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# **Vascular Plant Indicators of Calcareous Fens in Minnesota**

Update of calcareous fen vegetation analysis and indicator score development criteria

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## Summary

To meet the vascular plant criterion to identify fens in Minnesota, plant species are assigned values, and a total score is a vegetation score for a site. When a plant community has a vegetation score of 50 or more it meets the vegetation criterion for identifying calcareous fens. This project updates the list of vascular plant indicators used to identify calcareous fens in Minnesota, focusing on the Prairie Extremely Rich Fen Native Plant Community OPp93. Bryophyte criteria and indicators of Spring Fen class Calcareous Fens (OPn93) are out of scope, as data is being assembled for future analysis. The identification of calcareous fens by the DNR is required by Minnesota Administrative Rule [8420.0935 Subpart 3](#). The intended users of this document are the Calcareous Fen Technical Team, and the Calcareous Fen Management Team for use in updating the technical criteria for the identification of calcareous fens. The information may also be helpful for a wider audience who would like to learn more about calcareous fen vegetation.

**Past analyses:** Since the initial vegetative criteria were developed, the Minnesota Department of Natural Resources (DNR) has collected more data and can use more advanced methods to refine the vascular plant indicators. The 1995 criteria used 381 species lists with 63 from calcareous fens and 284 from non-calcareous fen wetlands. The 2005 test of the 1995 criteria used data from 26 fens and 7 non-calcareous fens.

**Current analysis:** The most recent analysis completed in 2025 used 682 species lists, 199 from calcareous fens and 483 from non-calcareous fen wetlands.

Cluster analysis and ordination were used to confirm Native Plant Community assignments for plant lists. Cluster analysis showed a clear split between north and south regions. An initial set of species was identified, and assigned draft indicator point values based on relative frequency of occurrence in calcareous fens versus other wetland types. The list of indicator species and associated point values were subsequently reviewed and refined by botanists and ecologists with calcareous fen expertise. Point values were corrected where bias in the dataset was identified, and rare obligate fen species were added to the list.

Final point values (Table 1) were then tested against the plant list dataset used in the analysis. A comparison of the proposed point list versus the 2005 calcareous fen vegetation point list indicates the proposed list better differentiates calcareous fen communities from others at the 50-point threshold. This process indicated the proposed scores may decrease potential for non-calcareous fen wetlands to meet the vegetation criteria from 10% to near zero (0.4%). Additionally, the proposed scores may increase the ability to positively identify calcareous fens with a single relevé or meander survey from 62% to 87%, increasing the speed at which determinations can be made. Minnesota's calcareous fen technical criteria should be revised to reflect these findings.

Table 1. Regionalized list of vascular plant indicators used to identify calcareous fens in Minnesota. A dash indicates a species not likely to be encountered in that region, if it is encountered it will receive the points from the alternate region. For purposes of this list and report, southern and northern Minnesota is separated by mapped zones in Figure 6.

Scientific Name	Common Name	Southern Minnesota Points	Northern Minnesota Points
<i>Agalinis paupercula</i>	small-flower false foxglove	5	5
<i>Berula erecta</i>	cut-leaf water parsnip	5	-
<i>Betula pumila</i>	bog birch	10	0
<i>Bromus ciliatus</i>	fringed brome	5	0
<i>Bidens trichosperma</i>	crowned beggarticks	5	0
<i>Cardamine bulbosa</i>	spring cress	5	0
<i>Carex aquatilis</i>	water sedge	0	5
<i>Carex interior</i>	inland sedge	5	5
<i>Carex limosa</i>	mud sedge	-	5
<i>Carex livida</i>	livid sedge	-	1
<i>Carex prairea</i>	prairie sedge	15	10
<i>Carex sterilis</i>	sterile sedge	25	20
<i>Carex viridula</i>	little green sedge	-	15
<i>Cladium mariscoides</i>	smooth sawgrass	25	20
<i>Dasiphora fruticosa</i>	shrubby cinquefoil	20	1
<i>Eleocharis quinqueflora</i>	few-flowered spikerush	10	10
<i>Eleocharis rostellata</i>	beaked spikerush	25	25
<i>Equisetum variegatum</i>	variegated scouring-rush	-	1
<i>Eriophorum</i>	tall cottongrass	15	1
<i>Fimbristylis puberula</i>	hairy fimbry	25	25
<i>Gentianopsis virgata</i>	lesser fringed gentian	25	10
<i>Liparis loeselii</i>	Loesel's twayblade	15	1
<i>Lobelia kalmii</i>	Kalm's lobelia	25	5
<i>Muhlenbergia</i>	spike muhly	1	0
<i>Oxypolis rigidior</i>	cowbane	10	-
<i>Parnassia glauca</i>	American grass of Parnassus	25	15
<i>Parnassia palustris</i>	marsh grass of Parnassus	5	5
<i>Primula mistassinica</i>	Mistassini primrose	-	25
<i>Rhynchospora capillacea</i>	Hair-like beak rush	25	25
<i>Salix candida</i>	sage-leaved willow	15	1
<i>Salix serissima</i>	autumn willow	10	0
<i>Schoenoplectus pungens</i>	three-square bulrush	15	15
<i>Scleria verticillata</i>	whorled nutrush	25	25
<i>Symphyotrichum boreale</i>	northern bog aster	10	0
<i>Triantha glutinosa</i>	sticky false Asphodel	25	10
<i>Trichophorum</i>	tufted bulrush	25	20
<i>Triglochin maritima</i>	seaside arrowgrass	20	5
<i>Triglochin palustris</i>	marsh arrowgrass	25	25
<i>Valeriana edulis</i>	edible valerian	15	-

## Introduction

In 1995, the DNR Calcareous Fen Technical Committee established criteria to identify calcareous fens within the state. The criteria were developed in response to the legal protections given to calcareous fens with the passage of Minnesota Statute [103G.223](#) in 1991. The committee set out to create a method compatible with Minnesota Administrative Rule [8420.0935](#) which states that “The commissioner must investigate wetlands to determine if the wetland is properly identified as a calcareous fen.” By reviewing the available published literature on calcareous fen communities and conducting a data analysis from Minnesota wetlands, the committee established criteria based on vegetation, soils, hydrology, and water chemistry.

In the 1995 fen criteria, a point threshold method was established. A site met vegetation criterion if it scored 50+ points in total, summing all values assigned to indicator species detected on the site. The point system for vascular plant indicators in 1995 was determined by cluster analysis and ordination of 253 plots or meander surveys of vascular plants. Vascular plant indicators of calcareous fen communities were grouped into three indicator levels based on the plant's frequency of occurrence in calcareous fen plant communities: strong indicator (25 points), moderate indicator (5 points), and weak indicator (1 point) indicator. This resulted in a vegetation criterion with a 50-point threshold for identifying non-degraded calcareous fens. At that time, the technical committee highlighted the need for future refinement of the criteria (DNR 1995).

*“...the Technical Committee acknowledges that this is but a start to define the technical criteria for calcareous fens and that deliberate research efforts are needed to refine these definitions...”*

To determine whether the 1995 criteria were meeting the objective of correctly identifying calcareous fens, the calcareous fen technical committee reconvened in 2005 to test criteria against new data collected from 26 calcareous fens and seven non-calcareous fen wetlands. They found the criteria identified 21 of the 26 calcareous fens and no non-fens. The committee noted that fens that failed to meet the criteria were in the southern portion of the state, and the group proposed a regionalized scoring method for indicators to both decrease potential misidentifications and to enhance identification of calcareous fens across different ecological regions of the state. These changes are reflected in the current criteria used to identify calcareous fen (DNR 2005, DNR 2016). Like the 1995 committee, the group called for additional refinement and review of the criteria as more data were collected.

*“We continue to believe, as did the original committee, that technical criteria and guidelines for identifying calcareous fens will continue to evolve with continued field surveys and repeated applications.”*

During the time of the 1995 to 2005 criteria development, another project was working to refine definitions of Minnesota's vegetation classification, including calcareous fens. The definitions of calcareous fens used in previous versions of technical criteria were confirmed and remain consistent from 1995 onward. These community concepts were confirmed by this large project update to the classifications of Minnesota's Native Plant Communities. This project applied more consistent naming conventions across calcareous fen types (DNR 2005). The Calcareous Fen Boreal subtype is synonymous in the current classification to Northern Extremely Rich Vascular plant indicators of calcareous fens in Minnesota

Fen (OPn93, DNR 1993, DNR 2005). The three prairie subtypes are retained in the current classification (DNR 2005) as Northwestern, Southwestern, and Southeastern Prairie Extremely Rich Fen (OPp93a, OPp93b and OPp93c) subtypes. For discussion of historical terminology for calcareous fens, see the 1995 criteria (DNR 1995).

Although little additional data have been collected on the Northern Extremely Rich Fen (OPn93) type of calcareous fen, additional data have been collected from hundreds of Prairie Extremely Rich Fens and thousands of other wetland communities since the original criteria were written. These additional data were used to further refine the vascular plant indicators of calcareous fens in the Prairie Extremely Rich Fens class, OPp93.

## Scope

The scope of this report is to identify updates and refinements to the list of vascular plant indicators used to identify the Prairie Extremely Rich Fen class (OPp93), equivalent to calcareous fens. Bryophytes and indicators of the Northern Extremely Rich Fen class (OPn93) are out of scope as we develop datasets for future analysis.

## Methods

To create an initial dataset, we extracted the 1,736 relevé plots marked as open, non-forested, wetlands from the Minnesota Department of Natural Resources (DNR) relevé database (DNR 2023b). In addition, we included the 28 data records available from the DNR calcareous fen geospatial field application and 139 site survey records from the DNR species list database, which contains meander survey species lists from open wetland communities (wet meadow, wet prairie, open peatland, calcareous fen). For all sources, data were transformed to presence/absence, for the rest of this document we will refer to data collected at a site as a 'species list'. We collected a total of 1,903 species lists to be considered for inclusion in an indicator analysis (Figure 1). The 31 relevé plots which were resurveys of earlier relevés were considered redundant and excluded. Eight plots collected from outside of Minnesota were also removed. Species names across data sources were cross walked to the current taxonomy using the MnTaxa synonymy database (DNR 2023a). Species that are difficult to identify or those with taxonomic complexity were grouped. Groups are: *Agrostis gigantea*/ *Agrostis stolonifera*, *Agropyron* spp., *Alisma* spp.; *Amaranthus* spp., *Amelanchier* spp.; *Antennaria* spp.; *Arabis* spp., *Carex brevior*/*Carex bicknellii*/*Carex bebbii*; *Chenopodium* spp., *Crataegus* spp.; *Cuscuta* spp., *Dichanthelium* spp., *Epilobium* spp., *Helianthus gigantea*/*Helianthus grosseserratus*/*Helianthus xlaetiflorius*/ *Helianthus nuttallii*, *Hieracium* spp., *Lactuca* spp., *Lemna* spp., *Luzula* spp., *Melilotus* spp., *Packera aurea*/*Packera pseud aurea*, *Oxalis* spp., *Parthenocissus* spp., *Pilea* spp., *Poa* spp. (excluding *P. pratensis* and *P. palustris*), *Sedum* spp., *Smilax* spp., *Sonchus* spp., *Taraxacum* spp. and *Typha* spp., and heart-leaved violet group. Species with uncertain identification that were not in these groups were removed.

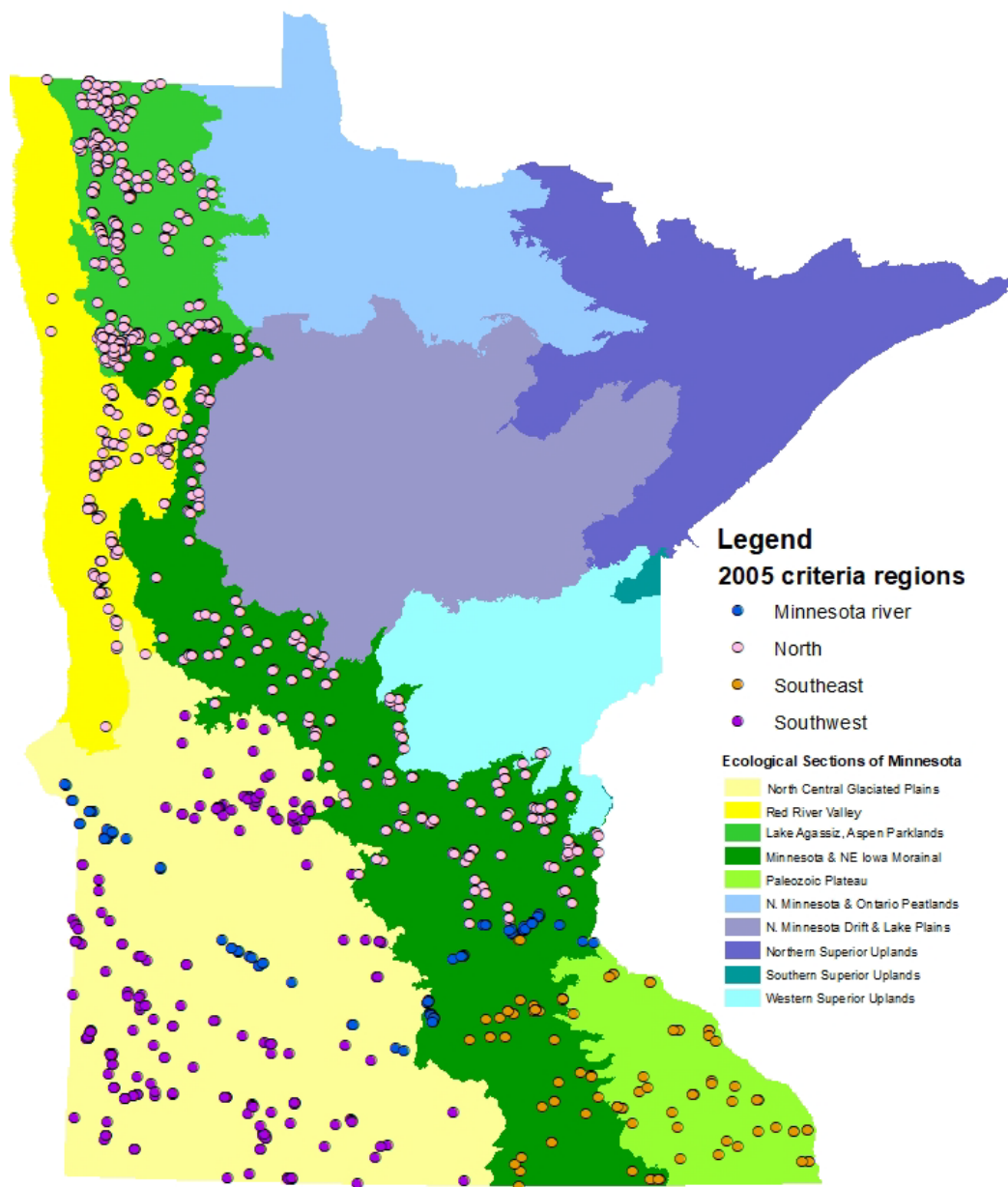


Figure 1: Initial set of plant community data considered for analysis. Point data colors indicate the 2005 fen criteria zones; background colors correspond to the Ecological Sections of Minnesota (DNR 1999).

