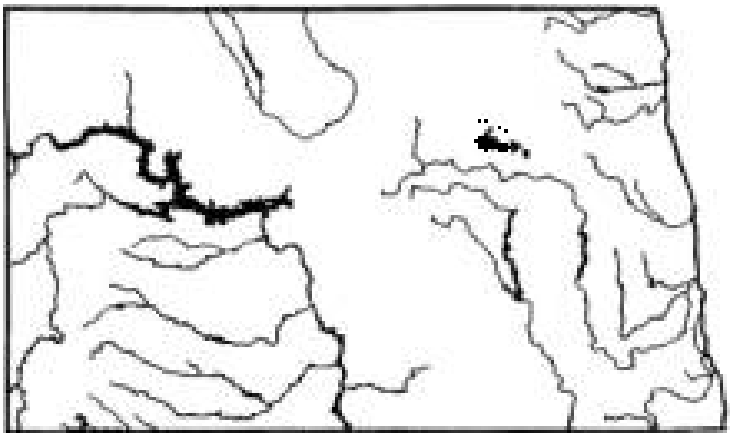

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EVALUATION OF AN INDEX OF PLANT COMMUNITY INTEGRITY FOR ASSESSING WETLAND PLANT COMMUNITIES IN THE PRAIRIE POTHOLE

by

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by

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Abstract

An evaluation of the Index of Plant Community Integrity (IPCI) was conducted for assessing wetland plant communities in the Prairie Pothole Region. The IPCI evaluates the condition of temporary, seasonal, and semi-permanent wetland plant communities based on disturbance level and multiple community attributes. During 2003 and 2004, vegetative composition was measured for temporary, seasonal, and semi-permanent wetlands located in South Dakota, North Dakota, and Montana concentrated in the Northern Glaciated Plains and Northwestern Glaciated Plains Ecoregions. Wetlands were selected based on classification and type of disturbance ranging from little disturbance (native rangeland) to heavily disturbed (cropland). Wetland data was analyzed using vegetation metrics and further analyzed using nonmetric multidimensional scaling and cluster analyses. All metrics tested were significant in indicating disturbance level in wetlands. Three classes were determined (Good, Fair, and Poor) for temporary and semi-permanent wetlands. Five classes were determined (Very Good, Good, Fair, Poor, and Very Poor) for seasonal wetlands. Based on these classes, score ranges were assigned to the metrics that better defined the ranges designated in the original IPCI. Using the modified IPCI, wetlands in the Northern and Northwestern Glaciated Plains of South Dakota, North Dakota, and Montana can be placed into disturbance classes for ecological purposes and mitigation needs.

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Introduction

Since the implementation of the Clean Water Act in 1972 (Public Law 92-500), there has been increased effort to restore and maintain our nation's wetlands. The Clean Water Act states as its primary goal the restoration and maintenance of chemical, physical, and biological integrity of the Nation's waters. This idea has become the top priority of the Environmental Protection Agency (EPA) and became policy when the Wetland Conservation Provision (Swampbuster) went into effect. The Wetland Conservation Provision encourages land owners to preserve wetlands by restricting USDA benefits to landowners who damage them. Prior to and following this legislation, substantial wetland draining primarily for agricultural purposes occurred in the Prairie Pothole Region (PPR). This, accompanied with a wide range of land uses (cropping, grazing, haying, idle) within the PPR, resulted in the EPA and other government agencies attempting to assess wetland health and needing new methods to do it. These methods will be implemented by 2011, as this is the year the EPA has designated for each state to have a wetland monitoring program implemented.

In an attempt to create new methods the Index of Biological Integrity (IBI) for biological assessment was created (Karr 1981). This was a joint venture of the EPA and several state agencies. A number of assemblages including invertebrates, amphibians, birds and plants have been used to assess the ecological integrity of prairie wetlands (Milewski et al. 2001, Helgen 2002). DeKeyser et al. (2003) developed an IBI for seasonal wetlands in the PPR that was termed the Index of Plant Community Integrity (IPCI). Wetland assessment using the IPCI was based on disturbance level and multiple vegetative composition measurements. The focus of their research was the Northwestern Glaciated Plains (NWGP) Ecoregion located in the mixed grass prairie of North Dakota.

The IPCI was found useful in assessing the condition of wetland plant communities in the NWGP of the PPR (DeKeyser et al. 2003). However, its applicability to other ecoregions of the PPR and its reliability as an assessment tool given major climatic disturbances such as droughts were in question. In the current study, the seasonal wetland IPCI research was evaluated over a wider geographic area of the PPR and over a wider range of anthropogenic and natural disturbances. An IPCI for temporary and semi-permanent wetlands was also developed in the same geographic area. This study moves beyond the DeKeyser et al. (2003) research to include more of the PPR, specifically the entire NWGP and Northern Glaciated Plains (NGP) of South Dakota, the NGP of North Dakota, and the NWGP of Montana (Omernik 1987). In addition to expansion into adjacent ecoregions, wetlands in the present study were assessed under a wider range of disturbances including natural disturbances such as drought and wet cycles.

Objectives

The specific objectives of this study include:

1) Evaluate the IPCI assessment technique over a larger spatial area within the PPR.
2) Evaluate the IPCI assessment method based on a wider variety of disturbances.
3) Validate the metrics, quality classes, and assessment methods used in the IPCI.

