TRANSFERABILITY OF REGIONAL AND WETLAND SPECIFIC ASSESSMENT METHODS FOR A STATEWIDE APPROACH

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ABSTRACT

The transferability and expansion of current wetland assessment methods to other wetland classes and ecoregions throughout the state of North Dakota is the primary goal of this research. During the growing season of 2011, 53 wetlands ranging from lacustrine depressional, palustrine depressional and forested class wetlands were sampled. Additionally, 40 ecoregion specific “reference” wetlands sampled during the growing seasons of 2009 and 2010 were also considered. Vegetation, soil, hydrologic, and landscape attributes were collected based on the protocols for the Index of Plant Community Integrity, Hydrogeomorphic Model, and the North Dakota Rapid Assessment Method. Non-metric Multidimensional Scaling was used to validate each assessment’s ranking criteria amongst different wetlands in different ecoregions. A test of concordance the three assessment methods was conducted with Kendall’s *W* program. Validation results indicated that the Index of Plant Community Integrity and North Dakota Rapid Assessment Method can have state wide applicability; however, protocols should be adjusted to regional ecological processes. Concordance was not found amongst the assessments when using the ecoregion reference dataset.

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I have always dreamed about making a difference in environmental conservation and I hoped to do so now and in the future. North Dakota might be a simple landscape to a tourists eye, but behold, North Dakota has much more to offer and in much grandeur.

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INTRODUCTION

The United States Environmental Protection Agency (USEPA) has published reports that recommend states and tribes develop wetland assessment and monitoring programs that have the ability to evaluate a wetland's biological, physical and chemical integrity (Barbour et al. 1999). These criteria for evaluation stem from the major goals set forth by the Clean Water Act (CWA) 33 USC 1251, "maintain and restore the physical, chemical and biological integrity of the nation's waters." Currently, many different methods have been developed, researched, and utilized to fulfill these goals set by the CWA. Some methods are directed towards evaluating biological integrity or rather, "the ability of an environment to support and maintain assemblages of organisms similar to that produced by long-term evolutionary processes (Karr and Chu 1999)". The Index of Biological Integrity (IBI) developed by Karr (1981) is a widely used method that quantitatively expresses the quality of water resource systems. Karr (1981) evaluated the biological integrity of a watershed's streams by taxon composition and richness attributes of fish communities.

A similar method utilizing Karr's (1981) IBI principals was tested and developed in North Dakota. DeKeyser et al. (2003) utilized the IBI concept by assessing vascular plant assemblages in seasonal depressional wetlands located in North Dakota's Prairie Pothole Region (PPR). Their method, the Index of Plant Community Integrity (IPCI), was later researched, tested, and expanded to different spatial scales in order to validate whether the method had the potential of assessing other depressional wetlands throughout the Northern Glaciated Plains and Northwestern Glaciated Plains ecoregions (DeKeyser et al. 2003; Hargiss et al. 2008).

Another method developed to accommodate CWA goals, and also assist in Army Corps of Engineers section 404 regulatory programs, evaluates the capacity of wetlands' biological, chemical, hydrological, and physical functions. Developed by Brinson (1993), the Hydrogeomorphic (HGM) model determines the capacity of wetlands' functions in comparison to a profile of reference wetlands with similar geographic and hydrologic properties. The HGM is spatially explicit to a certain classification of wetlands for a given region. For North Dakota, the only HGM assessment has been developed for the given subclass: prairie pothole, low permeability substrate, temporary and seasonal hydroperiods, depressions (Gilbert et al. 2006).

Hargiss (2009) created a North Dakota Rapid Assessment Method (NDRAM) to evaluate the condition of depressional wetlands in the PPR in a relatively quick and non-intensive assessment. The protocol requires an on-site evaluation of a wetland's hydrology, hydric soils and hydrophytic vegetation, by using Best Professional Judgment (BPJ) to score narrative based metrics. An overall score is calculated to predict a wetland's current condition.

The goal of this research is to validate the expansion in spatial scope of the IPCI, HGM, and NDRAM to wetlands outside their developed regional and wetland type jurisdictions. Examining the current North Dakota assessment methods through validation and correlation analysis can provide future guidance in modifying the IPCI and NDRAM to fit wetlands of different types and classes throughout North Dakota. An expansion of assessment methods for the whole state and different wetland types will allow proper indexing of wetland condition for management, conservation, and protection of wetlands.

LITERATURE REVIEW

Wetland Condition Assessments

The longstanding goal of the CWA is to "maintain and restore the physical, chemical, and biological integrity of the nations waters." This has generated many efforts to assess a wetland's condition or health (Danielson 2002; Mack 2007; Stoddard et al. 2008). These attempts have contributed to the development of quantitative and qualitative biological assessment methods, which evaluate the biological integrity of wetlands and aid in the nation's goal of "no net loss," of wetlands (Mack 2007).

A successful biological assessment framework is the Index of Biological Integrity (IBI) developed by Karr (1981). This method evaluates biological integrity by investigating biotic assemblages indicative to the environmental health or condition of a water resource (Karr 1981; Yoder and Rankin 1998; Danielson 2002). Biotic assemblages investigated by this method are selected for their ability to best represent the scope and distribution of wetland types in a given area, and have a response that is sensitive to a gradient of human caused perturbations (Karr 1981; Fore et al. 1996; Helgen 2002).

Generally, wetlands' disturbance levels are assessed by measuring attributes or characteristics attributed to the habitat or the surrounding watershed (Danielson 2002). Attributes measured include buffer size and quality (Lillie et al. 2002) or percentage of land use in the surrounding area. Some IBI methods have used other methods such as the Landscape Development Index (Brown and Vivas 2005; Mack 2007, 2009) or a rapid assessment method (Mack 2007, 2009) to determine a wetland's disturbance level.