Species lists were assigned to a geographic region based on the 2005 criteria (southeast, southwest, Minnesota River Valley, and northwest regions, DNR 2005). Species lists were later assigned a north or south region based on the findings of the cluster analysis. In most cases, species lists were already assigned a plant community classification from past analyses and/or expert evaluation in the field. To assist with interpretation, Vascular plant indicators of calcareous fens in Minnesota



species lists without an assigned classification were given an initial Native Plant Community classification by assigning the class of the most similar plot (nearest neighbor in Bray-Curtis dissimilarity, Bray 1957). These classifications were used to interpret the results of a hierarchical cluster analysis.

We verified the Native Plant Community classifications of the data with hierarchical (agglomerative) cluster analysis using the complete linkage method (Oksanen 2020). Hierarchical clustering identifies groupings of similar multivariate data within a dataset; the result is an easy-to-interpret tree-based representation of the observations, called a dendrogram. In our analysis, the hierarchical cluster process calculated the proximity between two plant communities by measuring how dissimilar the species lists are between pairs of communities (Bray-Curtis dissimilarity, Bray 1957). We conducted hierarchical cluster analysis using the statistical software R version 4.0.2 (R Core Team 2020), using the 'hclust' function in the vegan package (Oksanen 2020). Cluster groups were interpreted according to the classifications of their constituent species lists.

We used within-group sum of squares compared to the number of clusters used to classify the data as a guideline for the number of groups to consider for further analysis. This process provides a way to determine how many groups capture most of the variation in the data. The number of groups suggested by this method is the number of groups at which adding additional groups to the cluster analysis results in diminishing explanation of the data (measured by within group sum of squares).

Each grouping from the hierarchical clustering analysis was examined in PC-ORD using an Outlier Analysis (McCune 2018). We identified each plot within a group with over two standard deviations from the group centroid (in Bray-Curtis space) as an outlier. When outlier species lists were found, the data were reviewed before deciding whether to remove them from the analysis. Additionally, we reviewed the set of species lists marked as fens in non-fen groups and vice versa, these were removed after review. This resulted in 1,821 species lists. As the cluster analysis indicated differences between the northern and southern calcareous fens, we split the analysis into northern and southern datasets, thereafter.

Results from hierarchical clustering were used to assign northern and southern regions to species lists. Spatial distribution of species lists was checked, and a few were moved between regions and were grouped together with similar species lists for ordination and indicator analysis (regions were changed on relevés #7809, 8945, 8932, 7580). This was then followed by separate Non-metric Multidimensional Scaling (NMS) ordinations for northern and southern datasets to find additional outliers and examine cohesiveness in the groupings along environmental gradients (McCune 2018). This process was iterative and as re-classifying all wetlands was not within the scope of the project, many species lists were dropped at this point to allow for more clear community delineation. This process began by reviewing all species lists that were over two standard deviations away from the group's centroids of the lowest level of the hierarchical clusters.

NMS attempts to display complex data in as few dimensions as possible. Like Hierarchical Cluster analysis, NMS also begins with a distance matrix. Here, dissimilarity was assessed using Bray-Curtis distance (Bray 1957). Species recorded from only two species lists or less were not included in the data. This was an iterative process, where outliers were removed, and the process was repeated until well defined groupings were evident. Ordinations were conducted using the default "slow and thorough" settings in PC-ORD (McCune 2018). This

option poorly represented the data for northern wetlands (stress > 0.20). Therefore, three dimensions were chosen manually with the same settings, and this resulted in lower stress and more clear group delineation.

Using these final datasets, which included 293 species lists for southern Minnesota and 389 species lists for northern Minnesota, an Indicator Species Analysis was completed using the Multipatt function in the indicpecies (De Caceres 2009) package in R statistical software. Multipatt compares Pearson’s *phi* coefficient of association, a measure of species fidelity to a plant community, between groups. To determine the initial list of species for consideration in fen criteria, the significance of a species fidelity to calcareous fens was determined using a Monte Carlo test with 9,999 randomizations.

Vegetation threshold scores were then assigned to the species that had significant fidelity to calcareous fens based on proportion that the plant occurred in calcareous fen species lists compared to other communities. This was done by assigning an expanded version of the point system used in the 1995 criteria and grouping levels of (Table 2, DNR 1995). Point levels are: 25 points for obligate species, i.e. plants only know from calcareous fens in the region; 20 points for strong indicators, plants that occur almost exclusively in calcareous fens, but are know from a few other communities; 15 points for plants occurring between ≥85 and <99 percent in calcareous fens ; 10 points for plants occurring from ≥80 and <85 percent of the time in calcareous fens; 5 pts for plants occurring ≥75 and <80 percent in calcareous fens; and 1 point for plants occurring ≥70 and <75 percent of the time in calcareous fens (Table 2). Plants identified in the Indicator Species Analysis as potential indicators were reviewed and assigned a score as appropriate.

Table 2. Criteria based points for assigning indicator scores based on the relative frequency of occurrence in calcareous fen communities used to create initial draft species point values.

criteria based points	Relative frequency
1	≥70 and <75
5	≥75 and <80
10	≥80 and <85
15	≥85 and <99
20	100
25	Obligate

All species with significant indicator values were considered for inclusion in the proposed calcareous fen vegetation criteria. In addition, select species identified by ecologists were reviewed especially in the case of vary rare species poorly captured in the community-level data. Species points suggested by the above criteria passed points (table 2) were reviewed based on expert opinion and review of Bell herbarium collections. Up ranked or downranked where data issues were identified. Typical issues include: 1) species occurring in species lists but being more typical for wetland edges (e.g., *Rhamnus alnifolia*), 2) inadequate data for a species, or 3) a species which is known to occur in a variety of wetlands not represented in the species lists. While considering plant communities that may be absent or poorly represented in the dataset, we removed or downranked species which may be present in non-calcareous fen communities which could potentially meet soils, chemistry or hydrology requirements of the calcareous fen criteria (DNR 2016). Under this logic, species like three-square bulrush (*Schoenoplectus pungens*) is an indicator of calcareous fens as the other communities (shores and shallow water) in which it occurs would not have potential to meet the other technical criteria requirements.

Initial comments were collected from team members on the values and resolved in small team meetings. The team generally followed an informed consent decision making process to determine changes to the values suggested from the analysis.

During the resolution process, review of Plant records in the Bell Herbarium database was regularly used in decision making. The review of Bell data had two aspects, 1) review fen obligate species with little data to ensure they were not known to occur in other communities, and 2) review lower pointed species and former indicator species to ensure that the communities they occur in may not be mistaken for calcareous fens under soil, hydrology, chemistry criteria in the technical criteria (DNR 2016). Species records available from the Bell Museum Herbarium were used to exclude some species from the proposed list after DNR botanist/ecologist review (Bell 2023). In addition, select species were added to the list of indicators based on the Bell herbarium data and recommendations of DNR ecologists (table 4 and 6).

## Results and Discussion

### Classification and Ordination

The graph of within-group sum of squares compared to the number of clusters suggests 10-15 clusters efficiently capture the variation in the dataset (Figure 2). Further analysis proceeded with 15 clusters.

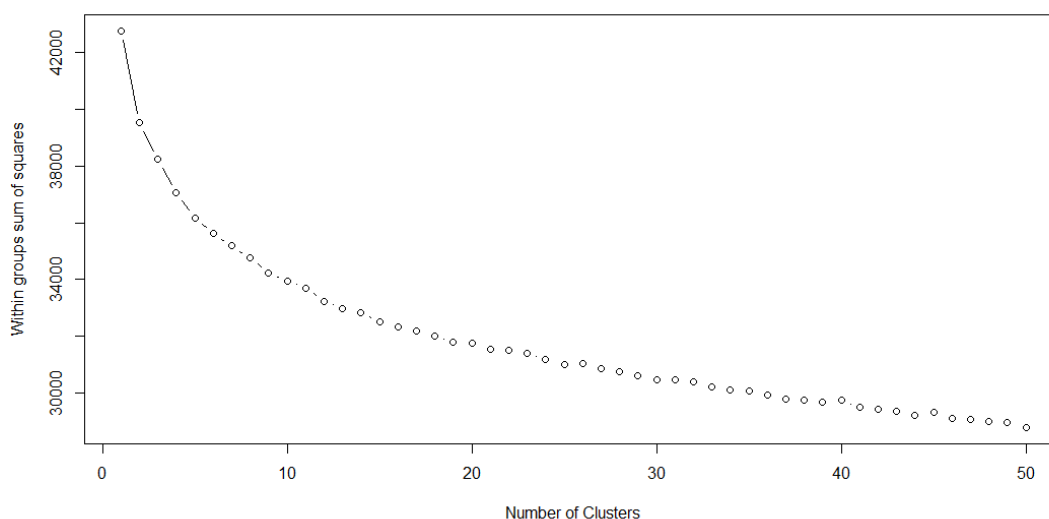


Figure 2: Scree plot comparing within-group sum of squares versus number of clusters used to group the wetland plot data. Fifteen was the chosen number of clusters.

The cluster analysis first split communities geographically with wetlands in the northern portion of state distinct from southern wetlands, reflected by region column in Table 3 and clade labels in figure 3. This includes calcareous fen communities with southwestern and southeastern Prairie Extremely Rich Fens (OPp93b, OPp93c)

in clade 1, which is most closely related to Southern wet seepage meadows (WMs83a) in clade 2. Northern prairie extremely rich fens (OPp93a) in clade 9 were most like clade 10 northern rich fen (Water Track) (OPn91b). Northern communities clustered distinctly from southern ones, and ordinations and species scoring were conducted separately for northern and southern communities.

Table 3. Cluster groups based on cluster analysis Figure 3 with region and the interpretation of the group.

<b>Group</b>	<b>NPC Class</b>	<b>Region</b>	<b>Interpretation</b>
<b>15</b>	OPn92	North	Northern Rich Fen (Basin)
<b>14</b>	WPn53	North	Northern Wet Prairie
<b>13</b>	WMp73	North	Prairie Wet Meadow
<b>12</b>	OPp91	North	Prairie Rich Fen
<b>11</b>	WMn82b	North	Northern Wet Meadow (Sedge Meadow)
<b>10</b>	OPn91b	North	Northern Rich Fen (Water Track)
<b>9</b>	OPp93a	North	Prairie Extremely Rich Fen (Northwestern)
<b>8</b>	WPn53	North	Northern Wet Prairies
<b>7</b>	OPn92(WMn82b)	North	Northern Rich Fen Basin, Wet Meadow, Sedge Meadow
<b>6</b>	WMn/WMs83a	South	Wet Meadow Systems
<b>5</b>	WPs53	South	Southern Wet Prairie
<b>4</b>	WMs/MRp	South	Southern Wet Meadow and Marsh Systems
<b>3</b>	WMs92	South	Southern Basin Wet Meadow
<b>2</b>	WMs83a	South	Southern Wet Seepage Meadow
<b>1</b>	OPp93b/OPp93c	South	Southern Prairie Extremely Rich Fens

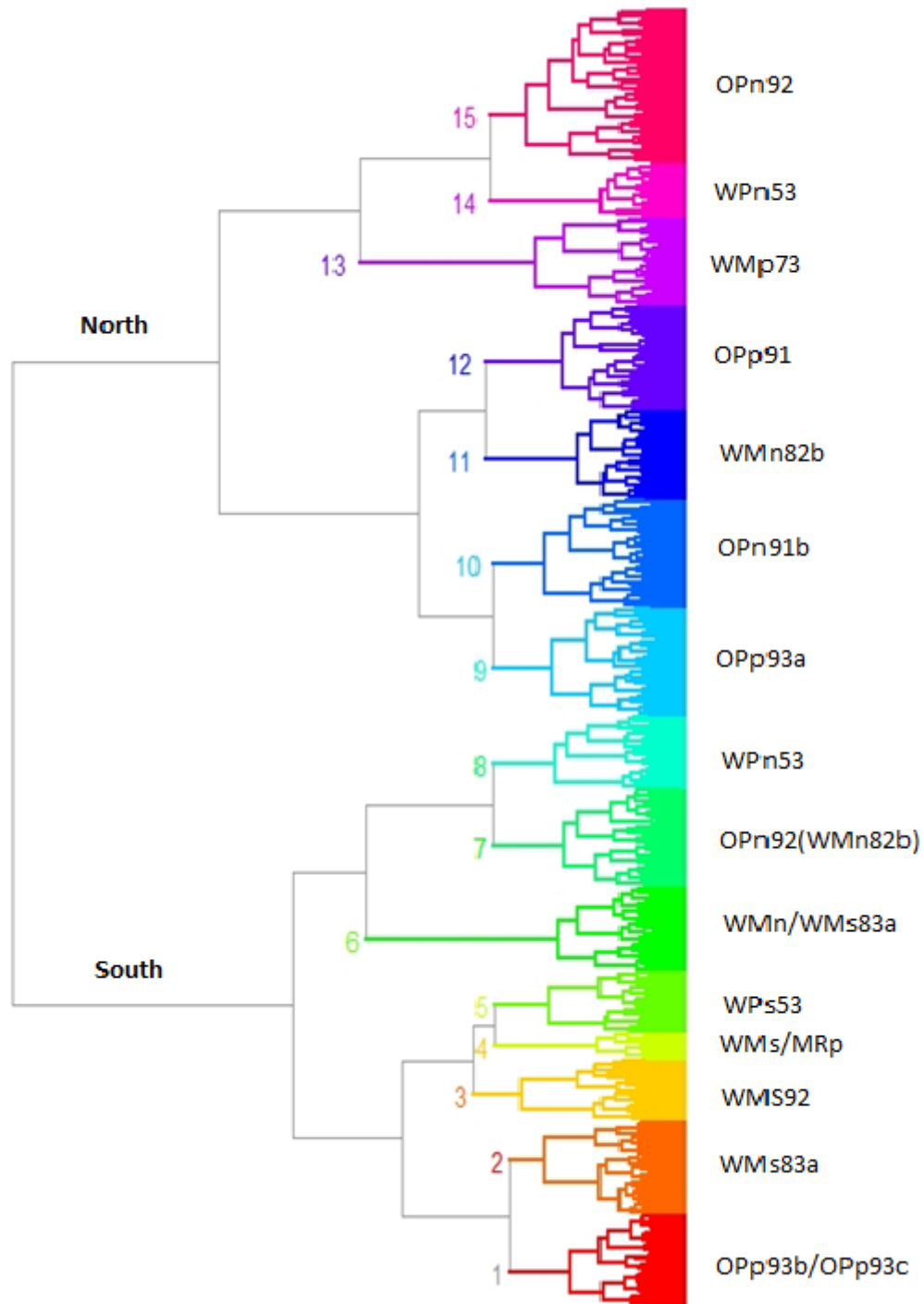


Figure 3: Dendrogram of the cluster analysis. See Table 3 for clad/group interpretations based on previous classification of species lists and nearest neighbor assigned classification.