Methods and Analysis

Study area

The NGP ecoregion is in the transition zone between the eastern tall grass prairie and the western mixed grass prairie (Barker and Whitman 1988), and is composed of glacial drift with flat to rolling topography (Bryce et al. 1998). The NWGP ecoregion is in the western mixed grass prairie (Barker and Whitman 1988) and marks the most western edge of continental glaciation (Bryce et al. 1998). The dominant land use in the sub-ecoregions sampled of the NGP and the NWGP is small grain and livestock agriculture (Bryce et al. 1998). Prominent disturbances include grazing, haying (mowing), burning, sedimentation, and cropping which include cultivation, and the possibility for excessive nutrient loads and anoxia, and pesticide and heavy metal contamination (Walker and Coupland 1968, Kantrud et al. 1989, Adamus 1996).

The study was conducted between 2003 and 2004 on wetlands within North Dakota, South Dakota, and Montana. During the 2003 field sampling season, 20 temporary, 20 seasonal, and 13 semi-permanent wetlands were assessed in North and South Dakota. The wetlands were located within the Missouri Coteau, Drift Plains, Glaciated Lake Basins, and James River Lowlands of the NGP and NWGP (Figure 1)

(Bryce et al. 1998) in Aurora, Beadle, Charles Mix, Deuel, Douglas, Edmunds, Jerauld, McPherson, Marshall, and Sanborn counties of South Dakota, and Eddy county of North Dakota.

A total of 16 temporary, 19 seasonal, and 22 semi-permanent wetlands were assessed in 2004. Wetlands were located within the Missouri Coteau, Drift Plains, Glaciated Dark Brown Prairie, Northern Missouri Coteau, Prairie Coteau, and the Glaciated Northern Uplands (Figure 1). The wetlands were located in Deuel county South Dakota; Benson, Burke, Eddy, Kidder, and Stutsman counties in North Dakota; and Phillips, Roosevelt, Blaine, and Sheridan counties in Montana including sites on the Fort Peck and Fort Belknap Reservations in Montana. Wetlands in the southern part of South Dakota were experiencing drought conditions, while wetlands in the northern part of South Dakota, North Dakota, and Montana were having average to above-average precipitation when assessed.

Wetland data from this study were combined with data from 27 temporary, 46 seasonal, and 32 semi-permanent wetlands studied in 1998 through 2002 by DeKeyser (2000), DeKeyser et al. (2003), and Kirby and DeKeyser (2003). This wetland data set was collected in North Dakota under average to above-average precipitation regime. Their wetlands were selected within Emmons, Kidder, Burleigh, Wells, Sheridan, Burke and Stutsman counties in the Missouri Coteau and Drift Plains, and represented a wide range of disturbances.