A multimetric indices approach is used to illustrate how attributes and characteristics of a biotic community are affected by different degrees of human disturbances. Metrics derived from selected attributes of a biotic assemblage, help in predicting how different degrees of impairment affect an ecosystem's condition (Karr and Chu 1999; Helgen 2002; Mack 2007). Metric's scoring regimes are determined by their plotted relationship, may it be a linear, curvilinear, or threshold against a gradient of human disturbance (Karr 1981; Helgen 2002; Mack 2007). This standard procedure can then be applied towards similar sampled wetland types of unknown condition in order to reveal a wetland system's biological integrity (Weigel and Dimick 2011).

Implications amongst wetland assessment methods with this framework are restrictions to geographic scope and limits on evaluating a single class of wetland (Mack 2007). Expanding the scope of a bioassessment method to larger spatial scales, entertains the challenge and uncertainty with multimetric transferability beyond the boundaries in which they were developed (Stoddard et al. 2008). Not only is the inherent abiotic and biotic variance in wetlands a challenging obstacle for large-scale assessments, but, the diversity of landscapes and land use presents another challenge (Danielson 2002; Stoddard et al. 2008). The state of Ohio has been developing a comprehensive vegetation based IBI method with statewide application. These efforts developed an iterative classification scheme in order to guide the assessment of similar wetland classes towards specifically designed IBIs (i.e. Emergent, Shrub, Forest) (Mack 2007). Each IBI is designed to accommodate natural and anthropogenic variation for its defined class of wetland (Mack 2007). Continual tests and evaluations are still being done in order to investigate any need for modification or calibration of each IBI (Mack 2007, 2009).

In Wisconsin, depressional, palustrine, seasonal and semi-permanent wetlands of aquatic bed emergent and forested classes are assessed by an IBI using multiple biotic indicators (i.e. macroinvertebrates, plant communities, diatoms, zooplankton, amphibians, and small mammals) (Lillie et al 2002). In result, multiple biotic indicators allowed an increase in sensitivity to disturbances and variation amongst wetlands (Karr 1981; Lille et al. 2002).

The IBI method for North Dakota's seasonal depressional class wetlands in the PPR is the IPCI. This approach assesses a wetland's condition by vascular plant assemblages (DeKeyser et al. 2003). Hargiss et al. (2008) further expanded the IPCI method to assess temporary, seasonal, and semi-permanent depressional class wetlands in the Northern and Northwestern Glaciated Plains ecoregions of North Dakota, South Dakota, and Montana. Implications and challenges for the IPCI method are the dynamic spatial and temporal natural variations of depressional class wetlands of the PPR of North Dakota (Euliss and Mushet 2011).

Inherent natural variation in the PPR, such as inter and intra annual climates, is a challenge for selecting candidate biotic indicators for an IBI assessment method (Euliss and Mushet 2011). The dynamic variation in precipitation for the PPR has an effect on the distribution and area of "wet" or "dry" wetlands in the landscape (Niemuth et al. 2010). In effect there is considerable variation amongst wetlands' hydrology (i.e. groundwater inputs, amount of surface flow received, water deluged basins). Hydrological cycles between wet and dry conditions of wetlands have an impact on potential plant communities (Euliss et al. 2004). In terms of using vegetation as an indicator, as noted by van der Valk (1981), succession of vegetation in freshwater wetlands readily occurs in the stages of drought and flooding. Drought conditions, or drawdown, reveal a substrate most readily established by mudflat annuals (Stewart and Kantrud 1971; van der Valk 1981). IPCI metrics, which are associated with the richness of native perennial vegetation and average plant species C-Values (Coefficients of Conservation), can be confounded by this temporal and spatial natural variation (Euliss and Mushet 2011). Other natural variations within individual wetland basins in the PPR include: concentrations of salt, temporal shifts in biological communities, and variations amongst glacial soils.

Functional Capacity Assessments

Another approach to quantitatively assessing wetlands is a Hydrogeomorphic (HGM) approach, which emphasizes evaluating an ecosystem's ability to function rather than assessing condition. The HGM approach, as outlined by Smith et al. (1995), follows a different framework than wetland condition assessments: (1) the focus type of wetland is classified by a hydrogeomorphic classification; (2) functions are identified and calculated by wetland variables, which are defined by quantitative field measures; and (3) a suite of reference wetlands are used to calibrate, compare, and contrast the capacity for functions to perform (Stutheit et al. 2004; Wardrop et al. 2007).

HGM assessments evaluate the capacity or performance of associated biological, chemical, hydrologic, and physical functions for a specific classification of wetlands

(Brinson 1993; Smith et al. 1995). Wetlands are classified by Brinson's (1993) hydrogeomorphic classification. It emphasizes on aggregating similar wetland ecosystems by their abiotic (i.e. geographic, landscape, and hydrological dynamics) characteristics in order to increase the detection of variation amongst wetland functions (Brinson 1993; Gilbert et al. 2006, Hill et al. 2006) and reveal relationships amongst biotic and abiotic components of a wetland ecosystem (Brinson 1993; Smith et al. 1995). Regional HGM field guides use this classification scheme, and additionally add sub-region classes, in order to refine the scope of the assessment area (Smith et al.1995).

The HGM assessment defines a wetland function as, "a process necessary for the self maintenance of an ecosystem" (Brinson 1993). Examples of a function include but are not limited to: nitrogen cycling, nutrient cycling, biogeochemical cycling, and ecosystem integrity (Smith et al. 1995). Functions are assessed by model variables, otherwise known as characteristics or attributes of a wetland that have an influence on a wetland's ability to perform the function. Determined by field measurements and remote sensing tools, each model variable is assigned a subindex score that ranges from 0.0, characterizing poor functional capacity, to 1.0 or reference functional capacity. Model variables are then organized into an equation to mathematically predict how their associations reflect the capacity for a function to operate (Hill et al. 2006; Wardrop et al. 2007). The output of the equation is a Functional Capacity Index (FCI) number ranging from 0.0 to 1.0. The number represents the ability of a function to operate (0.0 =

non-functioning, 1.0 = fully functioning). This scoring scale is determined by comparing a function's performance to reference standards (Smith et al. 1995).