## Southern Wetlands

Southern ordinations were reviewed for outliers, resulting in an ordination of 293 species lists and 353 species (Figure 4). After outliers were removed, a 3-dimensional ordination with stress of 14.38 ( $p < 0.01$ ) was selected (Figure A1-A3). Indicator Species Analysis identified 73 species that were significantly associated with calcareous fens in the southern dataset. Of these, 14 species were excluded after reviewing the Bell Herbarium data. Additionally, 29 had fewer than 70% of occurrences in calcareous fens (i.e., scoring 0 points). Only one species list in the OPp93 group was not associated with an officially listed calcareous fen (relevé #B730) (DNR 2018). However, this relevé is associated with a potentially listable fen and is awaiting a formal listing report.

Indicator species analysis identified 44 vascular plants with over 70% of their occurrences in Southern Prairie Extremely Rich Fens (OPp93a and OPp93b, Table 3). These scores were again reviewed by DNR calcareous fen experts, and final scores and comments are in Table 4. Additionally, *Fimbristylis puberula* and *Eleocharis quinquefolia* were added to the indicator list, as most known records of these species are documented from calcareous fens, but their occurrence on the landscape is too rare to be evaluated by the Indicator Species Analysis.

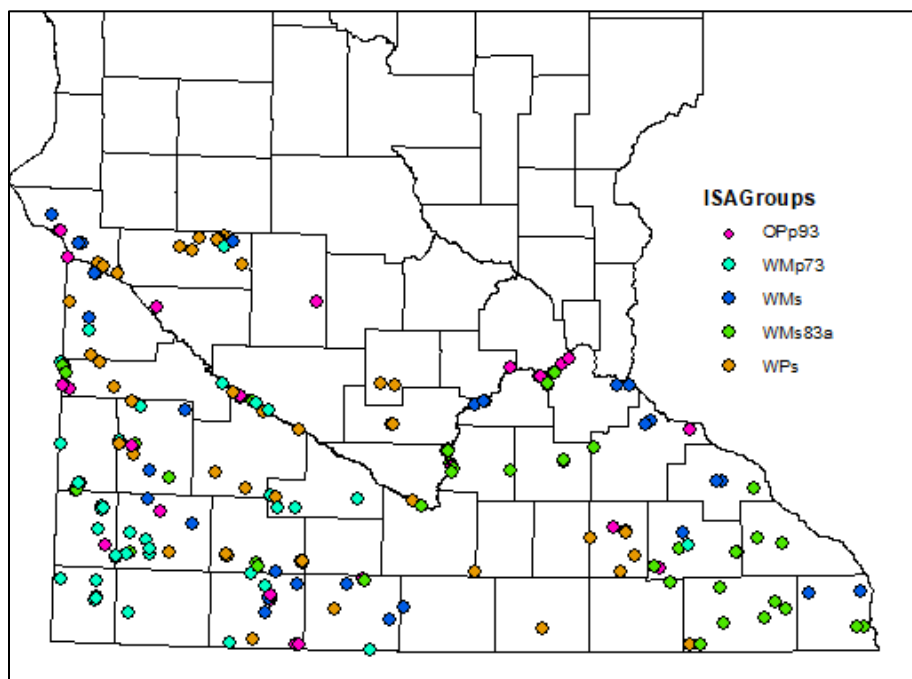


Figure 4: Distribution of southern region cluster analysis groups. Data were used to determine indicator species for southern calcareous fen communities. Indicator Species Analysis (ISA) groups were: OPp93 (Prairie Extremely Rich Fen), WMp73 (Prairie Wet Meadow/Carr), WMs (Southern Wet Meadow/Carr Systems), WMs83a (Southern Seepage Meadow/Carr), WPs (Wetland Prairie Systems).

Table 4. Number of observations of indicator species in southern region plant communities. OPp93 (Prairie Extremely Rich Fen), WMp73 (Prairie Wet Meadow/Carr), WMs (Wet Meadow/Carr), WMs83a (Seepage Meadow/Carr), and WPs (Wetland Prairie Systems). Relative frequency (Count of records in calc fens over total records of occurrences), criteria-based points (from Table 2), phi (measure of plant fidelity to calc fens) and p-values derived from the Indicator Species Analysis.

Species Name	OPp93 (n=89)	WMp73 (n=52)	WMs (n=38)	WMs83a (n=56)	WPs (n=58)	Relative Frequency	Criteria Based Points	Phi	p.value
<i>Agalinis paupercula</i>	8	0	0	0	0	100	20	0.271	0.0002
<i>Amorpha fruticosa</i>	19	3	0	4	0	73.1	1	0.287	0.0002
<i>Berula erecta</i>	9	0	0	3	0	75	5	0.203	0.0095
<i>Betula pumila</i>	20	0	0	3	1	83.3	10	0.351	0.0001
<i>Bidens trichosperma</i>	7	0	0	0	0	100	20	0.253	0.0012
<i>Bromus ciliatus</i>	27	0	0	7	1	77.1	5	0.376	0.0001
<i>Cardamine bulbosa</i>	37	1	0	11	0	75.5	5	0.436	0.0001
<i>Carex interior</i>	67	9	0	14	1	73.6	1	0.603	0.0001
<i>Carex prairea</i>	69	2	0	14	1	80.2	10	0.679	0.0001
<i>Carex sterilis</i>	38	0	0	0	0	100	20	0.611	0.0001
<i>Cirsium muticum</i>	36	3	0	9	3	70.6	1	0.395	0.0001
<i>Cladium mariscoides</i>	8	0	0	0	0	100	20	0.271	0.0003
<i>Cypripedium parviflorum</i>	13	0	0	0	0	100	20	0.347	0.0004
<i>Cypripedium reginae</i>	8	0	0	0	0	100	20	0.271	0.0003
<i>Dasiphora fruticosa</i>	9	0	0	0	0	100	20	0.287	0.0003
<i>Eleocharis rostellata</i>	8	0	0	0	0	100	20	0.271	0.0006
<i>Equisetum fluviatile</i>	19	0	0	6	2	70.4	1	0.277	0.0004
<i>Erigeron philadelphicus</i>	19	19	1	5	1	70.4	1	0.246	0.0001
<i>Eriophorum angustifolium</i>	34	0	0	1	0	97.1	15	0.557	0.0001
<i>Gentianopsis virgata</i>	35	0	0	1	0	97.2	20	0.566	0.0001
<i>Hypoxis hirsuta</i>	38	1	0	1	4	86.4	15	0.519	0.0001
<i>Juncus alpinoarticulatus</i>	4	0	0	0	0	100	20	0.190	0.0207
<i>Liparis loeselii</i>	10	1	0	0	0	90.9	15	0.269	0.0005
<i>Lobelia kalmia</i>	52	0	0	0	0	100	20	0.728	0.0001
<i>Maianthemum stellatum</i>	24	2	0	6	0	75.0	5	0.338	0.0001
<i>Muhlenbergia glomerata</i>	62	10	0	14	7	66.6	0	0.512	0.0001
<i>Muhlenbergia mexicana</i>	9	2	0	0	1	75	5	0.200	0.0109
<i>Oxypolis rigidior</i>	21	0	0	1	3	84	10	0.365	0.0001
<i>Parnassia glauca</i>	57	0	0	0	0	100	20	0.767	0.0001
<i>Pedicularis lanceolata</i>	71	13	0	9	5	72.5	1	0.615	0.0001
<i>Phragmites australis</i>	14	0	0	3	0	82.4	10	0.286	0.0004

Species Name	OPp93 (n=89)	WMp73 (n=52)	WMs (n=38)	WMs83a (n=56)	WPs (n=58)	Relative Frequency	Criteria Based Points	Phi	p.value
<i>Prenanthes alba</i>	10	0	0	0	0	100	20	0.303	0.0001
<i>Frangula alnus</i>	4	0	0	0	0	100	20	0.190	0.0188
<i>Rhynchospora capillacea</i>	34	0	0	0	0	100	20	0.575	0.0001
<i>Salix Bebbiana</i>	31	0	0	5	4	78.5	5	0.409	0.0001
<i>Salix candida</i>	30	0	0	2	0	93.7	15	0.500	0.0001
<i>Salix serissima</i>	10	0	0	1	0	90.9	15	0.271	0.0002
<i>Schoenoplectus pungens</i>	26	3	0	0	1	86.6	15	0.419	0.0001
<i>Scleria verticillata</i>	15	0	0	0	0	100	20	0.374	0.0001
<i>Symphyotrichum boreale</i>	43	0	0	8	0	84.3	10	0.541	0.0001
<i>Triantha glutinosa</i>	4	0	0	0	0	100	20	0.190	0.0183
<i>Trichophorum cespitosum</i>	8	0	0	0	0	100	20	0.271	0.0005
<i>Triglochin maritima</i>	35	0	0	0	3	92.1	15	0.534	0.0001
<i>Triglochin palustris</i>	26	0	0	0	0	100	20	0.498	0.0001
<i>Valeriana edulis</i>	24	0	0	0	3	88.8	15	0.419	0.0001



Table 4: Finalized species scores for the southern region based on DNR expert review. Criteria points come from the Indicator Species Analysis. Review result is the modification to the criteria points based on expert evaluation. Review comments explain modifications to the criteria-based points.

Scientific Name	Criteria Based Points	Review Result	South Final Indicator Points	Review Comments
<i>Agalinis paupercula</i>	20	Downrank	5	Recent taxonomic change leading to inadequate data.
<i>Amorpha fruticosa</i>	1	Exclude	0	Found in calcareous fen margins and in other communities.
<i>Berula erecta</i>	5		5	
<i>Betula pumila</i>	10		10	
<i>Bidens trichosperma</i>	20	Downrank	5	Inadequate data, poorly vouchered.
<i>Bromus ciliatus</i>	5		5	
<i>Cardamine bulbosa</i>	5		5	
<i>Carex interior</i>	1	Up rank	5	Most records in calcareous fens. Fen associate in most of its range. Foundational species of calcareous fens (Opp93).
<i>Carex prairea</i>	10	Up rank	15	Most records in calcareous fens. Fen associate in most of its range. Foundational species of calcareous fens (Opp93).
<i>Carex sterilis</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Cirsium muticum</i>	1	Exclude		Found in calcareous fen margins and in other communities.
<i>Cladium mariscoides</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Cypripedium parviflorum</i>	20	Exclude		Found in calcareous fen margins and in other communities. Inadequate data. Bell Herbarium records indicate association with other communities.
<i>Cypripedium reginae</i>	20	Exclude		Found in calcareous fen margins and in other communities. Inadequate data. Bell Herbarium records indicate association with other communities.
<i>Dasiphora fruticosa</i>	20		20	
<i>Eleocharis quinqueflora</i>	10	Include	10	Species added post analysis. Bell Herbarium data indicates association with calcareous fen.
<i>Eleocharis rostellata</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Equisetum fluviatile</i>	1	Exclude		Common across many wetland types.
<i>Erigeron philadelphicus</i>	1	Exclude		Common across many wetland types.
<i>Eriophorum angustifolium</i>	15		15	
<i>Fimbristylis pubescens</i>	20	Include	25	Species added post analysis. Included from Bell Herbarium data.
<i>Frangula alnus</i>	20	Exclude		Nonnative plant. Found in calcareous fen margins and in other communities.
<i>Gentianopsis virgata</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Hypoxis hirsuta</i>	10	Exclude		Common in wet prairies. Inadequate data due to flowering time.

Scientific Name	Criteria Based Points	Review Result	South Final Indicator Points	Review Comments
<i>Juncus alpinoarticulatus</i>	20	Exclude	0	Inadequate data. Bell Herbarium records show distribution in multiple communities
<i>Liparis loeselii</i>	15		15	
<i>Lobelia kalmii</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Maianthemum stellatum</i>	5	Exclude	0	Found in calcareous fen margins and in other communities.
<i>Muhlenbergia glomerata</i>	0	Up rank	1	Fen associate in most of its range.
<i>Muhlenbergia mexicana</i>	5	Exclude	0	Common in other communities (Bell Herbarium). Found on edges.
<i>Oxypolis rigidior</i>	10		10	
<i>Parnassia glauca</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Pedicularis lanceolata</i>	1	Exclude	0	Common in other communities (Bell Herbarium).
<i>Phragmites australis</i>	10	Exclude	0	Indicator of degradation. Found in calcareous fen margins and in other communities.
<i>Prenanthes alba</i>	20	Exclude	0	Found in calcareous fen margins and in other communities.
<i>Rhynchospora capillacea</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Salix Bebbiana</i>	5	Exclude	0	Common across many wetland types.
<i>Salix candida</i>	15		15	
<i>Salix serissima</i>	15	Downrank	10	Inadequate data. Occurs in other communities e.g., sedge meadows, shores, bogs, swamps, and other peatlands in other parts of its range.
<i>Schoenoplectus pungens</i>	15		15	Occurs in other communities which are not expected to meet soil or chemistry criteria.
<i>Scleria verticillata</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region. Species is an obligate to calcareous fens in this region.
<i>Symphyotrichum boreale</i>	10		10	
<i>Triantha glutinosa</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Trichophorum cespitosum</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Triglochin maritima</i>	15	Up rank	20	Occurs in other communities which are not expected to meet soil or chemistry criteria.
<i>Triglochin palustris</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Valeriana edulis</i>	15		15	

## Northern Wetlands

Northern ordinations were reviewed for outliers, resulting in ordination of 520 species lists and 359 species (Figure 5). After reviewing preliminary ordinations, data from the far northern portion of the region were excluded as this area contains only the subtype of calcareous fen called Northern Extremely Rich Fen (OPn93). These calcareous fens frequently had a differing composition of species in wetlands including higher abundance of some potential calcareous fen indicators in non-calcareous fen wetlands. These areas are illustrated in Figure 6 (see regionalization section below). These areas should be considered in future work to identify spring fen type calcareous fens. To balance group size, we combined groups 9 and 15 which contained different types of Northern Rich Fens (OPn92).