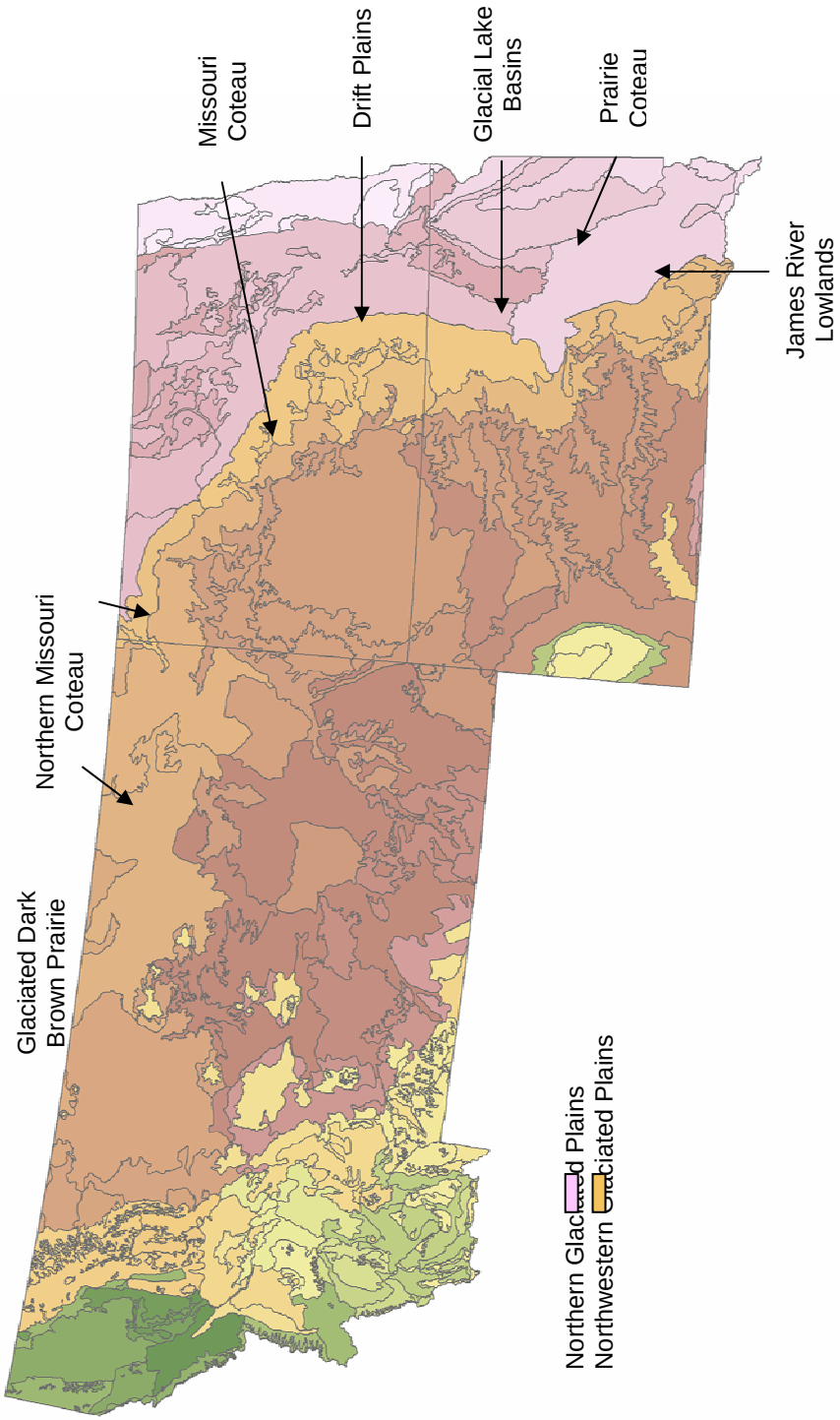

Figure 1. Ecoregions of North Dakota, South Dakota, and Montana. Modified from Bryce et al. (1998) and Omernik (1987).

Sampling technique

Wetlands were selected during May and June of 2003 and 2004 based on visual inspection (best professional judgment) of disturbance level within the wetland and surrounding area. Also, selection was based on classification of temporary, seasonal, and semi-permanent wetlands according to the Stewart and Kantrud (1971) wetland classification system. The Stewart and Kantrud (1971) classification system categorizes wetlands based on permanency of water, salinity, tillage, and major plant species found.

At each wetland, vegetation counts were taken using the quadrat method, similar to methods used by DeKeyser et al. (2003), Euliss and Gleason (1997), and Kantrud and Newton (1996). The efficiency and relevance of this method was discussed in detail by DeKeyser (2000). Within each zone of a given wetland, $1m^2$ quadrats were spaced evenly in a spiral fashion at the observers discretion around wetland zones (Figure 2). Eight quadrats were sampled in the low prairie zone, 7 quadrats in the wet meadow zone, 5 quadrats in the shallow marsh zone, and 5 quadrats in the deep marsh zone. A total of 15 quadrats were sampled for temporary wetlands, 20 for seasonal wetlands, and 25 for semi-permanent wetlands. Within each $1m^2$ quadrat, all plants were identified and given a percentage aerial cover. These species were considered to be primary species. Another list of plants found outside quadrats but within wetland zones was also recorded as secondary species, similar to the methods of DeKeyser et al. (2003), Euliss and Gleason (1997), and Kantrud and Newton (1996). At each quadrat, litter thickness, percent litter, percent open water, water depth, percent bare bottom, and percent standing dead were also recorded.

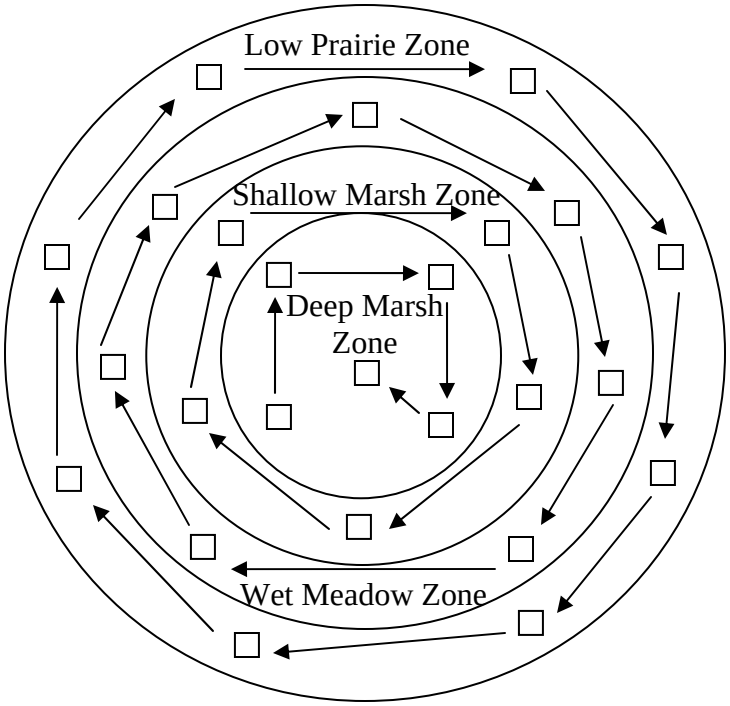

Figure 2. Example of quadrat arrangement within zones of a semi-permanent wetland.

At each wetland, disturbance quantification was assessed using the Hydrogeomorphic (HGM) Model. HGM Model data was used to determine the overall disturbance to hydrologic, water quality, and vegetative functioning of the wetland. This model was developed by the NRCS and the COE and takes into account landscape, hydrologic, soil, and land use attributes to quantify disturbance within the wetland basin and in the surrounding catchment basin (Lee et al. 1997). Data collected in the field included soil measurements, wetland assessments, and catchment basin area assessments. In the lab, data was collected using aerial photos and GIS equipment.

Data analysis

Data were analyzed according to the same multimetric system used by DeKeyser et al. (2003) to test metric effectiveness, therefore new metrics were not tested. Metrics

chosen by DeKeyser et al. (2003) were based on response to disturbance and ability to form an overall analysis of the plant community (Table 1). Metric values were calculated using the plant species encountered within quadrats as well as secondary species found between quadrats at each wetland. Value ranges assigned by DeKeyser et al. (2003) to the three ratings of metrics for the original seasonal wetland data set are given in Table 1.