The HGM assessment assumes that the least impaired wetlands perform functions to optimal capacity. By selecting a reference domain of wetlands that best demonstrate possible fluctuation in function for a specific sub class, unimpaired wetlands can be identified and selected in order to develop a standard baseline for optimal functional capacity.

The HGM assessment is, for the most part, developed for regional application towards specific wetlands of similar HGM class. The purpose for specificity is to reduce variance and increase resolution in detecting the performance of wetland functions (Smith et al. 1995). However, the transferability of its robust regional classification scheme (Brinson 1993) and associated assessment model, have been tested for broad scale application to wetlands of similar contiguous geographic contexts (Cole et al. 2008) and towards evaluating wetlands at the watershed scale (Lee et al. 2003; Whigham et al. 2007).

The argument for testing the transferability of a regional and wetland specific HGM assessment method is to indentify contingencies and similarities amongst similar class wetlands. Comparing the assessment results, FCI scores, and model variable index scores can bridge similarities and identify the applicability of an HGM assessment for other wetlands of similar class and contiguous geographic contexts (Cole et al. 2008). Cole et al. (2008) tested the transferability of a HGM assessment to similar contiguous regions and identified some parallels in hydrologic functional performance; however, the transferability to other regions was limited by dynamic perturbations such as climatic factors, amount precipitation, and the influence of beaver activities. Moreover, by testing the transferability of a HGM assessment amongst similar contiguous regions, similarities can be identified and pre-development steps can be made in developing separate HGM assessment models.

Evaluating the performance of a watershed by integrating individual wetland's HGM assessment data has its implications (Whigham et al. 2007). Observing HGM assessment results for each wetland in the watershed provides a monitoring and management tool for identifying impaired or marginal wetlands that need further attention. However, aggregating HGM results from all wetlands within a watershed doesn't provide a valid overall watershed condition. Concluding that a watershed's condition reflects the overall condition of wetlands found with in it, is inaccurate since individual wetland's HGM scores may vary within a watershed from reference (1.0) to impaired (0.0).

Comparison of FCI scores amongst different subregional class wetlands is possible. However, because each subregion has its FCI's calibrated to a different reference set, direct correlation amongst index scores is inhibited (Smith et al. 1995). Instead comparison has to be carried out by using gathered quantitative information and subjective BPJ.

Alternatively, the HGM assessment can be integrated into other assessments or monitoring protocols. Data collected for certain FCI variables may highlight how a wetland function correlates with other measures such as soil composition and nitrogen processing (Jordan et al. 2007). The HGM classification system may be utilized in determining the scope of a study area for investigating associations amongst plant community assemblages, or the influence of disturbances on environmental or hydrogeomorphic model variables (Peterson-Smith et al. 2009).

Rapid Assessment Method

Many state water quality programs in the United States have implemented Rapid Assessment Methods (RAMs) to monitor and assess water resources such as streams, rivers, and wetlands (Resh 1995; Fennessy et al. 2004). Compared to IBI and HGM assessments, that have a restricted range of application and require more investment in time and resources, RAMs determine the condition of multiple types of wetlands in a relatively inexpensive and non-intensive assessment method that is not limited in scope (Fennessy et al. 2004; Collins et al. 2008; Sifneos et al. 2010). The method's framework uses semi-quantitative measures and BPJ to assign a numerical score representing the magnitude and influence anthropogenic activities have on key ecological attributes of wetland systems (Fennessy et al. 2004; Sifneos et al. 2010). Higher scores are awarded to wetlands that represent reference standards or native attributes. Lower scores reflect a wetland that is impaired or affected by anthropogenic activities or other stressors (Fennessy et al. 2004; Wardrop et al. 2007; Collins et al. 2008).

Another aspect of RAMs is to establish a reference set of wetlands in order to gauge the effects of anthropogenic activities on wetland system's integrity (Stoddard et al. 2006). The term reference wetland has been arbitrarily used to describe habitats in the absence of anthropogenic stressors (Stoddard et al. 2006). However, in some spatial aspects there may not be wetland systems characteristic of being undisturbed by historical or current anthropogenic activities (Omnerick 1995). Therefore, should choosing reference wetlands be curtailed towards selecting wetlands that are least disturbed by anthropogenic stressors or wetlands that are the best attainable condition for a given region? Stoddard et al. (2006) proposes a nomenclature that mediates this predicament and depicts reference conditions based on historical or spatial contexts. Reference wetlands can be chosen to depict: historical condition, least disturbed condition, minimally disturbed condition, or best attainable condition. When choosing the proper nomenclature for reference condition, the spatial context and objectives of the assessment design should be considered. In view of the spatial scope of a RAM, reference sets are selected to represent the physical characteristics of specific geographic regions (Yoder and Rankin 1995). The use of ecoregions to spatially delineate the scope of a reference set has been valuable in the assessment of streams in the states of Arkansas, Nebraska, Ohio, Oregon, Washington, and Wisconsin (Hughes 1995). Ecoregions delineate geographic regions by ecological contexts (i.e. vegetation, soils, geology), climatic patterns, and the extent, range, and influence of human perturbations (Omnerick 1995).

