	-70	
84	viciam	142	348	133	77	tortru	-44	18	careaq	-184	

Appendix 4. TWINSPAN results. Length of raw data array:854 non-zero items; cut levels: 0, 1, 2, 5, 10, 15, 20, 40, and 60 %;Minimum group size for division = 2; Maximum number of indicators per division = 5; Maximum number of species in final table = 84; 4 divisions; Length of data array after defining pseudospecies: 1876; Total number of species and pseudospecies: 501.

```
                         CLASSIFICATION OF SAMPLES
****************************************************************************
 DIVISION   1  (N= 48)         i.e. group *   (Where * can = 0 or 1)
   Eigenvalue:  .788  at iteration  3
 INDICATORS and their signs:
 carela  1(+)    tomeni  1(+)

 DIVISION   2  (N= 42)         i.e. group *0
 Eigenvalue:  .676  at iteration  2
 INDICATORS and their signs:
 picegl  4(+)    amelal  1(-)    arctuv  1(-)    alnute  1(+)    pinuba  5(-)

 DIVISION   3  (N=  6)         i.e. group *1
 Eigenvalue:  .786  at iteration  2
 INDICATORS and their signs:
 betupu  1(-)

 DIVISION   4  (N= 19)         i.e. group *00
 Eigenvalue:  .618  at iteration  2
 INDICATORS and their signs:
 arctuv  1(-)    aralnu  1(+)    poputr  5(+)    pinuba  1(-)

 DIVISION   5  (N= 23)         i.e. group *01
 Eigenvalue:  .698  at iteration  3
 INDICATORS and their signs:
 equiva  1(+)

 DIVISION   6  (N=  3)         i.e. group *10
 Eigenvalue:  .558  at iteration  2
 INDICATORS and their signs:
 bryups  1(-)

 DIVISION   7  (N=  3)         i.e. group *11
 Eigenvalue:  .785  at iteration  3
 INDICATORS and their signs:
 calaca  1(+)

 DIVISION   8  (N= 13)         i.e. group *000
 Eigenvalue:  .627  at iteration  2
 INDICATORS and their signs:
 pleusc  1(+)

 DIVISION   9  (N=  6)         i.e. group *001
 Eigenvalue:  .672  at iteration  2
 INDICATORS and their signs:
 lathoc  1(-)

 DIVISION  10  (N= 20)         i.e. group *010
 Eigenvalue:  .644  at iteration  2
 INDICATORS and their signs:
 pleusc  1(+)    ledugr  1(+)    cornst  1(-)    hylosp  4(+)

 DIVISION  11  (N=  3)         i.e. group *011
 Eigenvalue:  .660  at iteration  6
```

```
INDICATORS and their signs:
bryups  1(+)

DIVISION  12  (N=  1)         i.e. group *100


DIVISION  13  (N=  2)         i.e. group *101
Eigenvalue:  .421  at iteration  0
INDICATORS and their signs:
carech  1(+)

DIVISION  14  (N=  2)         i.e. group *110
Eigenvalue:  .708  at iteration  0
INDICATORS and their signs:
bryups  1(-)

DIVISION  15  (N=  1)         i.e. group *111
Group too small for further division.

              --------  E N D   O F   L E V E L   4 --------

                        CLASSIFICATION OF SPECIES
****************************************************************************
DIVISION   1  (N= 84)         i.e. group * (Where * can = 0 or 1)

Eigenvalue:  .719  at iteration  2

DIVISION   2  (N= 66)         i.e. group *0
Eigenvalue:  .343  at iteration  1

DIVISION   3  (N= 18)         i.e. group *1
Eigenvalue:  .554  at iteration  1

DIVISION   4  (N= 34)         i.e. group *00
Eigenvalue:  .189  at iteration  1

DIVISION   5  (N= 32)         i.e. group *01
Eigenvalue:  .111  at iteration  1

DIVISION   6  (N=  4)         i.e. group *10
Eigenvalue:  .352  at iteration  6

DIVISION   7  (N= 14)         i.e. group *11
Eigenvalue:  .291  at iteration  1

DIVISION   8  (N= 27)         i.e. group *000
Eigenvalue:  .082  at iteration  2


DIVISION   9  (N=  7)         i.e. group *001
Eigenvalue:  .055  at iteration  1

DIVISION  10  (N= 29)         i.e. group *010
Eigenvalue:  .094  at iteration  1

DIVISION  11  (N=  3)         i.e. group *011
Eigenvalue:  .262  at iteration  6

DIVISION  12  (N=  1)         i.e. group *100
Group too small for further division.
```

```
DIVISION  13  (N=  3)         i.e. group *101
Eigenvalue:  .131  at iteration  2

DIVISION  14  (N=  6)         i.e. group *110
Eigenvalue:  .254  at iteration  1

DIVISION  15  (N=  8)         i.e. group *111
Eigenvalue:  .170  at iteration  1
```