After outliers were removed, NMDS was conducted on 389 species lists containing 359 species resulting in a 3-dimensional ordination with stress of 14.382 ( $p < 0.01$ ), see Appendix A: Figure A4-6. Indicator Species Analysis indicated 62 species were significantly associated with the calcareous fen species lists in the northern dataset. Of these, 27 species had less than 70% of records in calcareous fens (scoring 0 points). An additional 11 species were excluded after reviewing the Bell Herbarium data. All Prairie Extremely Rich Fens (OPp93) species lists in the northern dataset were closely associated with listed fens except relevé B144. This relevé has very typical calcareous fen composition and it occurs just south of the region dividing line described below, however it was included in the northern ordinations by the cluster analysis.

Indicator Species Analysis identified 39 potential vascular plant indicators of Northwestern Prairie Extremely Rich Fens (OPp93a, see table 5). After review by ecologists three species were up ranked too weak indicators: *Carex interior*, *Lobelia kalmii*, and *Eriophorum angustifolium*. *Fimbristylis puberula* was added to the indicator list as an obligate species, as known records of these plants are from calcareous fens, but their occurrence on the landscape was too rare to include in the Indicator Species Analysis. Northern scores were reviewed by experts and final scores and comments are in Table 6.

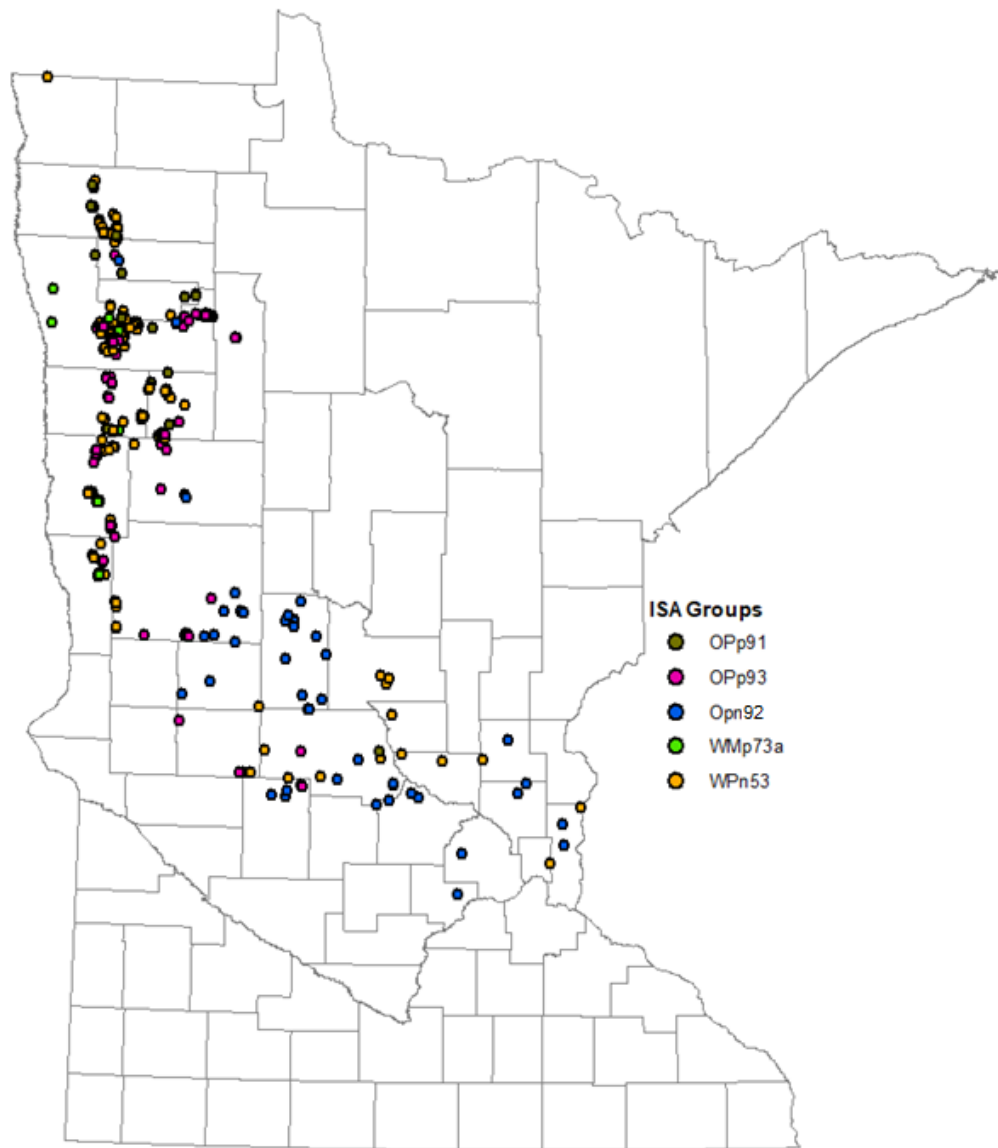


Figure 5: Distribution of northern region cluster analysis groups. Data was used to determine indicator species for northern calcareous fen communities. Native Plant Community treatment respectively is OPp91 (Northern Rich Fen (Water Track)), OPp93 (Prairie Extremely Rich Fen), OPn92 (Northern Open Rich Peatland Systems), WMp73 (Prairie Wet Meadow/Carr), WPn53 (Northern Wet Prairie)

Table 5. Number of observations of each indicator species in northern region plant communities. OPn92 (Northern Rich Fen (Basin)), OPp91 (Prairie Rich Fen), OPp93 (Prairie Extremely Rich Fen), WMp73a (Prairie Wet Meadow/Carr), WPn53 (Northern Wet Prairie), Relative frequency (plus percent of records for each species in calcareous fens vs. non-calcareous fen communities). Criteria based points (from Table 2) assigned indicator score, phi (measure of plant fidelity) and p-values derived from Indicator Species Analysis.

Scientific name	OPn92 (n=54)	OPp91 (n=41)	OPp93 (n=110)	WMp73a (n=19)	WPn53 (n=165)	Relative Frequency	Criteria based points	Phi	p-value
<i>Agalinis paupercula</i>	0	0	14	0	0	100	20	0.323	0.0003
<i>Agalinis tenuifolia</i>	0	0	5	0	0	100	20	0.191	0.0303
<i>Carex aquatilis</i>	0	10	56	0	3	81.2	10	0.491	0.0001
<i>Carex interior</i>	22	1	32	0	10	49	0	n.s.	n.s
<i>Carex limosa</i>	8	0	31	0	0	79.5	5	0.349	0.0001
<i>Carex livida</i>	6	5	31	0	0	73.8	1	0.294	0.0017
<i>Carex prairea</i>	10	0	37	0	0	78.7	5	0.380	0.0001
<i>Carex sterilis</i>	0	0	93	0	2	97.9	15	0.894	0.0001
<i>Carex viridula</i>	0	0	29	0	1	96.7	15	0.464	0.0001
<i>Cladium mariscoides</i>	0	0	9	0	0	100	20	0.258	0.0057
<i>Cypripedium parviflorum</i>	1	0	11	0	0	91.7	15	0.251	0.007
<i>Dasiphora fruticosa</i>	1	6	58	0	35	58.0	0	0.450	0.0001
<i>Eleocharis quinqueflora</i>	0	0	14	0	0	100	20	0.323	0.0003
<i>Eleocharis rostellata</i>	0	0	12	0	0	100	20	0.299	0.0016
<i>Equisetum variegatum</i>	0	0	7	0	0	100	20	0.227	0.0122
<i>Eriophorum angustifolium</i>	11	10	57	0	0	63.3	0	0.382	0.0001
<i>Eupatorium perfoliatum</i>	1	0	14	0	2	82.4	10	0.273	0.0038
<i>Gentianopsis virgata</i>	0	3	51	0	10	79.7	5	0.530	0.0001
<i>Juncus brevicaudatus</i>	1	0	10	0	0	90.9	15	0.236	0.012
<i>Juncus nodosus</i>	0	1	21	2	2	80.8	10	0.250	0.0058
<i>Liparis loeselii</i>	4	1	16	0	1	72.7	1	0.219	0.0181
<i>Lobelia kalmii</i>	2	6	79	3	31	65.3	0	0.542	0.0001
<i>Lonicera oblongifolia</i>	0	0	6	0	0	100	20	0.210	0.0305
<i>Parnassia glauca</i>	0	0	77	0	12	86.5	15	0.754	0.0001
<i>Parnassia palustris</i>	2	0	27	0	6	77.1	5	0.372	0.0004
<i>Platanthera aquilonis</i>	1	0	13	0	2	81.3	10	0.260	0.0058
<i>Primula mistassinica</i>	0	0	22	0	0	100	20	0.408	0.0001
<i>Rhamnus alnifolia</i>	2	0	18	0	5	72.0	1	0.280	0.004
<i>Rhynchospora capillacea</i>	0	0	39	0	0	100	20	0.553	0.0001
<i>Salix candida</i>	9	9	90	0	15	73.2	1	0.638	0.0001
<i>Sarracenia purpurea</i>	1	0	16	0	0	94.1	15	0.316	0.0006
<i>Schoenoplectus pungens</i>	0	1	24	1	0	92.3	15	0.338	0.0007

Scientific name	OPn92 (n=54)	OPp91 (n=41)	OPp93 (n=110)	WMp73a (n=19)	WPn53 (n=165)	Relative Frequency	Criteria based points	Phi	p-value
<i>Schoenoplectus tabernaemontani</i>	0	0	8	0	2	80.0	10	0.216	0.0135
<i>Scleria verticillata</i>	0	0	14	0	0	100	20	0.323	0.0008
<i>Solidago uliginosa</i>	2	0	15	0	1	83.3	10	0.270	0.0041
<i>Spiranthes romanzoffiana</i>	0	0	5	0	0	100	20	0.192	0.0306
<i>Symphyotrichum boreale</i>	19	18	85	2	23	57.8	0	0.427	0.0001
<i>Triantha glutinosa</i>	0	0	45	0	9	83.3	10	0.545	0.0001
<i>Trichophorum cespitosum</i>	0	0	52	0	0	100	20	0.646	0.0001
<i>Triglochin maritima</i>	4	10	76	5	35	58.5	0	0.431	0.0001
<i>Triglochin palustris</i>	0	0	57	0	0	100	20	0.680	0.0001

Table 6: Finalized species scores for the northern region based on DNR expert review. Criteria points come from the Indicator Species Analysis. Review result is the modification to the criteria points based on expert evaluation. Review comments explain modifications to the criteria-based points.

Species	Criteria points	Review Result	Final North Scores	Review Comments
<i>Agalinis paupercula</i>	20	Downrank	5	Recent taxonomic change leading to inadequate data.
<i>Agalinis tenuifolia</i>	20	Exclude	0	Bell Herbarium collections not clearly fen associated.
<i>Carex aquatilis</i>	10	Downrank	5	Occasional in other rich peatlands. Tends to be on edge of fen areas.
<i>Carex interior</i>	0	Up rank	5	Dataset includes a lot of northern wet meadows from the Anoka Sand Plain skewing data.
<i>Carex limosa</i>	5		5	
<i>Carex livida</i>	1		1	
<i>Carex prairea</i>	5	Up rank	10	Distinctive calcareous fen indicator. Strong fidelity to OPp93.
<i>Carex sterilis</i>	15	Up rank	20	Near obligate. Only been found 2 times in a wet prairie.
<i>Carex viridula</i>	15		15	
<i>Cladium mariscoides</i>	20	Downrank	20	Obligate in OPp93; rare or occasional in OPn92 (larger rich fen) as well.
<i>Cypripedium parvifolia</i>	15	Exclude	0	Found in calcareous fen margins and in other communities. Inadequate data. Bell Herbarium collections are not clearly fen associated
<i>Dasiphora fruticosa</i>	0	Up rank	1	Occurs twice as much in OPp93 as the next community.
<i>Eleocharis quinqueflora</i>	20	Downrank	10	Plant of calcareous fen margins and found in other communities
<i>Eleocharis rostellata</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Equisetum variegatum</i>	20	Downrank	1	Bell Herbarium collections are not clearly fen associated. Under sampled. Inadequate data.
<i>Eriophorum angustifolium</i>	0	Up rank	1	Distinguishes open peatland from other communities, Most records in OPp93.
<i>Eupatorium perfoliatum</i>	10	Exclude	0	Bell Herbarium collections are not clearly fen associated
<i>Fimbristylis puberula</i>	0	Obligate	25	Added to indicator list post-ISA. Extremely rare two known populations in MN. Included from Bell Herbarium records
<i>Gentianopsis virgata</i>	5	Up rank	10	Most occurrences were found in OPp93.
<i>Juncus brevicaudatus</i>	15	Exclude	0	Bell Herbarium collections are not clearly fen associated
<i>Juncus nodosus</i>	10	Exclude	0	Plant of calcareous fen margins and found in other communities, especially disturbed edges. Bell Herbarium collections are not clearly fen associated
<i>Liparis loeselii</i>	1		1	
<i>Lobelia kalmii</i>	0	Up rank	5	Majority of occurrences from OPp93.
<i>Lonicera oblongifolia</i>	20	Exclude	0	Possible indicator of OPn93. Unclear from Bell Herbarium collections
<i>Parnassia glauca</i>	15		15	
<i>Parnassia palustris</i>	5		5	

Species	Criteria points	Review Result	Final North Scores	Review Comments
<i>Platanthera aquilonis</i>	10	Exclude	0	Plant of calcareous fen margins and found in other communities Bell Herbarium collections are not clearly fen associated
<i>Primula mistassinica</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Rhamnus alnifolia</i>	1	Exclude	0	Plant of calcareous fen margins and found in other communities
<i>Rhynchospora capillacea</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Salix candida</i>	1	Up rank	5	Majority of occurrences in OPp93
<i>Schoenoplectus pungens</i>	15		15	
<i>Schoenoplectus tabernaemontani</i>	10	Downrank	1	Bell Herbarium collections not clearly fen associated. Need more data.
<i>Scleria verticillata</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.
<i>Solidago uliginosa</i>	10	Downrank	1	Inadequate data. Possible spring fen (OPn93) indicator.
<i>Spiranthes romanzoffiana</i>	20	Exclude	0	Inadequate data. Possible spring fen (OPn93) indicator.
<i>Triantha glutinosa</i>	10		10	
<i>Trichophorum cespitosum</i>	20	Downrank	20	Non-Obligate, Due to occurrences other rich fens.
<i>Triglochin maritima</i>	0	Up rank	5	Majority of records in OPp93. May be skewed by amount of (WPn) northern wet prairie relevés.
<i>Triglochin palustris</i>	20	Obligate	25	Species is an obligate to calcareous fens in this region.