RAMs evaluating condition have a reference set of wetlands that are of similar classification, abiotic and biotic characteristics, and portray minimum anthropogenic influences (Hughes 1995; Resh 1995). Dependent on the spatial context of the assessment, some region's highest quality wetlands may have been altered or impacted to some degree by anthropogenic perturbations in the past (Omnerick 1995). Nearly native or untouched reference wetlands may be rarely occurring benchmarks for some regions (Yoder and Rankin 1995). The alternative in this situation is to set best attainable benchmarks in order to define acceptable conditions and prevent further deterioration of the resource (Hughes 1995; Omnerick 1995; Yoder and Rankin 1995). In general, reference sites should illustrate a region's best attainable and least impacted habitat conditions, however, if a region is extensively disturbed a reference site may have no purpose (Hughes 1995).

RAMs that assess a range of wetland classes over a large scope are more robust and may include a survey design that is consistent and similar across different wetland classes (Collins et al. 2008), or have a scoring regime specifically adjusted for each wetland class (Fennessy et al. 2004). RAMs are a precision-based tool, calibration and adjustments against intensive quantitative datasets increases a RAM's resolution. Calibration increases the detection of stressors and reveals patterns of their occurrence for a specific wetland class (Wardrop et al. 2007). The California Rapid Assessment Method (CRAM), a statewide wetland assessment method, evaluates all wetland classes by four standardized attributes; (i.e. landscape context and buffer, hydrology, physical structure, and biotic structure) which, in turn, are assessed by a consistent set of field metrics (Collins et al. 2008). The goal of the CRAM is to assess wetland condition separate from stress; therefore, each field metric has a selection of narrative descriptions that portray a range of wetland form and structure. Stressors are also noted on a separate checklist in order to correlate and identify the influence of certain perturbations to CRAM scores.

An alternative approach to RAMs is the biodiversity scorecard developed by the Colorado Natural Heritage Program (CNHP). This approach evaluates plants, animals, and ecological systems by indentifying and ranking multiple “elements of biodiversity” by their size, condition, and landscape context (CNHP and The Nature Conservancy 2008). The threat status, biodiversity status, and resilience to remain extant are some ranks awarded to reflect the overall status of an ecological, plant, or animal system. As an end result, each scorecard provides insight for management and monitoring programs by highlighting ecological, plant, and animal systems by their condition, probability of impairment, and protection or conservation status. The scorecard approach can be applied to large scope assessments and even small, localized areas.

An issue with the RAM’s collection of data is the use of BPJ (characterized by the use of general field notes, photos of the area, prior field visits, and general knowledge) to score and report on a metric’s condition. The results or output produced from BPJ techniques are generally subjective without any quantitative substance (Sifneos et al. 2010). To correct for subjective BPJ data, RAM scores and results for a set of wetlands can be calibrated to results from intensive quantitative assessment data for the same sampled wetlands (Fennessy et al. 2004; Sutula et al. 2006; Stein et al. 2009). Sifneos et al. (2010) found that when RAM condition scores for a set of wetlands was compared to their condition results from an intensive HGM derived wetland condition assessment, there was a strong relationship between both assessments results. This process of calibration, via independent quantitative data, has been utilized to correct or validate confidence in RAMs (Fennessy et al. 2004; Wardrop et al. 2007; Stein et al. 2009; Sifneos et al. 2010).

The NDRAM, created by Hargiss (2009) was developed for the PPR of North Dakota in assessing temporary, seasonal, and semi-permanent depressional type wetlands. The protocol uses BPJ to score 3 metrics. For each metric is a list of sub-metrics that are scored by selecting a narrative description that best describes the wetland's condition. Narrative descriptions for each sub-metric are based on the degree of stressors and anthropogenic activities impacting the wetland. An overall condition score is produced by adding up all the sub-metric scores. This overall score ranges from a possible 0 to 100 points.

Hargiss (2009) found that the NDRAM final condition score has an 87% concordance with the IPCI intensive assessment final condition score for depressional wetlands found in the PPR of South Dakota, North Dakota, and Montana. However, the NDRAM has not been used on other wetland classes found in the state of North Dakota. Hargiss (2009) also mentions that there is an unequal distribution of overall wetland condition scores amongst temporary and semi-permanent depressional wetlands. Temporary wetlands assessed by Hargiss (2009) had low overall condition scores (0-26 points); on the other hand, semi-permanent wetlands had overall condition scores that trended to be characteristic of the middle range (score ~ 50 points).

Three-Tiered Approach

An effective way at optimizing condition, functional capacity, and rapid assessments is to integrate the three methods into a comprehensive assessment that provides multiple lines of evidence (Solek et al. 2011). The three-tiered approach, introduced in the USEPA's (2006) report, "Elements of a State Water Monitoring and Assessment Program for Wetlands," places wetland assessments into a hierarchy of levels or tiers based on their intensity and scale (Table 1) (Reiss and Brown 2007; Solek et al. 2011).

Table 1. Levels for the three tiered system modified from USEPA 2006.

Assessment Level	**Assessment Utilization**
Level 1 - Landscape Assessment: Use of GIS and remote sensing to gain a landscape view of watershed and wetland condition. Typical assessment indicators include wetland coverage (NWI), land-use and land cover	•Targeting restoration and monitoring •Landscape condition assessment •Status and trends •Integrated reporting CWA 305(b)/303(d)
Level 2 – Rapid Wetland Assessment: Evaluate the general condition of individual wetlands using relatively simple field indicators. Assessment is often based on the characterization of stressors know to limit wetland functions e.g., road crossings, tile drainage, ditching.	•401/404 permit decisions •Integrated reporting •Watershed planning •Implementation monitoring of restoration projects, including nonpoint source BMPs, and Farm Bill programs
Level 3 – Intensive Site Assessment: Produce quantitative data with known certainty of wetland condition within an assessment area, refines rapid wetland assessment methods and diagnoses causes for wetland degradation. Assessment is accomplished using indices of biological integrity or hydrogeomorphic function.	•WQS development, including use designation • Integrated reporting •Compensatory mitigation performance standards •Verify levels 1 and 2 methods

Level one methods are focused on landscape-scale assessment of targeted wetlands. Data is collected by using remote sensing data and Geographic Information

Systems (GIS) software to assess landscape land-use (Wardrop et al. 2007), buffer size and quality (Houlahan and Findlay 2004), or immediate stressors (Brown and Vivas 2005; Wardrop et al. 2007). Level one methods are usually conducted in an office without the need for a site visit (Wardrop et al. 2007). Landscape-scale assessments may be used as indices for characterizing a gradient of disturbance surrounding a targeted wetland (Brown and Vivas 2005, USEPA 2006; Mita et al. 2007).