Table 1. Metric value ranges assigned by DeKeyser et al. (2003) for the metric scores of 1, 3, and 5.

Metrics	Value Range for 1	Value Range for 3	Value Range for 5
Sp. Rich.[1]	0-31	32-42	43+
# Genera[2]	0-21	27-38	39+
Grass-like[3]	0-8	9-17	18+
% of intro.[4]	56.1+	19.7-56.0	0-19.6
# Nat. in WMZ[5]	0-9	10-21	22+
# C $\geq$ 5[6]	0-5	6-20	21+
# C $\geq$ 4 in WMZ[7]	0-4	5-13	14+
Avg. C[8]	0-3.15	3.16-4.00	4.01+
FQI[9]	0-22.99	23.00-28.99	29.00+

[1] Species richness of native perennial plant species.
[2] Number of genera of native perennial plant species.
[3] Number of grass and grass-like species (Poaceae, Juncaceae, and Cyperaceae).
[4] Percentage of the total species list that are annual, biennial, and introduced.
[5] Number of native perennial plant species found in the wet meadow zone.
[6] Number of plant species with a C-value $\geq$ 5*.
[7] Number of plant species with a C-value $\geq$ 4 found in the wet meadow zone*.
[8] Average C-value of all species present*.
[9] Floristic Quality Index = Average C-value multiplied by the square root of the total number of species*.
* C-value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

Value ranges for the metric ratings as well as approximate disturbance groupings in the present study, were assigned with the use of Nonmetric Multidimensional Scaling (NMS) (Kruskal 1964, Mather 1976), Cluster Analysis (McCune and Grace 2002), and Multiresponse Permutation Procedure (MRPP) (Mielke and Berry 2001). Statistical

analyses were made using the PC-Ord program. Statistical analyses were conducted similar to the methods of DeKeyser et al. (2003).

Metric values for each wetland, including wetlands assessed by DeKeyser et al. (2003), were analyzed in NMS using the Relative Euclidian distance measure. The starting configurations were user supplied using random numbers. Fifty runs were conducted with real data, and 100 randomized runs were conducted. Final solutions were based on Clarke's and Kruskal's rules of thumb for final stress as well as final instability less than 10^{-4}. Wetlands were then grouped using significant axis numbers derived in NMS as the clustering factors in cluster analysis. Groups derived in cluster analysis were then tested to see if they were significantly different using MRPP. If the initial cluster analysis groups were significantly different, then the groups were subdivided into smaller groups and tested again. The procedure was repeated until a number of statistically different, but biologically similar cluster analysis groups were found.

Results

Metric value ranges for the ratings of 0, 4, 7, and 11 are listed in tables for temporary (Table 2), seasonal (Table 3), and semi-permanent (Table 4) wetlands. Four value ranges, as used in Mack (2004), were found to be optimal because of increased sensitivity to changes in plant communities, when compared to the 3 value range system used by DeKeyser et al. (2003). The nine metrics were added together to get the total metric score. Based on total metric scores, wetlands were separated into five condition categories representing a disturbance continuum: temporary and semi-permanent wetlands (Good, Fair, and Poor); seasonal wetlands (Very good, Good, Fair, Poor, and Very Poor). Temporary and semi-permanent wetlands with total metric scores ranging

Table 2. Metric value ranges for the metric scores of 0, 4, 7, and 11 for the combined temporary wetland data set.

Metrics	Value Range for 0	Value Range for 4	Value Range for 7	Value Range for 11
Sp. Rich.[1]	0-16	17-23	24-40	41+
# Genera[2]	0-11	12-19	20-26	27+
Grass-like[3]	0-8	9-10	11-15	16+
% of intro.[4]	41.1+	35.1-41.0	27.1-35.0	0.0-27.0
# Nat. in WMZ[5]	0-7	8-10	11-13	14+
# C $\geq$ 5[6]	0-4	5-11	12-16	17+
# C $\geq$ 4 in	0-3	4-9	10-12	13+
Avg. C[8]	0.00-2.50	2.51-3.57	3.58-4.58	4.59+
FQI[9]	0.00-13.60	13.61-21.70	21.71-27.20	27.21+

[1] Species richness of native perennial plant species.
[2] Number of genera of native perennial plant species.
[3] Number of grass and grass-like species (Poaceae, Juncaceae, and Cyperaceae).
[4] Percentage of the total species list that are annual, biennial, and introduced.
[5] Number of native perennial plant species found in the wet meadow zone.
[6] Number of plant species with a C-value $\geq$ 5*.
[7] Number of plant species with a C-value $\geq$ 4 found in the wet meadow zone*.
[8] Average C-value of all species present*.
[9] Floristic Quality Index = Average C-value multiplied by the square root of the total number of species*.
* C-value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

from 0-32 were considered to be in Poor condition; scores from 34-65 were in Fair condition; and scores from 66-99 were in Good condition. Using this method for the temporary wetlands, there were 24 wetlands grouped into the Good class, 16 in the Fair class, and 23 in the Poor class. For semi-permanent wetlands, there were 22 wetlands grouped into the Good class, 23 in the Fair class, and 22 in the Poor class. Seasonal wetlands with total metric scores ranging from 0-19 were considered in Very poor condition; scores from 20-39 were in Poor condition; scores from 40-59 were in Fair condition; scores from 60-79 were in Good condition; and scores from 80-99 were in

Table 3. Metric value ranges for the metric scores of 0, 4, 7, and 11 for the combined seasonal wetland data set.