## Efficacy of Proposed Points

After review, the proposed point system was tested against the original dataset to determine if calcareous fens would be better distinguished from non-fen communities. We retained the 50-point threshold for meeting the vegetation requirements as in previous iterations of the technical criteria. Under the 2005 vegetation criteria, 10.1% of non-calcareous fen species lists met vegetation criteria (49 out of 483 total non-calcareous fen lists, Table 7). With the new proposed criteria, only two (0.4%) of the species lists that did not classify as calcareous fen in the cluster analysis ‘incorrectly’ met criteria. These are relevés 4318 and 6418. Although classified as other wetland community types in our cluster analysis, these two relevés are geographically nearby listed fens. These may represent sites with intermediate fen characteristics or sites where field data may have been collected outside of the best developed areas of calcareous fen vegetation.

Table 7: Efficacy test results of new indicator point values. Counts of species lists that meet the 50-point threshold for calcareous fen designation under the 2005 vegetation criteria compared to the current proposed vegetation point system.

Group	# of species lists which meet vegetation score under 2005 criteria	# of species lists which meet vegetation score under proposed vegetation points
Northern Rich Fen (OPn)	<u>14</u>	<u>0</u>
Prairie Rich Fen (OPp91)	<u>0</u>	<u>0</u>
Prairie Extremely Rich Fen (OPp93)	<u>124</u>	<u>174</u>
Prairie Wet Meadow/Carr (WMp73)	<u>2</u>	<u>0</u>
Prairie Meadow/Carr (WMp73a)	<u>2</u>	<u>0</u>
Wet Meadow (WMs)	<u>6</u>	<u>0</u>
Southern Wet Seepage (WMs83a)	<u>11</u>	<u>1</u>
Northern Wet Prairies (WPn53)	<u>12</u>	<u>1</u>
Southern Wet Prairies (WPs)	<u>2</u>	<u>0</u>

The proposed vegetation points identify fewer species lists as calcareous fens in error and appears to better identify calcareous fens where they do exist. The 2005 criteria correctly identified 62.3% of calcareous fens from one species list (174 calcareous fens of the total of 199 species lists from calcareous fen communities). The proposed criteria identified 87.4% (174 of 199 calcareous fen lists). Applying the scoring criteria to both June and August surveys as required in the DNR calcareous fen field assessment procedures (DNR 2018) should further increase the rate of correct identifications of calcareous fens. These proposed criteria will aid in the expeditious and timely identification of calcareous fens based on a single meander survey.

## Regionalization Revisited and Revised

Cluster analysis indicated differentiation between northern and southern communities; these determine the regions where vegetation points should be applied (See Figure 6). While the boundary between the north and south regions appears distinct, the areas where Northern Extremely Rich Fens (OPn93) may occur is much less clear. Northern Extremely Rich Fens are already known to exist in the northern region. During the analysis of the northern wetlands, the most northeastern sites were removed as they appeared to have composition affinity with more Northern Rich Fen Systems (OPn91) which occur in the larger peatlands in Roseau and northeast Kittson Counties. Future work on indicators for Northern Extremely Rich Fens should consider that these communities were removed from this analysis. The boundary between where the Northern criteria and Northern Extremely Rich Fens regions occur, appears to overlap. We suggest future work should focus on clarifying the relationship between Northern Extremely Rich Fens and Prairie Extremely Rich Fen classes of calcareous fen.

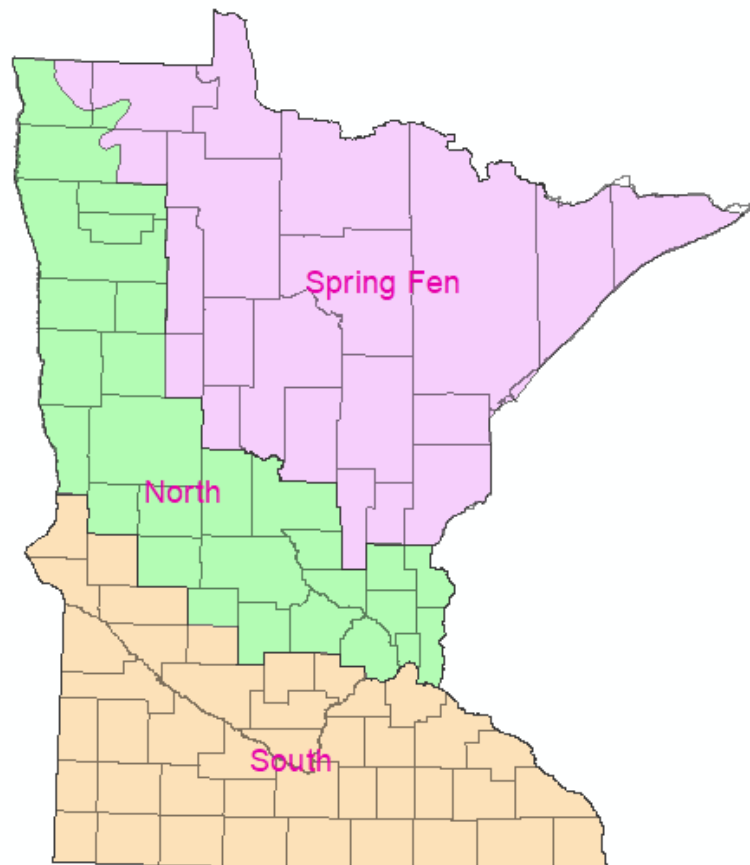


Figure 6: Generalized regions for use with calcareous fen vegetation criteria. Note: the delineation between Northern and Spring Fen zones needs further refinement and study.

## Conclusion

The DNR will be updating the calcareous fen technical criteria with these proposed new scores. Like prior efforts, we recognize the need to periodically update criteria as additional data are collected. New-future efforts should focus on distinguishing Northern Extremely Rich Fens (OPn93) from Prairie Extremely Rich Fens (OPp93a, OPp93b, and OPp93c), and reviewing the species added (or rejected) as indicators by this project.

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## Appendix A: Ordinations

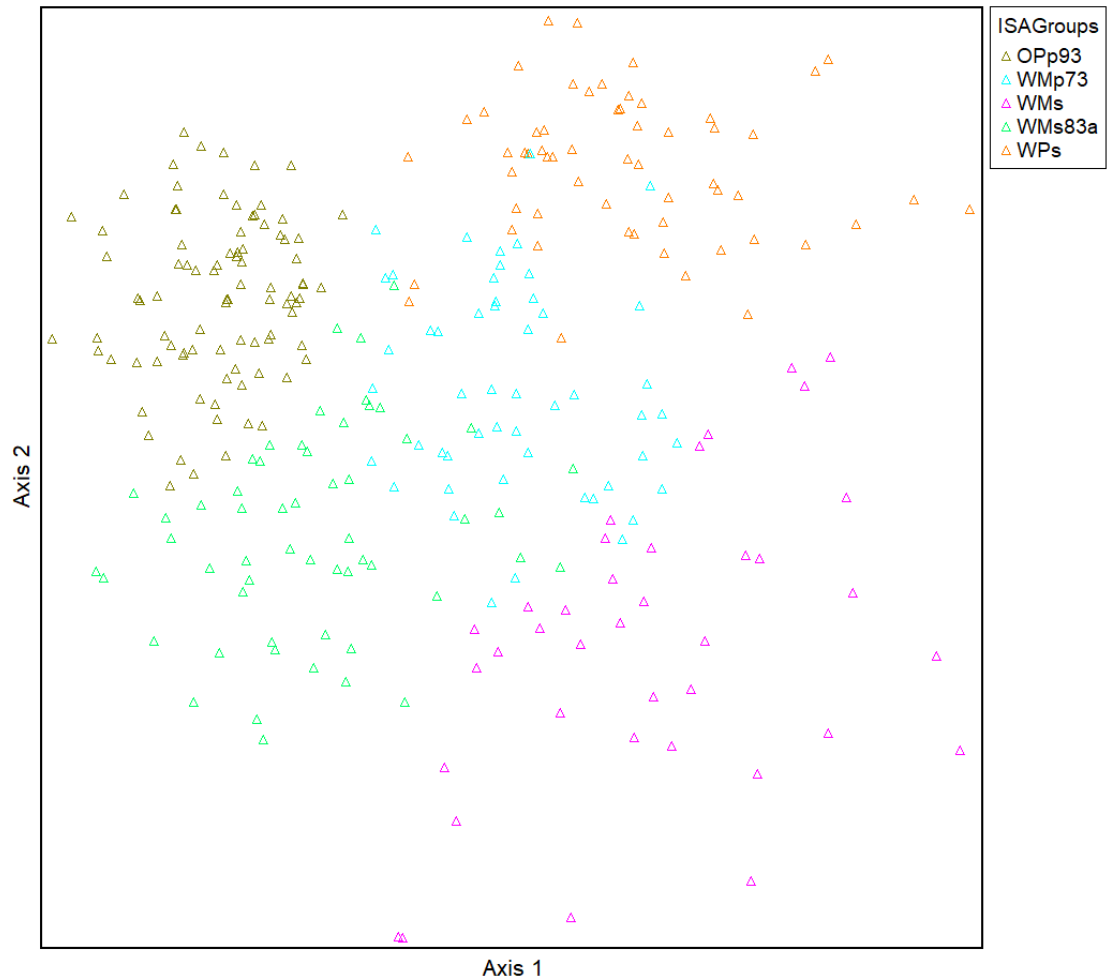


Figure A1: Axis one and two of NMS Ordination of Southern wetlands. Axis, one captures 32.8% of the variation in the data, Axis two captures 27.4% of the variation in the data. Indicator Species Analysis (ISA) groups were: OPp93 (Prairie Extremely Rich Fen), WMp73 (Prairie Wet Meadow/Carr), WMs (Southern Wet Meadow Systems), WMs83a (Southern Seepage Meadow/Carr), and WPs (Wet Prairie Systems).

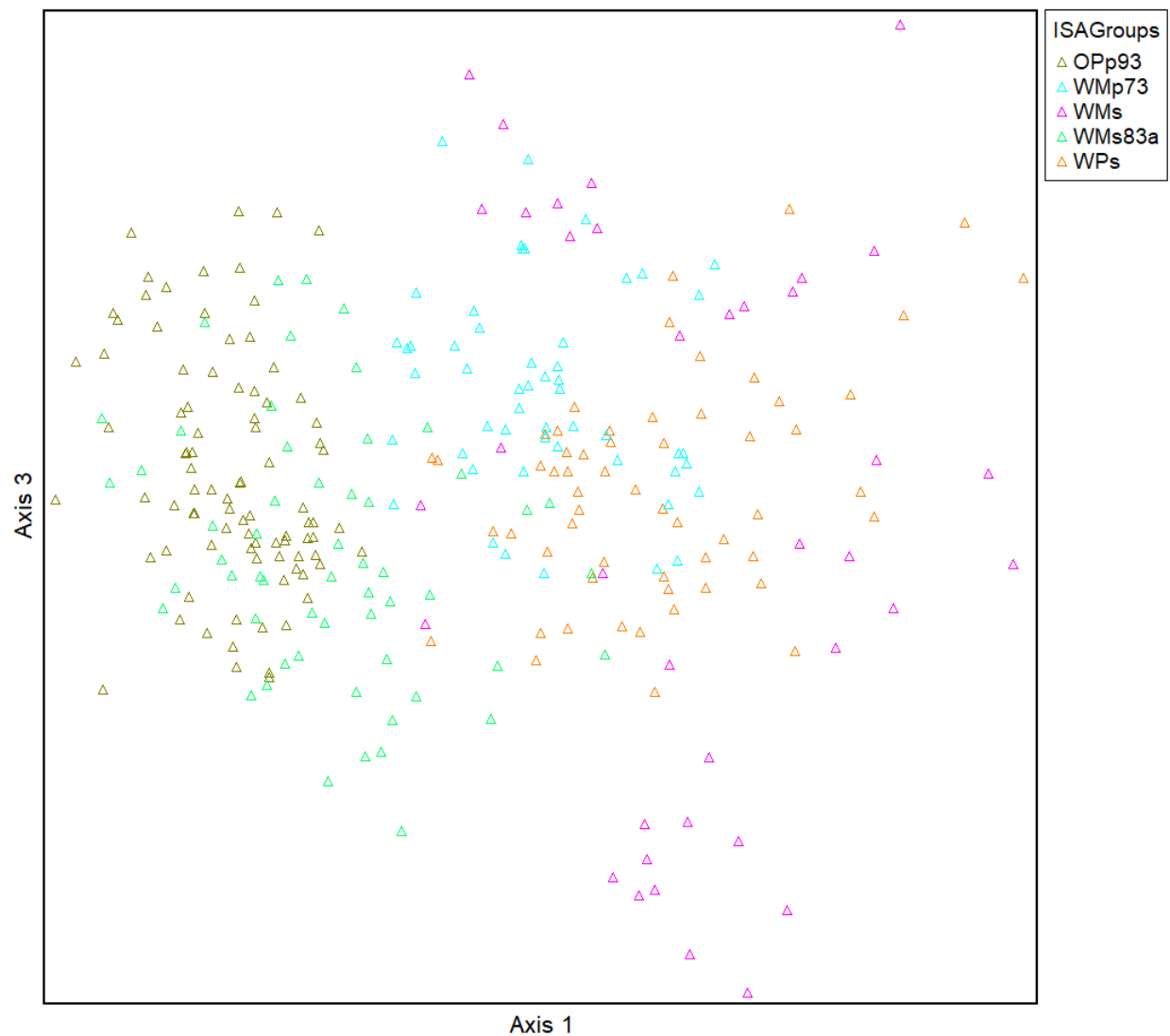


Figure A2: Axis one and three of MNS Ordination of Southern wetlands. axis one captures 52.1% of the variation in the data, Axis two captures 14.5% of the variation in the data. Indicator Species Analysis (ISA) groups were: OPp93 (Prairie Extremely Rich Fen), WMp73 (Prairie Wet Meadow/Carr), WMs (Southern Wet Meadow Systems), WMs83a (Southern Seepage Meadow/Carr), and WPs (Wet Prairie Systems).