Level two methods are rapid assessment protocols requiring an on-site evaluation of a wetland's biological and physical characteristics (Stein et al. 2009). Criteria being evaluated are scored using BPJ in order to evaluate the condition of a wetland and identify the presence and magnitude of stressors acting on a wetland. RAMs are further developed, adjusted, and defended by validating results to datasets from intensive methods (level three) (Fennessy et al. 2004; Stein et al. 2009).

Level three methods include intensive assessment methods (i.e. IBI, FQI, HGM), which are time intensive, rigorous, and attributed to their detailed quantitative on-site data collection. This type of method may require a professional background or taxonomic expertise and training. Data collected from level 3 methods can be used to cross validate level 1 and 2 methods (Fennessy et al. 2004; USEPA 2006; Collins et al. 2008; Stein et al. 2009).

Calibration

Wetland monitoring and assessment methods can be tested for confidence limits and scientific defensibility through the process of calibration (Fennessy et al. 2004; Collins et al. 2008; Stein et al. 2009). The process of calibration entails detecting associations between the results of an independent intensive assessment method and the assessment method in question across a gradient of disturbances in a known set of wetlands (Brinson and Rheinhardt 1996; Wardrop et al. 2007; Collins et al. 2008). This process allows for the enhancement and modification of assessment methods, in order to increase the reliability and validity (Fennessy et al. 2004; Stein et al. 2009). Results from calibration can provide information to improve performance of large-scale RAMs or other assessment methods (Collins et al. 2009).

The process of calibration plays a pivotal role in the development of California's CRAM (Sutula et al. 2006; Collins et al. 2008). The CRAM is an assessment tool that evaluates the condition or state of different types of wetlands, intra and inter regionally, throughout the state of California (Collins et al. 2008). In developing and drafting the CRAM, conceptual metrics, attributes, and formulae responsible for calculating an index of condition were calibrated by historical intensive assessment data (Sutula et al. 2006; Stein et al. 2009). Each of these criteria can be either calibrated independently or in aggregate to modify tested variables, scoring configuration, or instructions (Collins et al. 2008; Stein et al. 2009).

Another example of using the calibration technique is Sifneos et al.'s (2010) calibration of Delaware's Rapid Assessment Protocol (DERAP). Developed to assess three HGM wetland types – flat, riverine, and riparian wetlands – the DERAP scores wetlands by a stressor checklist derived from qualitative BPJ. Sifneos et al. (2010) used and intensive assessment – Index of Wetland Condition (IWC), a product from HGM variables' scores – to calibrate the DERAP score and condition rankings. Results from calibrating the DERAP scores to the IWC showed strong relations, however the presence of some outliers indicated that the DERAP may need some adjustments in order to resolve certain conflicts.

The calibration process has also been utilized to verify the use of a RAM in Pennsylvania's Upper Juanita watershed. Wardrop et al. (2007) used a quantitative measure from an intensive assessment method, the Floristic Quality Assessment Index (FQAI), in order to evaluate the efficacy of the RAM's evaluation on multiple wetland classes found in the watershed. The FQAI assigns present plant species a score based on the species tolerance and frequency of abundance across differing degrees of disturbance. Calibration of the RAM was guided by using classification and regression tree analysis (CART) to evaluate the correlation of the two assessments' condition rankings for similar sampled wetland sites. Results detected the RAM's ability to identify high and low condition wetland sites; however, compared to the FQAI, the RAM needs to adjust its condition ranking system.

Validation

The process of validation is a long-term evaluation on the efficacy of an assessment method in order to predict the condition of a set of randomly selected wetlands outside of the assessments reference network (Sutula et al. 2006; Wigand et al. 2011). Assessment methods are continually validated in order to optimize a method's efficacy and produce an overall robust method (Sutula et al. 2006). The procedure is most commonly used to validate RAM's metric, attribute, and scoring regimes (USEPA 2002;

Sutula et al. 2006; Collins et al. 2008; Stein et al. 2009; Wigand et al. 2011) and provide insight on their performance (Stein et al. 2009).

Validation conducted by Stein et al. (2009) evaluated CRAM results to other independent assessments' (i.e. HGM, riparian bird diversity, FQAI, index of biotic integrity) datasets. Through this procedure, relationships amongst datasets can iterate the ability of an assessment method to reflect a wetland's overall condition, detect and represent a range of disturbances, and reproduce consistent results (Sutula et al. 2006; Stein et al. 2009).

In order to optimize and interpret the performance of the CRAM, Stein et al. (2009) conducted validation by comparing multiple measures of an assessment method, such as overall condition scores, attribute, and metric results, to independent intensive assessments' results. Attributes (i.e. buffer and landscape context, hydrology, physical structure, and biotic structure) that are assessed by the CRAM were compared to similar attribute and metric measurements from other independent assessments in a weight-of-evidence approach (Burton et al. 2002). The approach is defined as using multiple lines of evidence in order to reach a conclusion on the condition of an ecological system (Stein et al. 2009). For example, the CRAM's biotic structure attribute and its metrics were validated against data from a Floristic Quality Index. This procedure can reveal the ability of an assessment to evaluate wetlands outside of the assessment's jurisdiction. Validation also evaluates the assessment's ability to detect and represent a range of attribute conditions, and reproduce consistent results.