Metrics	Value Range for 0	Value Range for 4	Value Range for 7	Value Range for 11
Sp. Rich.[1]	0-19	20-31	32-41	42+
# Genera[2]	0-14	15-24	25-32	33+
Grass-like[3]	0-6	7-10	11-17	18+
% of intro.[4]	41.1+	30.8-41.0	21.1-30.7	0.0-21.0
# Nat. in WMZ[5]	0-8	9-16	17-24	25+
# C $\geq$ 5[6]	0-7	8-17	18-26	27+
# C $\geq$ 4 in	0-4	5-9	10-16	17+
Avg. C[8]	0.00-2.60	2.61-3.12	3.13-3.52	3.53+
FQI[9]	0.00-10.00	10.01-16.11	16.12-22.99	23.00+

[1] Species richness of native perennial plant species.
[2] Number of genera of native perennial plant species.
[3] Number of grass and grass-like species (Poaceae, Juncaceae, and Cyperaceae).
[4] Percentage of the total species list that are annual, biennial, and introduced.
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[8] Average C-value of all species present*.
[9] Floristic Quality Index = Average C-value multiplied by the square root of the total number of species*.
* C-value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

Very good condition. Using this method, there were 17 wetlands grouped into the Very good class, 20 in the Good class, 16 in the Fair class, 14 in the Poor class, and 17 in the Very poor class.

NMS analysis of the nine metrics for the temporary wetland data set showed a final solution of 1 dimension. There were 92 iterations for the final solution. The 1 dimension solution had a final stress of 4.77, which means an excellent representation of the data with no risk of misinterpretation (McCune and Grace 2002). The probability that

Table 4. Metric value ranges for the metric scores of 0, 4, 7, and 11 for the combined semi-permanent wetland data set.

Metrics	Value Range for 0	Value Range for 4	Value Range for 7	Value Range for 11
Sp. Rich.[1]	0-44	45-60	61-71	72+
# Genera[2]	0-34	35-39	40-54	55+
Grass-like[3]	0-8	9-18	19-31	32+
% of intro.[4]	37.2+	34.1-37.1	29.1-34.0	0.0-29.0
# Nat. in WMZ[5]	0-21	22-31	32-44	45+
# C $\geq$ 5[6]	0-12	13-18	19-23	24+
# C $\geq$ 4 in	0-9	10-14	15-25	26+
Avg. C[8]	0-3.15	3.16-3.57	3.58-3.89	3.90+
FQI[9]	0-22.30	22.31-30.49	30.50-37.09	37.10+

[1] Species richness of native perennial plant species.
[2] Number of genera of native perennial plant species.
[3] Number of grass and grass-like species (Poaceae, Juncaceae, and Cyperaceae).
[4] Percentage of the total species list that are annual, biennial, and introduced.
[5] Number of native perennial plant species found in the wet meadow zone.
[6] Number of plant species with a C-value $\geq$ 5*.
[7] Number of plant species with a C-value $\geq$ 4 found in the wet meadow zone*.
[8] Average C-value of all species present*.
[9] Floristic Quality Index = Average C-value multiplied by the square root of the total number of species*.
* C-value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP 2001).

a similar stress would be obtained by chance is $p<.01$. The solution had a final instability less than 10^{-4}, with the final solution of 1 axis representing 99.2% of the variation. Cluster analysis of the temporary wetland data set, using the significant axis numbers from NMS, resulted in the dendrogram illustrated in Figure 3. Temporary wetlands were separated into three condition classes representing the disturbance conditions of Good, Fair, and Poor. The three condition classes were determined to be statistically different ($p<.05$). Using NMS and cluster analyses, the Good class contained 23 wetlands, the Fair