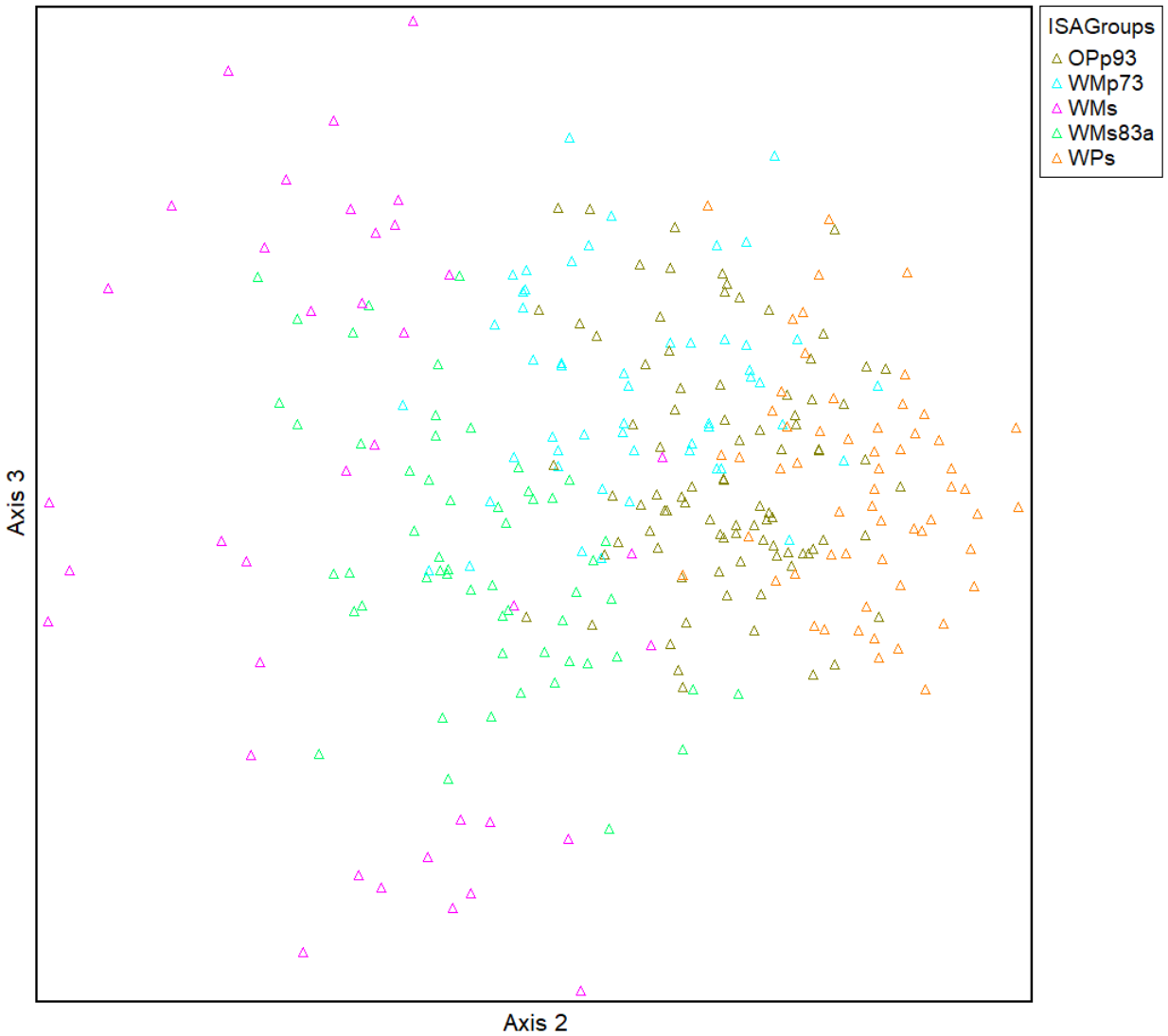


Figure A3: Axis two and three of MNS Ordination of Southern wetlands. axis one captures 27.4% of the variation in the data, Axis two captures 14.5% of the variation in the data. Indicator Species Analysis (ISA) groups were: OPp93 (Prairie Extremely Rich Fen), WMp73 (Prairie Wet Meadow/Carr), WMs (Southern Wet Meadow Systems), WMs83a (Southern Seepage Meadow/Carr), and WPs (Wet Prairie Systems).



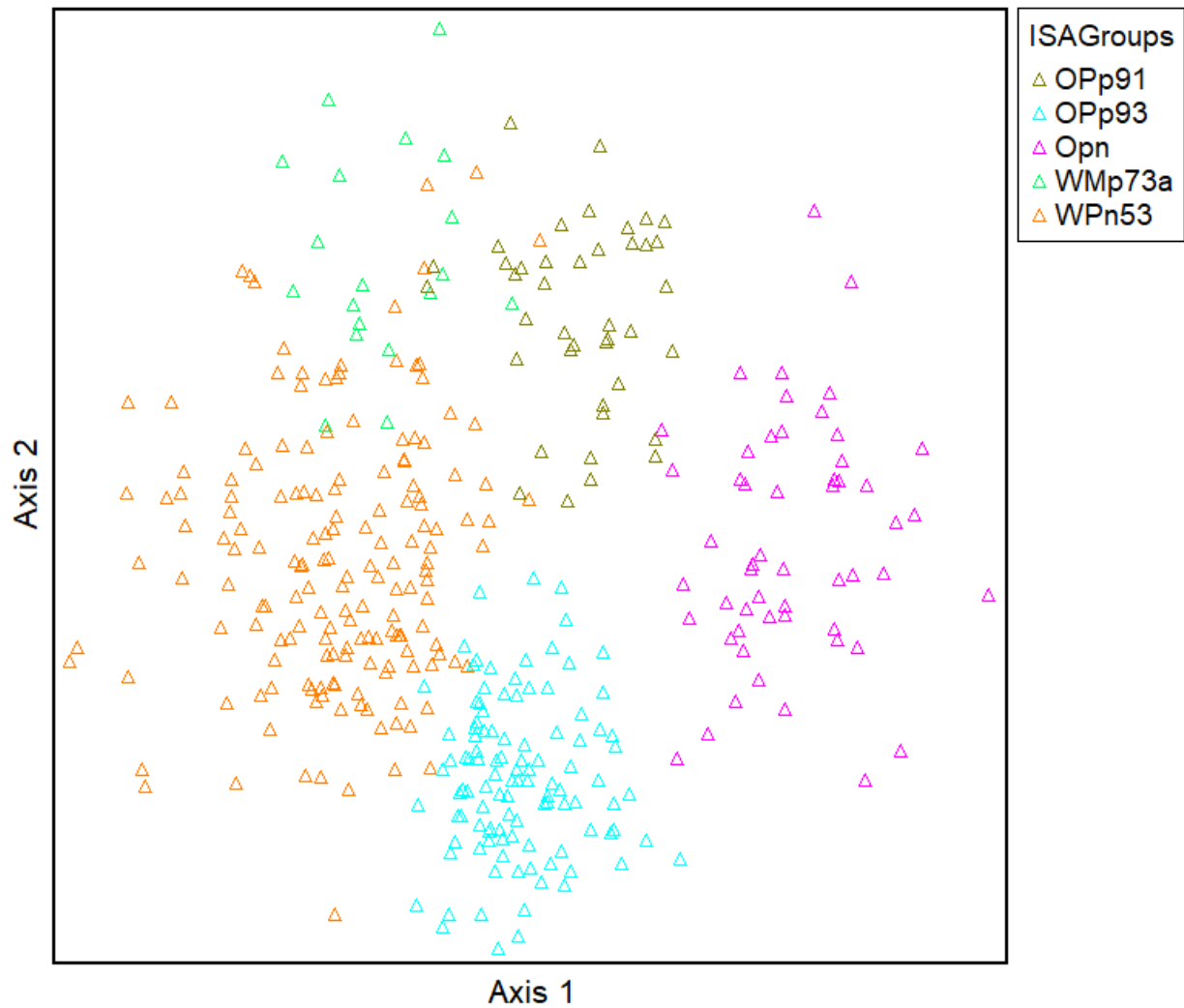


Figure A4: Axis one and two of MNS Ordination of Northern wetlands. axis one captures 52.1% of the variation in the data, Axis two captures 7.8% of the variation in the data. Indicator Species Analysis (ISA) groups were: OPp91 (Prairie Rich Fen), OPp93 (Prairie Extremely Rich Fen), OPn (Northern Open Rich Peatlands), WMp73a (Prairie Wet Meadow/Carr), WPn53 (Northern Wet Prairie).

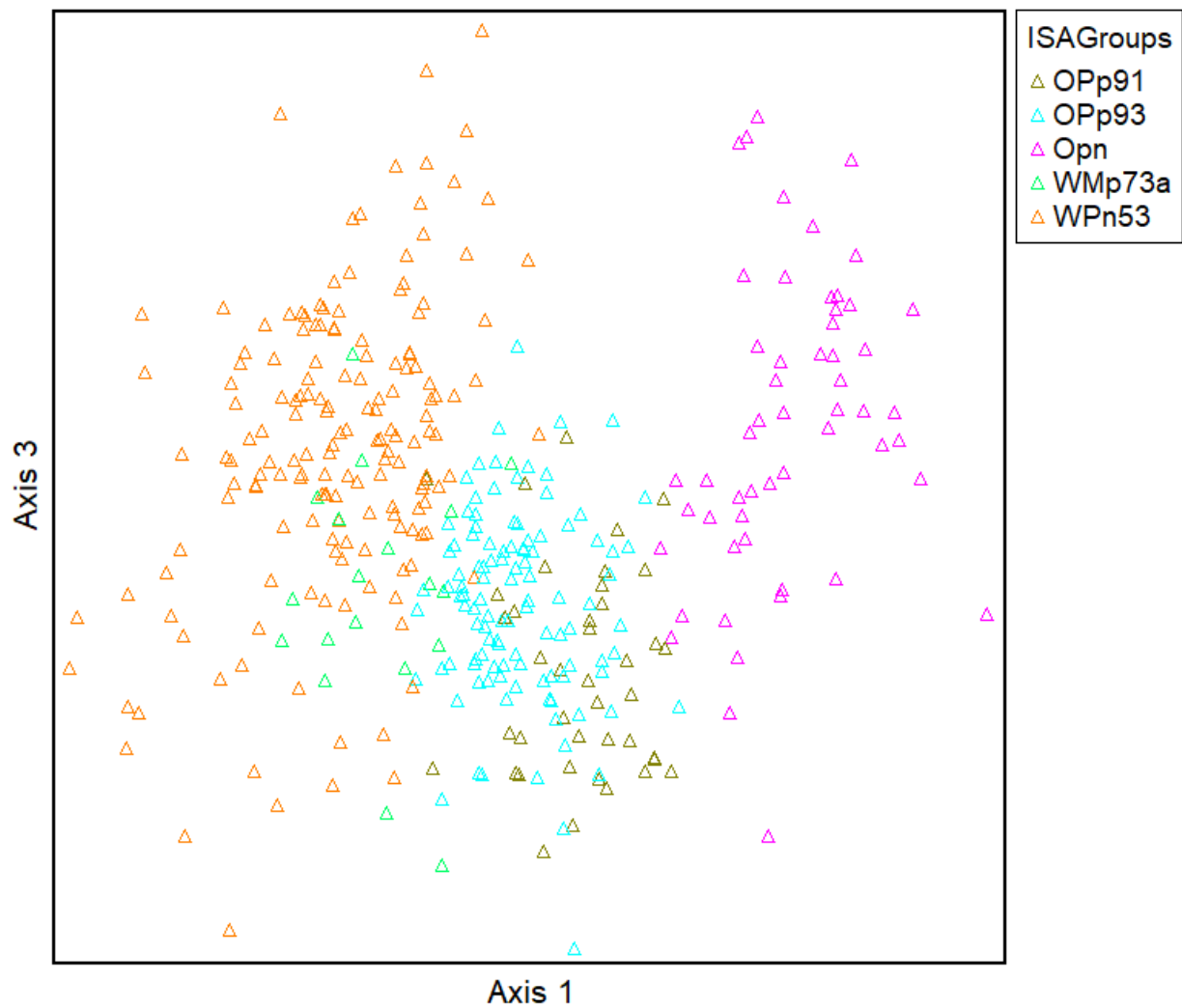


Figure A5: Axis one and three of MNS Ordination of Northern wetlands. axis one captures 52.1% of the variation in the data, Axis two captures 10.5% of the variation in the data. Indicator Species Analysis (ISA) groups were: OPp91 (Prairie Rich Fen), OPp93 (Prairie Extremely Rich Fen), OPn (Northern Open Rich Peatlands), WMp73a (Prairie Wet Meadow/Carr), WPn53 (Northern Wet Prairie).

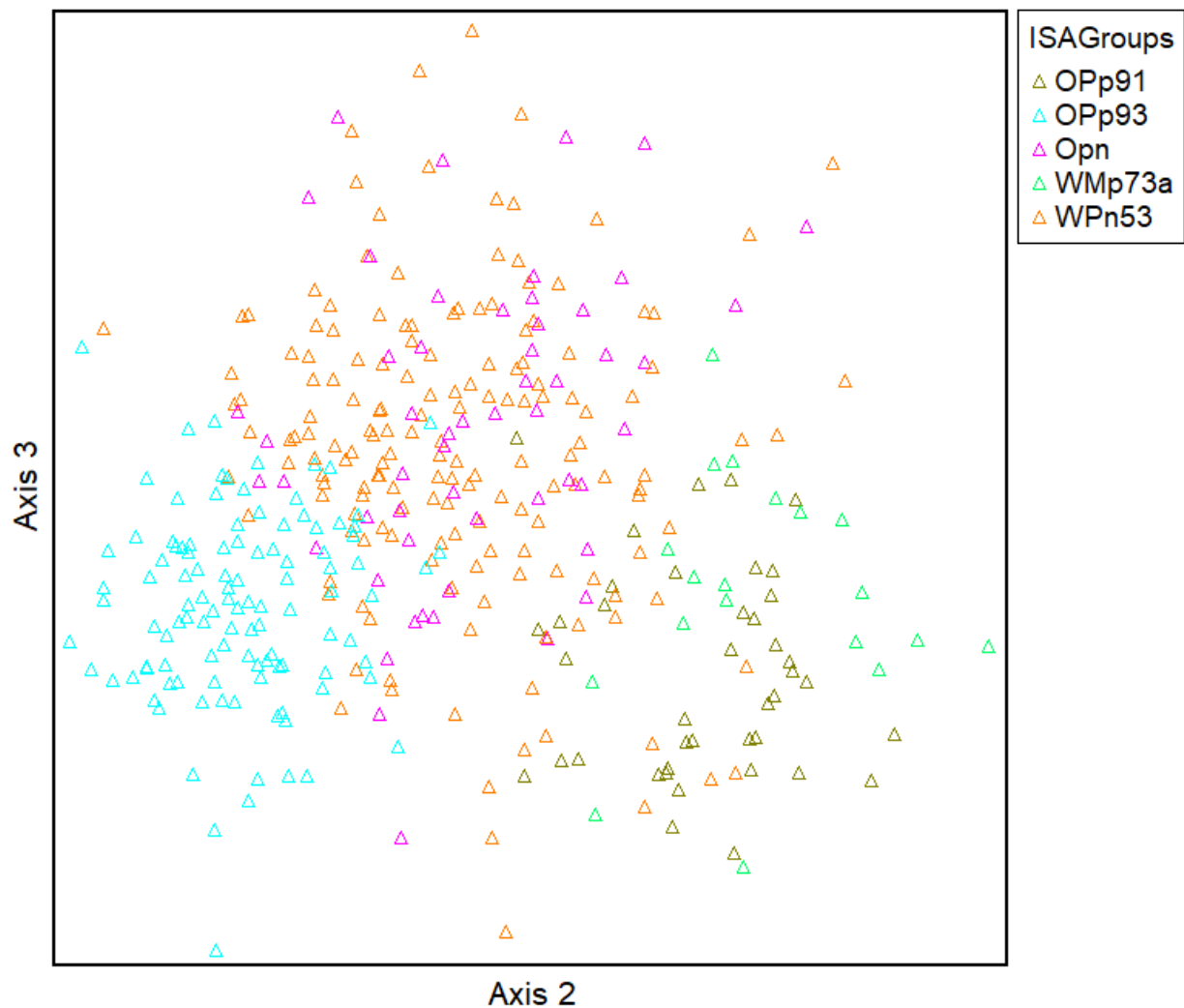


Figure A6: Axis two and three of MNS Ordination of Northern wetlands. axis one captures 7.8% of the variation in the data, Axis two captures 10.5% of the variation in the data. Indicator Species Analysis (ISA) groups were: OPp91 (Prairie Rich Fen), OPp93 (Prairie Extremely Rich Fen), Opn (Northern Open Rich Peatlands), WMp73a (Prairie Wet Meadow/Carr), WPn53 (Northern Wet Prairie).