Validating the expansion of a specific scoped method to a larger and diverse area, should provide results that either show a liner, curvilinear, or threshold relationship amongst specific attributes (Mack 2007). Validation allows for refinement or re-creation of metrics to better depict the disturbance level of a certain wetland's variable (i.e. hydrology, plant community, habitat).

The validation procedure has been done on the IPCI, NDRAM, and HGM methods developed for assessing North Dakota's depressional wetlands in the PPR (Hargiss 2009). Validation was conducted in order to evaluate each assessment's ability to predict the wetland condition of temporary, seasonal, and semi-permanent wetlands in the PPR of South Dakota, North Dakota, and Montana. Kendall's test of concordance (Legendre 2004) was used in order to discover the percentage of similarity or dissimilarity between wetland assessment methods, and provide insight as to whether assessment methods were concordant or not. Hargiss (2009) found that the IPCI and NDRAM overall condition scores ranked 87% similar and were concordant with each other. The IPCI final condition scores and HGM Non-metric Multidimensional Scaling (NMS) ordination axis were found to have 92% similarity and had concordance with each other.

Focus Wetlands

The natural variation and affinity of anthropogenic disturbances found across wetland types is a critical issue when assessing wetlands at large spatial scales. Classification schemes are used to alleviate the complications of variation by creating classes for similar biological, structural, or functional wetland types. The Cowardin et al. (1979) classification for "wetlands and deepwater habitats across the United States," is a hierarchal classification used by many wetland assessment methods (Lillie et al. 2002; Mack 2007, 2009; Collins et al. 2008; Genet and Olson 2008; Stein et al. 2009). It classifies wetlands based on a wetland's local plants (hydrophytes), soils (hydric soils), and hydrology (frequency of flooding) (Cowardin et al. 1979). Classification schemes are designed to organize similar structured and functioning wetlands in order to reduce natural variation and provide a template for intra-class comparison (Danielson 2002; Fennessy 2004). For the state of North Dakota, wetland classification has been developed for depressional class wetlands of the PPR (Stewart and Kantrud 1971, 1972).

PPR Depressional Wetlands

A majority of North Dakota's wetlands are hydrogeomorphic (HGM) (Brinson 1993) depressional type PPR wetlands. Depressional wetlands act as reservoirs for water due to underlying soil features. Soils are deep and poorly drained with coarse to fine texture (USDA-NRCS-ND, SD 2006a). Further classification divides depressional wetlands into closed and open depressions (USDA-NRCS-ND, SD 2006a,b). Closed depressional wetlands are characteristic of having clay textured sub-surface soil layers that inhibit water movement (USDA-NRCS-ND, SD 2006b). Parent material is typically alluvium. On the other hand, open depressional wetlands are moderately permeable with loamy textured sub-surface soil layers allowing water movement (USDA-NRCS-ND, SD 2006a). These depressional wetlands also have a parent material associated with lacustrine deposits, alluvium, and till.

Plant communities in depressional type wetlands of the PPR in North Dakota is highly dependent on the permanence of surface water and closely correlated with the water's salinity levels (Stewart and Kantrud 1972). Land-use also plays a role in plant communities' composition, especially in drawdown or bare ground phases in drought-like conditions (Stewart and Kantrud 1971, 1972).

Under Stewart and Kantrud's (1971) classification, depressional wetlands are classified as either temporary, seasonal, semi-permanent, and permanent. These wetland classes are assigned to prairie wetlands based off of the presence of vegetation zones and periods of inundation.

Temporary wetlands are characterized by Stewart and Kantrud (1971) to have a low prairie vegetation zone peripheral to a central wet meadow zone, with fresh to slightly brackish surface waters (<40 – 2,200 µMhos/cm^3) (Figure 1). The low prairie zone consists mostly of upland vegetation and is inundated with water during periods of high water abundance. The edge of the wetland habitat can be delineated between the low prairie zone and the wet meadow zone. The wet meadow zone is characterized by fine-textured grasses, rushes, and sedges of relatively short height, as well as various forbs (e.g. *Hordeum jubatum, Distichlis stricta, Poa palustris, Spartina pectinata, Calamagrostis canadensis, Hierochloe odorata, Carex praegracilis, Carex laeviconica, Aster simplex, Mentha arvensis, Cirsium arvensis, Potentilla norvegica*) (Stewart and Kantrud 1971, 1972). Also, the wet meadow zone is usually inundated for a relatively short period (in the beginning of the growing season or a few weeks after snow melt) due to rapid rates of seepage and porous soils (Stewart and Kantrud 1972).

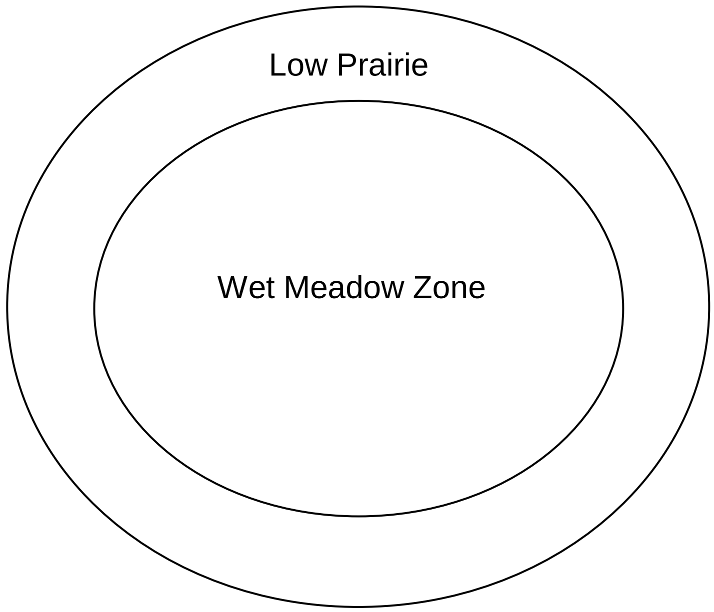

Figure 1**.** Zones of a PPR temporary depressional wetland modified from Stewart and Kantrud 1971.