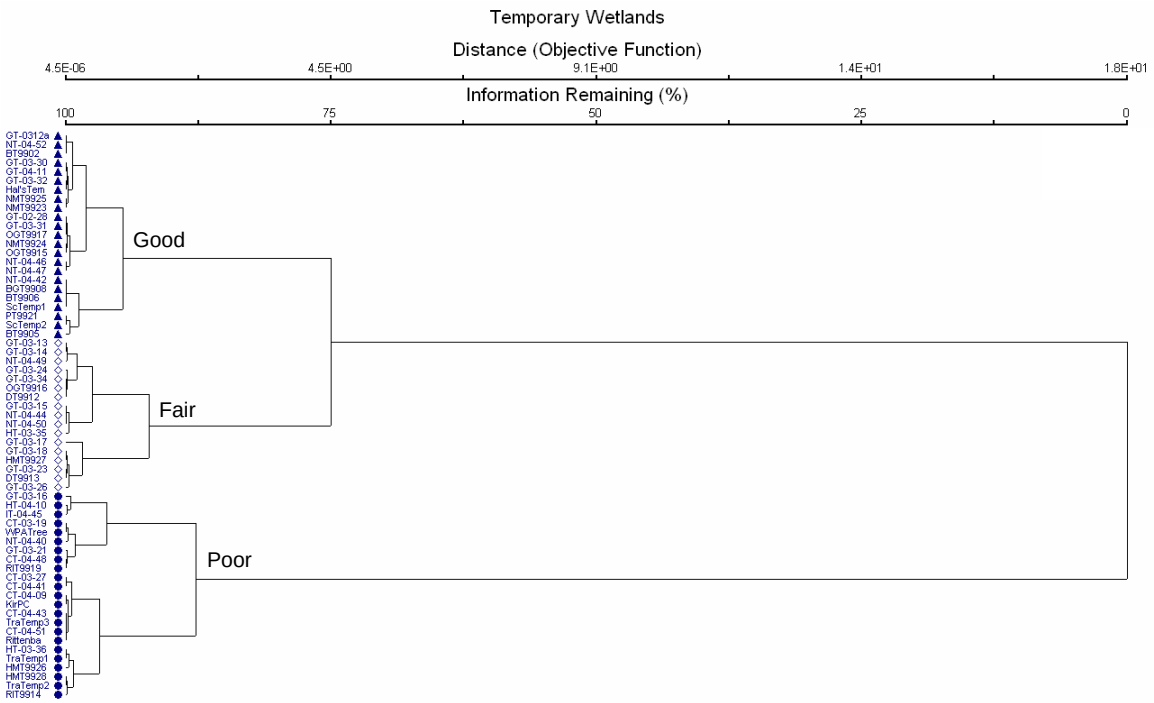

Figure 3. Dendrogram of temporary wetland data set groupings according to NMS, cluster analysis, and MRPP.

class 17 wetlands, and the Poor class 23 wetlands. Wetland placement into specific groupings between the NMS and cluster analysis classification, and the metric classification were similar 98% of the time.

NMS analysis of the nine metrics for the seasonal wetland data set showed a final solution of one dimension. There were 132 iterations for the final solution. The 1-dimensional solution had a final stress of 6.78, which represents a good ordination with no risk of making false inferences (McCune and Grace 2002). The probability that a similar stress could be obtained by chance is $p<.01$. The final 1-dimensional solution had a final instability less than 10^{-4} and represented 98.5% of the variation in the data. Cluster analysis of the seasonal wetland data set, using the significant axis numbers from NMS, resulted in the dendrogram illustrated in Figure 4. Seasonal wetlands were separated into five condition class categories of Very good, Good, Fair, Poor, and Very

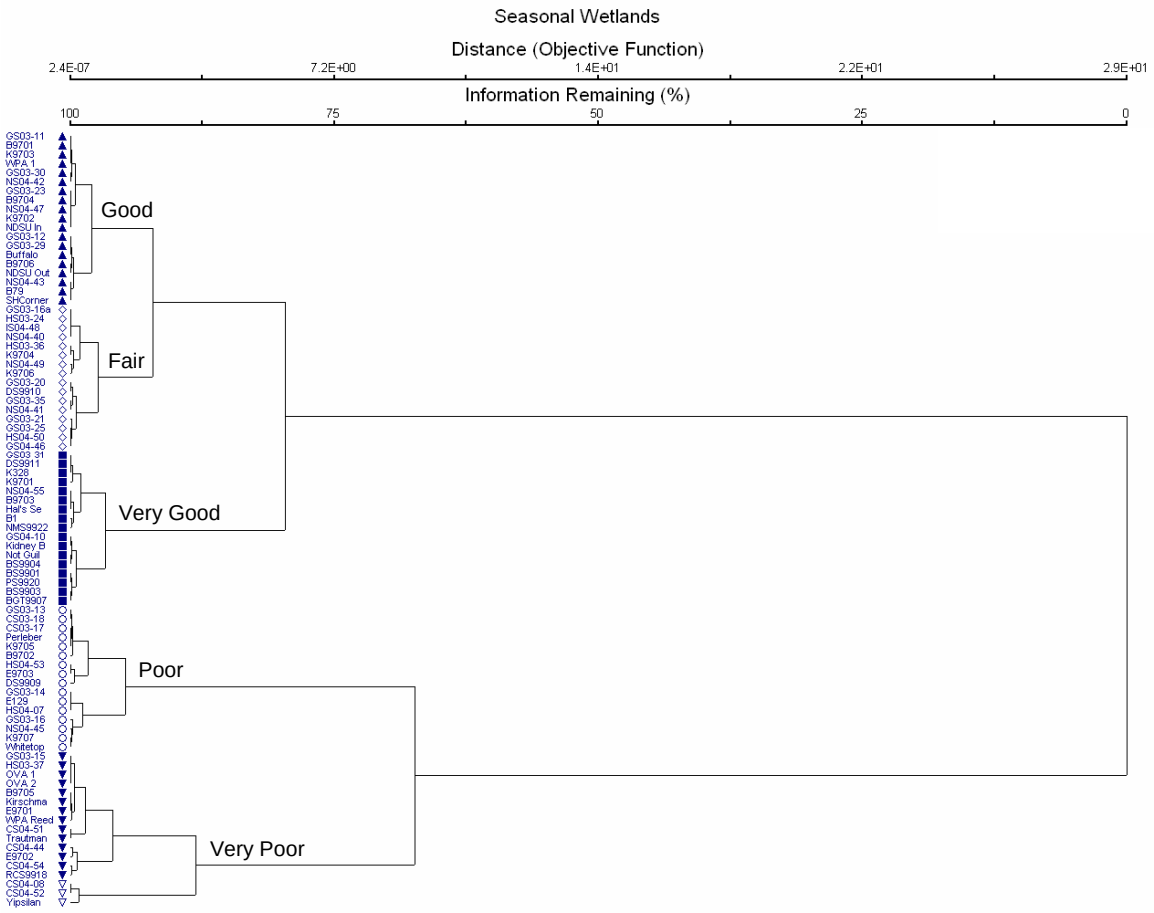

Figure 4. Dendrogram of seasonal wetland data set groupings according to NMS, cluster analysis, and MRPP.

poor. The five condition classes were determined to be statistically different ($p<.05$). There were three wetlands that were considered outliers of extremely low condition following statistical analyses. Wetlands CS-4-08, CS04-52, and Yipsilanti were, therefore, not included in MRPP and were grouped into the Very poor condition wetland class. NMS, cluster analysis, and MRPP showed that the Very good class contained 17 wetlands, the Good class contained 19 wetlands, the Fair class contained 16 wetlands, the Poor class contained 16 wetlands, and the Very poor class contained 17 wetlands. Wetland placement into specific groupings between NMS and cluster analysis classifications, and the metric classification were similar 88% of the time.