## Appendix B: Final Dataset of Species lists

Table B1. Data used in Southern Ordinations and Indicator species analysis. Plot prefix indicates data source: FA= field application, L= DNR species list database, X= DNR relevé database. 2005 Regions are Southeast (SE), Southwest (SW), Minnesota River Valley (MR), and Northwest (NW). Cluster groups are named in Table 3 of the report. Group interpretations are Prairie Extremely Rich Fen (OPp93), Wet Meadow/Carr (WMs), Wetland Prairie Systems (WPs), Prairie Wet Meadow/Carr (WMp73), and Seepage Meadow/Carr (WMs83a). UTM X and Y datum is NAD 83 Zone 15N.

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
FA1			SW	S	1	OPp93
FA1208			SW	S	1	OPp93
FA2410			SW	S	1	OPp93
FA2810			SW	S	1	OPp93
FA3211			SW	S	1	OPp93
FA3212			SW	S	1	OPp93
FA34			SW	S	1	OPp93
FA4010			SW	S	1	OPp93
FA4011			SW	S	1	OPp93
FA4012			SW	S	1	OPp93
FA4013			SW	S	1	OPp93
FA4410			SW	S	1	OPp93
FA4411			SW	S	1	OPp93
FA4412			SW	S	1	OPp93
FA4413			SW	S	1	OPp93
FA4414			SW	S	1	OPp93
FA4416			SW	S	1	OPp93
FA7			SW	S	1	OPp93
FA808			SW	S	1	OPp93
L9218			SW	S	1	OPp93
L9219			SE	S	1	OPp93
L9221			MR	S	1	OPp93
L9222			SW	S	1	OPp93
L9224			MR	S	1	OPp93
L9225			MR	S	1	OPp93

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
L9226			MR	S	1	OPp93
L9227			MR	S	1	OPp93
L9228			SW	S	1	OPp93
L9229			SW	S	1	OPp93
L9230			SE	S	1	OPp93
L9232			MR	S	1	OPp93
L9233			MR	S	1	OPp93
L9234			SE	S	1	OPp93
L9237			SE	S	1	OPp93
L9239			SW	S	1	OPp93
L9240			SW	S	1	OPp93
L9842			SW	S	1	OPp93
L9901			SW	S	1	OPp93
L9902			SW	S	1	OPp93
L9903			SW	S	1	OPp93
L9906			SW	S	1	OPp93
L9907			SW	S	1	OPp93
L9908			SW	S	1	OPp93
L9909			SW	S	1	OPp93
L9913			SE	S	1	OPp93
L9914			SE	S	1	OPp93
L9915			SE	S	1	OPp93
L9917			SE	S	1	OPp93
L9918			SE	S	1	OPp93
L9920			MR	S	1	OPp93
L9921			MR	S	1	OPp93
L9922			MR	S	1	OPp93
L9923			MR	S	1	OPp93
L9924			MR	S	1	OPp93
L9925			MR	S	1	OPp93
L9926			MR	S	1	OPp93

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
L9927			MR	S	1	OPp93
x0144			MR	S	1	OPp93
x0145			MR	S	1	OPp93
x0146			MR	S	1	OPp93
x0148			MR	S	1	OPp93
x0149			MR	S	1	OPp93
x4088			MR	S	1	OPp93
x4089			MR	S	1	OPp93
x4995			SE	S	1	OPp93
x5038			MR	S	1	OPp93
x7788			SW	S	1	OPp93
x7793			SW	S	1	OPp93
x7794			SW	S	1	OPp93
x7795			SW	S	1	OPp93
x7807			MR	S	1	OPp93
x7922			SW	S	1	OPp93
x7931			SW	S	1	OPp93
x7932			SW	S	1	OPp93
x9002			SW	S	1	OPp93
x9009			SW	S	1	OPp93
x9018			SW	S	1	OPp93
x9342			SW	S	1	OPp93
x9839			SW	S	1	OPp93
xA670			SW	S	1	OPp93
xB144			SW	S	1	OPp93
xB492			MR	S	1	OPp93
xB494			MR	S	1	OPp93
xB780			MR	S	1	OPp93
x3171			SE	S	2	WMs
x3172			SE	S	2	WMs
x3173			SE	S	2	WMs

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
x3174			SE	S	2	WMs
x3176			SE	S	2	WMs
x3177			MR	S	2	WMs
x3182			SE	S	2	WMs
x3186			SE	S	2	WMs
x3188			SE	S	2	WMs
x3200			SE	S	2	WMs
x3218			MR	S	2	WMs
x3225			SW	S	2	WMs
x3226			MR	S	2	WMs
x3230			SW	S	2	WMs
x3232			SW	S	2	WMs
x3236			SW	S	2	WMs
x3238			SW	S	2	WMs
x3240			SW	S	2	WMs
x3242			MR	S	2	WMs
x3244			SW	S	2	WMs
x3245			SW	S	2	WMs
x3307			MR	S	2	WMs
x3308			MR	S	2	WMs
x3309			MR	S	2	WMs
x3311			MR	S	2	WMs
x3413			SW	S	2	WMs
x3414			SW	S	2	WMs
x3416			SW	S	2	WMs
x5649			MR	S	2	WMs
x6688			MR	S	2	WMs
x9037			SW	S	2	WMs
x9343			SW	S	2	WMs
x9465			SW	S	2	WMs
x9468			SW	S	2	WMs

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
xA873			MR	S	2	WMs
xA874			MR	S	2	WMs
xB488			SW	S	2	WMs
xB497			SW	S	2	WMs
L9723			SE	S	5	WPs
x0003			SW	S	5	WPs
x0431			SW	S	5	WPs
x0447			MR	S	5	WPs
x3750			SW	S	5	WPs
x3751			SW	S	5	WPs
x3752			SW	S	5	WPs
x3758			SW	S	5	WPs
x4989			SE	S	5	WPs
x5351			SW	S	5	WPs
x6638			MR	S	5	WPs
x7029			SW	S	5	WPs
x7030			SW	S	5	WPs
x7047			SW	S	5	WPs
x7054			SW	S	5	WPs
x7074			SW	S	5	WPs
x7805			MR	S	5	WPs
x7814			MR	S	5	WPs
x7821			SW	S	5	WPs
x7905			SE	S	5	WPs
x7906			SE	S	5	WPs
x7915			SW	S	5	WPs
x7917			SW	S	5	WPs
x7925			SW	S	5	WPs
x7926			SW	S	5	WPs
x7927			SW	S	5	WPs
x7945			SW	S	5	WPs



Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
x7946			SW	S	5	WPs
x7948			SW	S	5	WPs
x8114			MR	S	5	WPs
x8120			SW	S	5	WPs
x8313			SW	S	5	WPs
x8314			SW	S	5	WPs
x8643			SW	S	5	WPs
x8644			SW	S	5	WPs
x8645			SW	S	5	WPs
x9022			SW	S	5	WPs
x9048			SW	S	5	WPs
x9240			SW	S	5	WPs
x9323			SW	S	5	WPs
x9414			SE	S	5	WPs
x9417			SE	S	5	WPs
xA658			SW	S	5	WPs
xB486			SW	S	5	WPs
x0141			MR	S	6	WMs83a
x0143			MR	S	6	WMs83a
x3290			SE	S	6	WMs83a
x3299			SE	S	6	WMs83a
x3301			SE	S	6	WMs83a
x3341			SE	S	6	WMs83a
x3417			SW	S	6	WMs83a
x3418			SW	S	6	WMs83a
x3420			SW	S	6	WMs83a
x4375			SE	S	6	WMs83a
x4506			SE	S	6	WMs83a
x4803			SE	S	6	WMs83a
x4969			SE	S	6	WMs83a
x4986			SE	S	6	WMs83a

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
x5023			SE	S	6	WMs83a
x5026			MR	S	6	WMs83a
x5028			MR	S	6	WMs83a
x6109			SE	S	6	WMs83a
x6129			SE	S	6	WMs83a
x6418			MR	S	6	WMs83a
x6419			MR	S	6	WMs83a
x6420			MR	S	6	WMs83a
x6431			MR	S	6	WMs83a
x7798			SW	S	6	WMs83a
x7810			MR	S	6	WMs83a
x7923			SW	S	6	WMs83a
x8110			MR	S	6	WMs83a
x8221			MR	S	6	WMs83a
x8222			MR	S	6	WMs83a
x8223			MR	S	6	WMs83a
x8224			MR	S	6	WMs83a
x8225			MR	S	6	WMs83a
x8226			MR	S	6	WMs83a
x8227			MR	S	6	WMs83a
x9003			SW	S	6	WMs83a
x9006			SW	S	6	WMs83a
x9337			SW	S	6	WMs83a
x9429			SE	S	6	WMs83a
x9441			SW	S	6	WMs83a
x9706			SW	S	6	WMs83a
x9734			SW	S	6	WMs83a
x9852			SW	S	6	WMs83a
x9853			SW	S	6	WMs83a
x9861			SW	S	6	WMs83a
xA550			SE	S	6	WMs83a

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
xB132			SE	S	6	WMs83a
xB640			SE	S	6	WMs83a
xB641			SE	S	6	WMs83a
xB642			SE	S	6	WMs83a
xB643			SE	S	6	WMs83a
xB936			SE	S	6	WMs83a
xB937			MR	S	6	WMs83a
xB938			SE	S	6	WMs83a
xB939			SE	S	6	WMs83a
xB959			SE	S	6	WMs83a
xB960			SW	S	6	WMs83a
x7809			MR	S	8	WPs
x5035			MR	S	9	OPp93
x6421			MR	S	9	OPp93
x6423			MR	S	9	OPp93
x6424			MR	S	9	OPp93
xB935			SE	S	9	OPp93
x3303			SW	S	13	WMp73
x7787			SW	S	13	WMp73
x7913			SW	S	13	WMp73
x7919			SW	S	13	WMp73
x7920			SW	S	13	WMp73
x7921			SW	S	13	WMp73
x7933			SW	S	13	WMp73
x8111			MR	S	13	WMp73
x8113			MR	S	13	WMp73
x8118			SW	S	13	WMp73
x8119			SW	S	13	WMp73
x8121			SW	S	13	WMp73
x8122			SW	S	13	WMp73
x8123			SW	S	13	WMp73

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
x8310			MR	S	13	WMp73
x8311			MR	S	13	WMp73
x8642			SW	S	13	WMp73
x9001			SW	S	13	WMp73
x9007			SW	S	13	WMp73
x9010			SW	S	13	WMp73
x9011			SW	S	13	WMp73
x9017			SW	S	13	WMp73
x9019			SW	S	13	WMp73
x9045			SW	S	13	WMp73
x9046			SW	S	13	WMp73
x9050			SW	S	13	WMp73
x9054			SW	S	13	WMp73
x9055			SW	S	13	WMp73
x9318			SW	S	13	WMp73
x9433			SW	S	13	WMp73
x9434			SW	S	13	WMp73
x9437			SW	S	13	WMp73
x9440			SW	S	13	WMp73
x9442			SW	S	13	WMp73
x9443			SW	S	13	WMp73
x9444			SW	S	13	WMp73
x9629			SW	S	13	WMp73
x9633			SW	S	13	WMp73
x9708			SW	S	13	WMp73
x9764			SW	S	13	WMp73
x9770			SW	S	13	WMp73
x9773			SW	S	13	WMp73
x9835			SW	S	13	WMp73
xA630			SW	S	13	WMp73
xA640			SW	S	13	WMp73

Plot	UTM X	UTM Y	2005 Region	Proposed Region	Cluster Analysis Group	Group Interpretation
xA641			SW	S	13	WMp73
xA654			SW	S	13	WMp73
xB487			SW	S	13	WMp73
xB491			SW	S	13	WMp73
xB496			SW	S	13	WMp73
xB956			SE	S	13	WMp73
xB957			MR	S	13	WMp73
x0094			MR	S	14	WPs
x0417			MR	S	14	WPs
x3315			MR	S	14	WPs
x5758			MR	S	14	WPs
x7053			SW	S	14	WPs
x7801			SW	S	14	WPs
x7803			SW	S	14	WPs
x7804			SW	S	14	WPs
x7934			SW	S	14	WPs
x8109			MR	S	14	WPs
xB499			MR	S	14	WPs
xB503			MR	S	14	WPs
xB505			SW	S	14	WPs

Table B2. Data used in Northern Ordinations and Indicator species analysis. Plot prefix indicates data source: FA= field application, L= DNR species list database, X= DNR relevé database. 2005 Regions are Southeast (SE), Southwest (SW), Minnesota River Valley (MR), and Northwest (NW). Cluster groups are named in Table 3 of the report. Group interpretations are Prairie Extremely Rich Fen (OPp93), Northern Wet Prairie (WPn53), Prairie Wet Meadow/Carr (WMp73a), Northern Rich Fen (Water Track) (OPp91), and Open Rich Peatland Systems (OPn). UTM X and Y datum is NAD 83 Zone 15N.