Seasonal wetlands include the vegetation zones of the temporary class, however, the wet meadow zone is peripheral to an interior shallow marsh zone (Figure 2). The shallow marsh zone is described by Stewart and Kantrud (1971) to normally hold water for extended periods during the spring and early summer months and have a water salinity ranging from fresh to subsaline (<40 – 45,000 µMhos/cm^3). Vegetation composition gradually changes in dominance or abundance due to the degrees of salinity in the shallow marsh zone (Stewart and Kantrud 1972). Primary species may include: *Sparganium eurycarpum, Alisma graminuem, Carex atheroides, Scolochloa festucacea, Polygonum coccineum* (Stewart and Kantrud 1972).

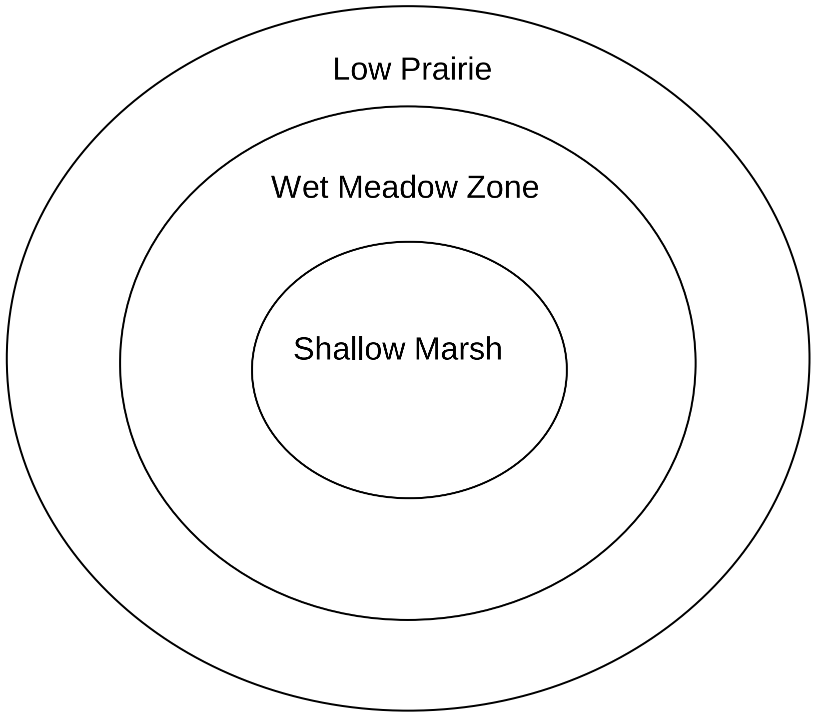

Figure 2**.** Zones of a PPR seasonal depressional wetland modified from Stewart and Kantrud 1971.

Semi-permanent wetlands are defined as having a central deep-marsh zone with concentric peripheral bands of a shallow marsh, wet meadow zone, and low prairie zone (Figure 3). The deep-marsh zone is normally maintains water throughout the spring and summer, however water may be present throughout the fall and winter. Also, salinity levels are negatively correlated with water permanence (Stewart and Kantrud 1972). During drought like conditions heavy grazing in this zone may consequence in pure stands of *Scirpus acutus*. Primary species in the emergent phase of the deep marsh are characteristic of: *Scirpus fluviatalis, Typha glauca X, Scirpus acutus, Scirpus heterochaetus, and Scirpus paludosus* (Stewart and Kantrud 1972).