NMS analysis of the nine metrics for the semi-permanent wetland data set showed a final solution of 2 dimensions. There were 92 iterations for the final solution. The 2-dimensional solution had a final stress of 6.14, representing a good ordination with no risk of making false inferences (McCune and Grace 2002). The probability that a similar stress could be obtained by chance was $p<.01$. The final instability was found to be less than 10^{-4}, with axis 1 representing 96.1% of the variation, and axis 2 representing 2.6% of the variation, for a total of 98.7% of the variation represented. Cluster analysis of the semi-permanent wetland data set, using the significant axis numbers from NMS, resulted in the dendrogram illustrated in Figure 5. Semi-permanent wetlands were separated into

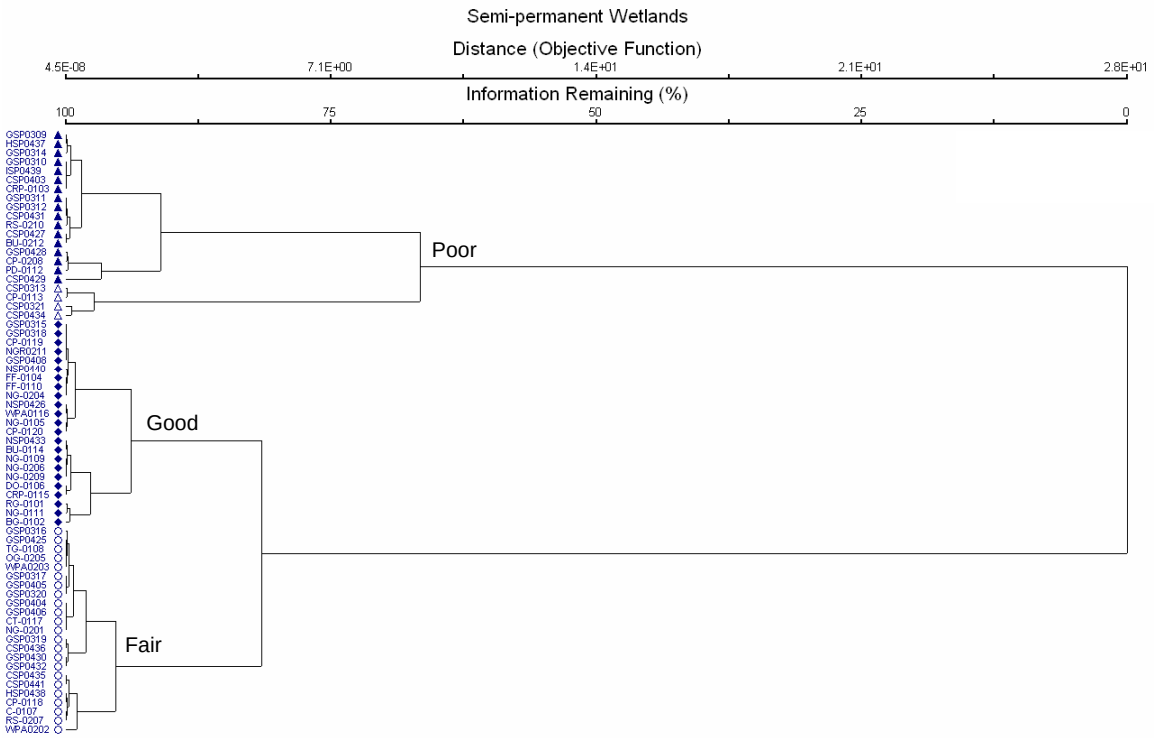

Figure 5. Dendrogram of semi-permanent wetland data set groupings according to NMS, cluster analysis, and MRPP.

three condition class categories of Good, Fair, and Poor. The three condition classes were determined to be statistically different ($p<.05$). There were four extremely low condition wetland plant communities that were considered to be outliers when grouping according to NMS and cluster analysis. Wetlands CSP0313, CSP0321, CSP0434, and CP-0113 were not included in the MRPP grouping of wetlands and were grouped into the Poor condition class of wetlands later. After NMS and cluster analysis grouping, the Good class contained 23 wetlands, the Fair class 23 wetlands, and the Poor class contained 21 wetlands. Wetland placement into specific groupings between the NMS and cluster analysis classification and the metric classification was 97% similar.

Discussion

A successful condition classification system for wetlands must represent dependable signs of a wetland's overall condition and should include aspects of the vegetative community (Karr and Chu 1997). The IPCI developed for seasonal wetlands by DeKeyser et al. (2003) was found to be relevant to the NWGP of the PPR during times of average to above-average precipitation; however, increased spatial and temporal sampling was deemed necessary to improve the applicability and reliability of the technique.