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x8634			N	N	1	OPp93
x8838			N	N	1	OPp93
x8902			N	N	1	OPp93
x8945			N	N	1	OPp93
L9069			N	N	5	WPn53

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
L9080			N	N	5	WPn53
L9419			N	N	5	WPn53
L9643			N	N	5	WPn53
L9650			N	N	5	WPn53
L9684			N	N	5	WPn53
L9899			N	N	5	WPn53
L9971			N	N	5	WPn53
x0010			N	N	5	WPn53
x0012			N	N	5	WPn53
x0241			N	N	5	WPn53
x0242			N	N	5	WPn53
x0338			N	N	5	WPn53
x0548			N	N	5	WPn53
x0995			N	N	5	WPn53
x3204			N	N	5	WPn53
x3206			N	N	5	WPn53
x3207			N	N	5	WPn53
x3214			N	N	5	WPn53
x3741			N	N	5	WPn53
x4050			N	N	5	WPn53
x4318			N	N	5	WPn53
x4691			N	N	5	WPn53
x4695			N	N	5	WPn53
x4901			N	N	5	WPn53
x5083			N	N	5	WPn53
x5174			N	N	5	WPn53
x5175			N	N	5	WPn53
x5176			N	N	5	WPn53
x5291			N	N	5	WPn53
x5390			N	N	5	WPn53
x5394			N	N	5	WPn53

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x5654			N	N	5	WPn53
x5737			N	N	5	WPn53
x6411			N	N	5	WPn53
x6497			N	N	5	WPn53
x6761			N	N	5	WPn53
x6770			N	N	5	WPn53
x6789			N	N	5	WPn53
x6965			N	N	5	WPn53
x6967			N	N	5	WPn53
x6969			N	N	5	WPn53
x6973			N	N	5	WPn53
x6974			N	N	5	WPn53
x6977			N	N	5	WPn53
x6999			N	N	5	WPn53
x7000			N	N	5	WPn53
x7010			N	N	5	WPn53
x7013			N	N	5	WPn53
x7016			N	N	5	WPn53
x7023			N	N	5	WPn53
x7099			N	N	5	WPn53
x7116			N	N	5	WPn53
x7127			N	N	5	WPn53
x7160			N	N	5	WPn53
x7163			N	N	5	WPn53
x7171			N	N	5	WPn53
x7177			N	N	5	WPn53
x7178			N	N	5	WPn53
x7179			N	N	5	WPn53
x7474			N	N	5	WPn53
x7909			N	N	5	WPn53
x7936			N	N	5	WPn53

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x8375			N	N	5	WPn53
x8382			N	N	5	WPn53
x8394			N	N	5	WPn53
x8395			N	N	5	WPn53
x8639			N	N	5	WPn53
x8863			N	N	5	WPn53
x8884			N	N	5	WPn53
x9081			N	N	5	WPn53
x9091			N	N	5	WPn53
xA100			N	N	5	WPn53
xB781			N	N	5	WPn53
xB787			N	N	5	WPn53
L9148			N	N	7	OPn
x0167			N	N	7	OPn
x0168			N	N	7	OPn
x0373			N	N	7	OPn
x3274			N	N	7	OPn
x3320			N	N	7	OPn
x3330			N	N	7	OPn
x3359			N	N	7	OPn
x3430			N	N	7	OPn
x3432			N	N	7	OPn
x3458			N	N	7	OPn
x3657			N	N	7	OPn
x4120			N	N	7	OPn
x5082			N	N	7	OPn
x6882			N	N	7	OPn
x7581			N	N	7	OPn
x7592			N	N	7	OPn
x7593			N	N	7	OPn
x7595			N	N	7	OPn



Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x7596			N	N	7	OPn
x7734			N	N	7	OPn
x7820			N	N	7	OPn
x8388			N	N	7	OPn
x8556			N	N	7	OPn
x8558			N	N	7	OPn
x8559			N	N	7	OPn
x8873			N	N	7	OPn
x8874			N	N	7	OPn
x8907			N	N	7	OPn
x8933			N	N	7	OPn
x8935			N	N	7	OPn
x8966			N	N	7	OPn
x8968			N	N	7	OPn
x8974			N	N	7	OPn
x8991			N	N	7	OPn
x8995			N	N	7	OPn
L9210			N	N	8	WPn53
L9607			N	N	8	WPn53
L9961			N	N	8	WPn53
L9973			N	N	8	WPn53
x0998			N	N	8	WPn53
x0999			N	N	8	WPn53
x3210			N	N	8	WPn53
x4055			N	N	8	WPn53
x4091			N	N	8	WPn53
x4102			N	N	8	WPn53
x4269			N	N	8	WPn53
x4273			N	N	8	WPn53
x4274			N	N	8	WPn53
x4279			N	N	8	WPn53

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x4294			N	N	8	WPn53
x4296			N	N	8	WPn53
x4298			N	N	8	WPn53
x4331			N	N	8	WPn53
x4334			N	N	8	WPn53
x4340			N	N	8	WPn53
x4390			N	N	8	WPn53
x4391			N	N	8	WPn53
x4478			N	N	8	WPn53
x4483			N	N	8	WPn53
x4501			N	N	8	WPn53
x4502			N	N	8	WPn53
x4637			N	N	8	WPn53
x4638			N	N	8	WPn53
x4641			N	N	8	WPn53
x4906			N	N	8	WPn53
x4908			N	N	8	WPn53
x4998			N	N	8	WPn53
x5000			N	N	8	WPn53
x5001			N	N	8	WPn53
x5002			N	N	8	WPn53
x5004			N	N	8	WPn53
x5005			N	N	8	WPn53
x5006			N	N	8	WPn53
x5171			N	N	8	WPn53
x5173			N	N	8	WPn53
x5179			N	N	8	WPn53
x5212			N	N	8	WPn53
x5339			N	N	8	WPn53
x5345			N	N	8	WPn53
x5375			N	N	8	WPn53

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x5389			N	N	8	WPn53
x5392			N	N	8	WPn53
x5393			N	N	8	WPn53
x5395			N	N	8	WPn53
x6773			N	N	8	WPn53
x6783			N	N	8	WPn53
x6784			N	N	8	WPn53
x6809			N	N	8	WPn53
x6810			N	N	8	WPn53
x6818			N	N	8	WPn53
x6819			N	N	8	WPn53
x6820			N	N	8	WPn53
x6827			N	N	8	WPn53
x7114			N	N	8	WPn53
x7411			N	N	8	WPn53
x7904			N	N	8	WPn53
x8229			N	N	8	WPn53
x8892			N	N	8	WPn53
x8893			N	N	8	WPn53
x9058			N	N	8	WPn53
x9082			N	N	8	WPn53
xA108			N	N	8	WPn53
xA129			N	N	8	WPn53
xA138			N	N	8	WPn53
xB783			N	N	8	WPn53
L9216			N	N	9	OPp93
L9217			N	N	9	OPp93
L9223			N	N	9	OPp93
L9231			N	N	9	OPp93
L9235			N	N	9	OPp93
L9236			N	N	9	OPp93

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
L9238			N	N	9	OPp93
L9273			N	N	9	OPp93
L9407			N	N	9	OPp93
L9408			N	N	9	OPp93
L9409			N	N	9	OPp93
L9896			N	N	9	OPp93
L9897			N	N	9	OPp93
L9898			N	N	9	OPp93
L9900			N	N	9	OPp93
L9939			N	N	9	OPp93
x0026			N	N	9	OPp93
x0212			N	N	9	OPp93
x3810			N	N	9	OPp93
x4037			N	N	9	OPp93
x4082			N	N	9	OPp93
x4083			N	N	9	OPp93
x4084			N	N	9	OPp93
x4085			N	N	9	OPp93
x4086			N	N	9	OPp93
x4087			N	N	9	OPp93
x4105			N	N	9	OPp93
x4106			N	N	9	OPp93
x4117			N	N	9	OPp93
x4124			N	N	9	OPp93
x4125			N	N	9	OPp93
x4126			N	N	9	OPp93
x4127			N	N	9	OPp93
x4129			N	N	9	OPp93
x4131			N	N	9	OPp93
x4285			N	N	9	OPp93
x4287			N	N	9	OPp93

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x4332			N	N	9	OPp93
x4339			N	N	9	OPp93
x4341			N	N	9	OPp93
x4342			N	N	9	OPp93
x4897			N	N	9	OPp93
x4902			N	N	9	OPp93
x4903			N	N	9	OPp93
x4905			N	N	9	OPp93
x5007			N	N	9	OPp93
x5008			N	N	9	OPp93
x5009			N	N	9	OPp93
x6491			N	N	9	OPp93
x6492			N	N	9	OPp93
x6501			N	N	9	OPp93
x6602			N	N	9	OPp93
x6762			N	N	9	OPp93
x6768			N	N	9	OPp93
x6772			N	N	9	OPp93
x7413			N	N	9	OPp93
x7587			N	N	9	OPp93
x7588			N	N	9	OPp93
x8231			N	N	9	OPp93
x8390			N	N	9	OPp93
x8631			N	N	9	OPp93
x8897			N	N	9	OPp93
x8898			N	N	9	OPp93
x8899			N	N	9	OPp93
x8900			N	N	9	OPp93
x8901			N	N	9	OPp93
x8906			N	N	9	OPp93
x9083			N	N	9	OPp93

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x9500			N	N	9	OPp93
x9501			N	N	9	OPp93
x9502			N	N	9	OPp93
x9503			N	N	9	OPp93
x9505			N	N	9	OPp93
x9506			N	N	9	OPp93
x9507			N	N	9	OPp93
x9509			N	N	9	OPp93
x9826			N	N	9	OPp93
x9827			N	N	9	OPp93
xA000			N	N	9	OPp93
xA101			N	N	9	OPp93
xA106			N	N	9	OPp93
xA121			N	N	9	OPp93
xA122			N	N	9	OPp93
xA123			N	N	9	OPp93
xA127			N	N	9	OPp93
xA128			N	N	9	OPp93
xA130			N	N	9	OPp93
xA131			N	N	9	OPp93
xA132			N	N	9	OPp93
xA133			N	N	9	OPp93
xA134			N	N	9	OPp93
xA135			N	N	9	OPp93
xA136			N	N	9	OPp93
xA139			N	N	9	OPp93
xA145			N	N	9	OPp93
xB077			N	N	9	OPp93
xB078			N	N	9	OPp93
xB771			N	N	9	OPp93
xB773			N	N	9	OPp93

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
xB774			N	N	9	OPp93
xB775			N	N	9	OPp93
xB776			N	N	9	OPp93
xC048			N	N	9	OPp93
xC049			N	N	9	OPp93
xC050			N	N	9	OPp93
xC051			N	N	9	OPp93
x7580			N	N	10	OPn
x8932			N	N	10	OPn
L9584			N	N	12	OPp91
x4028			N	N	12	OPp91
x4053			N	N	12	OPp91
x4054			N	N	12	OPp91
x4096			N	N	12	OPp91
x4272			N	N	12	OPp91
x4280			N	N	12	OPp91
x4281			N	N	12	OPp91
x4282			N	N	12	OPp91
x4283			N	N	12	OPp91
x4284			N	N	12	OPp91
x4292			N	N	12	OPp91
x4293			N	N	12	OPp91
x4297			N	N	12	OPp91
x4336			N	N	12	OPp91
x4337			N	N	12	OPp91
x4351			N	N	12	OPp91
x4387			N	N	12	OPp91
x4388			N	N	12	OPp91
x4997			N	N	12	OPp91
x5166			N	N	12	OPp91
x5167			N	N	12	OPp91

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x5220			N	N	12	OPp91
x5264			N	N	12	OPp91
x5288			N	N	12	OPp91
x5289			N	N	12	OPp91
x5388			N	N	12	OPp91
x5739			N	N	12	OPp91
x6494			N	N	12	OPp91
x6774			N	N	12	OPp91
x6785			N	N	12	OPp91
x6813			N	N	12	OPp91
x6814			N	N	12	OPp91
x6821			N	N	12	OPp91
x6825			N	N	12	OPp91
x6826			N	N	12	OPp91
x6828			N	N	12	OPp91
x8638			N	N	12	OPp91
x9087			N	N	12	OPp91
x9276			N	N	12	OPp91
xC042			N	N	12	OPp91
x0066			N	N	13	WMp73a
x0988			N	N	13	WMp73a
x0994			N	N	13	WMp73a
x3201			N	N	13	WMp73a
x3209			N	N	13	WMp73a
x3212			N	N	13	WMp73a
x3213			N	N	13	WMp73a
x3215			N	N	13	WMp73a
x3283			N	N	13	WMp73a
x4386			N	N	13	WMp73a
x5650			N	N	13	WMp73a
x6962			N	N	13	WMp73a



Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x6963			N	N	13	WMp73a
x7006			N	N	13	WMp73a
x7007			N	N	13	WMp73a
x7170			N	N	13	WMp73a
x8887			N	N	13	WMp73a
x9084			N	N	13	WMp73a
xA103			N	N	13	WMp73a
x0038			N	N	14	WPn53
x0039			N	N	14	WPn53
x0040			N	N	14	WPn53
x0246			N	N	14	WPn53
x3279			N	N	14	WPn53
x4000			N	N	14	WPn53
x4639			N	N	14	WPn53
x4642			N	N	14	WPn53
x4645			N	N	14	WPn53
x5003			N	N	14	WPn53
x5372			N	N	14	WPn53
x6951			N	N	14	WPn53
x7011			N	N	14	WPn53
x7012			N	N	14	WPn53
x7017			N	N	14	WPn53
x7018			N	N	14	WPn53
x7019			N	N	14	WPn53
x8176			N	N	14	WPn53
x8391			N	N	14	WPn53
x9057			N	N	14	WPn53
x4029			N	N	15	OPn
x4039			N	N	15	OPn
x4093			N	N	15	OPn
x4644			N	N	15	OPn

Plot	UTM X	UTM Y	2005 region	2024 region	Cluster analysis groups	Group Interpretation
x7728			N	N	15	OPn
x8912			N	N	15	OPn
x8914			N	N	15	OPn
x8917			N	N	15	OPn
x8957			N	N	15	OPn
x8961			N	N	15	OPn
x8962			N	N	15	OPn
x8963			N	N	15	OPn
x8964			N	N	15	OPn
x8967			N	N	15	OPn
xB138			N	N	15	OPn
xB495			N	N	15	OPn