Due to the size and nature of temporary wetlands, wetlands studied were best represented by three condition classes: Good, Fair, and Poor. Temporary wetlands tend to only hold water in the spring after snowmelt or during high precipitation events (Stewart and Kantrud 1971). Due to lack of water during the growing season and their smaller size, they are easy to disturb. Therefore, temporary wetlands generally fall into one of three ranges of disturbance: completely disturbed throughout the basin, moderately

disturbed by disturbances such as mowing, or negligible disturbance such as native rangeland. Seasonal wetlands studied were best represented by 5 condition classes: Very good, Good, Fair, Poor, and Very poor. Seasonal wetlands tend to hold water through the spring and part of the summer, and dry up in late summer or early fall (Stewart and Kantrud 1971). Seasonal wetlands tend to be too wet to disturb the entire wetland basin in most years, which allows for a greater range of disturbances in seasonal wetland basins. In dry years, the entire basin may be completely cropped while, during wet years, only one or two zones of the wetland may be disturbed. Semi-permanent wetlands were best represented by three condition classes: Good, Fair, and Poor. Semi-permanent wetlands are much larger and usually maintain water through spring and summer and frequently into fall and winter (Stewart and Kantrud 1971). Therefore, semi-permanent wetlands tend to be mostly affected by disturbance in the outermost zones of the wetland. Wetlands of this classification tend to be: (1) highly disturbed in the outermost zones, (2) moderately disturbed in the outermost zones, (3) or negligibly disturbed (native rangeland) throughout the wetland basin.

When wetland groupings were compared between the metric classification system and statistical analysis classification using NMS and cluster analysis temporary wetlands were found to be 98% similar. Seasonal wetlands were 88% similar, and semi-permanent wetlands were 97% similar. Differences between the two classification systems for temporary and semi-permanent appears to be related to the value for percent introduced, annual and/or biennial species. For seasonal wetlands differences usually wetlands associated with the number of native perennials either in the entire wetland or in the wet meadow zone. NMS accounted for spatial relations among these metrics in a different

way than did the metric system in which all metrics contribute equally to the IPCI, resulting in dissimilarity between the two assessment systems.

Vegetative metrics appear to be valuable and reliable in assessing wetland condition in the PPR. Wetlands were assessed spatially across sub-ecoregions of the PPR that consisted of areas experiencing drought and areas that had average to above-average precipitation, and yet were separated into consistent condition classes. Also, despite differing soil regimes, hydrology, and topography, wetlands throughout the various sub-ecoregions were assessed similarly when using vegetative metrics.

In the present study the method was evaluated in various sub-ecoregions: Missouri Coteau, Drift Prairie, Glaciated Dark Brown Prairie, Northern Missouri Coteau, Prairie Coteau, Glaciated Northern Uplands, Glaciated Lake Basins, and James River Lowlands and proved reliable. Wetland areas in the Drift Plains and Missouri Coteau have been extensively tested. However, further evaluation of wetlands in other sub-ecoreginos could prove useful in adjusting the value ranges used in the metric analysis.

The sampling methods used involving the sampling of quadrats, secondary species list, and development of metrics to form an IPCI (DeKeyser et al. 2003) proved both reliable and repeatable for temporary, seasonal, and semi-permanent. In any assessment of plant community health, there is a need to adequately sample and identify native and invasive species (Stohlgren et al. 1998). The IPCI technique proved to have this capability. The metric values for seasonal wetlands were somewhat modified in the present study to adapt to a larger sample size and variety of environmental conditions. Overall, metric value ranges were lower than those found in the DeKeyser et al. (2003) study. Wetlands assessed in both studies either stayed in the category identified in the

original IPCI or changed from a lower condition class to a higher condition class (ex. Fair to Good). This difference is most likely due to higher disturbance intensities in the southern NGP from drought and land use (dominance of cropping).

Conclusion

Plant communities are a valuable component of wetlands and can provide measurable variables indicative of the overall condition of a wetland over a wide spatial and temporal range. The IPCI is valuable in the evaluation of wetland condition throughout a large portion of the PPR. We believe tracking the total metric score and its variation over time is more valuable than looking at the condition class alone.

The IPCI is a tool that can be used for assessing wetlands and identifying areas that may have potential or need for conservation or restoration. The IPCI may be used to provide baseline data or to track the progress of restored and reclaimed areas and public lands such as waterfowl production areas. This may be beneficial to private and public land managers in their restoration and conservation efforts. Under current laws, the IPCI may also be used for mitigation purposes. With the large number of wetlands needing mitigation due to urban development or other disturbance, a rapid assessment technique will be useful in assessing long-term restoration efforts.

The IPCI, as described in this study, is suitable for assessing temporary, seasonal, and semi-permanent wetlands located in the Missouri Coteau, Drift Prairie, Glaciated Dark Brown Prairie, Northern Missouri Coteau, Prairie Coteau, Glaciated Northern Uplands, Glaciated Lake Basins, and James River Lowlands sub-ecoregions of the PPR. Rigorous testing of wetlands using the IPCI has been conducted in the Missouri Coteau and Drift Prairie. Areas not tested within other sub-ecoregions mentioned may need

further assessment before the IPCI is completely adopted. Also, the IPCI may not be relevant in other physiographic regions within the PPR as there are noticeable vegetative differences in these areas (Barker and Whitman 1988). Further research may be required to refine the metric value ranges of the IPCI for adjacent physiographic regions.

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