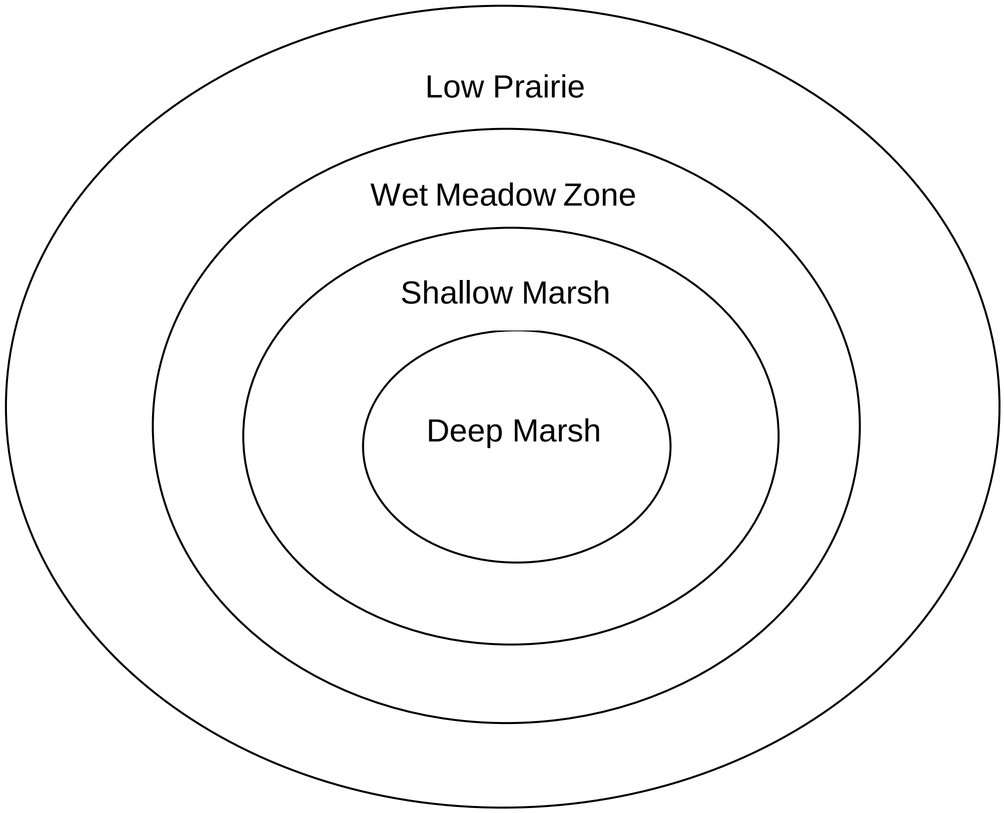

Figure 3**.** Zones of a PPR semi-permanent depressional wetland modified from Stewart and Kantrud 1971.

Permanent wetlands are characteristic of maintaining relatively stable water levels and may be otherwise considered small ponds/lakes or lacustrine system wetlands (Cowardin et al. 1979). The interior zone of a permanent wetland is usually devoid of emergent plants due to deepwater depths (Stewart and Kantrud 1971). The peripheral bands of deep marsh, shallow marsh, wet meadow zones have been considered to be classified as a lacustrine fringe wetland (Richardson and Vepraskas 2001). This classification is based on the effects that wave action has on the development of soils in these vegetation zones.

Fens

Prairie fens have been described for the PPR (Stewart and Kantrud 1971, 1972); however, there is little information on forest types in eastern North Dakota (Amon et al. 2002). Fens are an important and unique type of wetland that harbors a number of uncommon, rare, threatened, and endangered biotic species (e.g. Bog turtle, Eastern massasauga) (Bedford and Godwin 2003). Fen systems have been identified in 38 states; most fens are small in area with a few exceptions (e.g. Pine Butte Fen, MT ~ 450 ha). The most distinguishing characteristic of fen systems is the presence and influence of groundwater (Amon et al. 2002; Bedford and Godwin 2003). In addition, fens are present in humid regions and distinguished by the accumulation of organic matter, hummocks, and bottom soils consisting of muck or ooze consistency (Stewart and Kantrud 1972; Stein et al. 2004). Other attributes that further define fen ecosystems include: relationships within hydrogeologic settings and topographic landscapes, chemistry of water and soil substrates, and biotic communities (Amon et al. 2002; Bedford and Godwin 2003).

As mentioned earlier, the hydrology of fen ecosystems are dependent on the discharge of groundwater (Amon et al. 2002; Bedford and Godwin 2003). Water is not predominantly supplied to fens by precipitation or surface water sources, but rather by groundwater inputs (Figure 4) (Bedford and Godwin 2003). The continual supply of groundwater to the ecosystem maintains saturation in the soil's plant root zone (Amon et al. 2002; Bedford and Godwin 2003). In addition, water tables range from 0 – 75 cm below the soil surface (Amon et al. 2002). Waters in fen systems may have pH greater than 5 depending on the soils substrate and geologic materials present (Siegel 1983; Bedford and Godwin 2003).

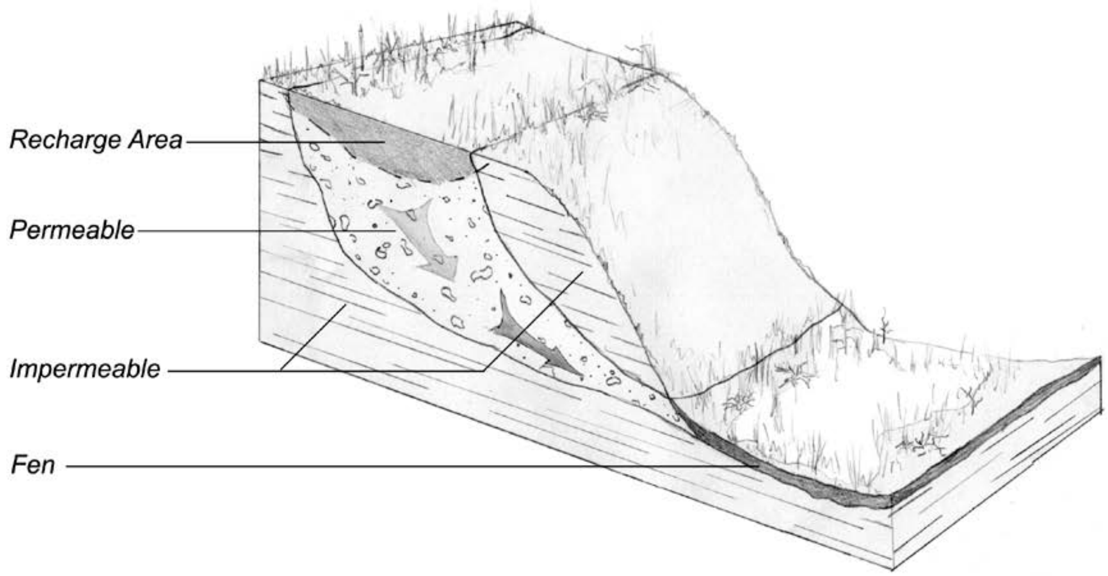

Figure 4**.** Illustration depicting fen systems hydrology modified from Amon et al. 2002 pg. 304.

Moreover, geologic processes and formations influence the flow and supply of ground water, and occurrence of fen habitats in the landscape (Amon et al. 2002; Bedford and Godwin 2003). The supply of groundwater can be attributed to breaks in the topography or stratigraphic zones. Upward flowing groundwater may source from breaches in lacustrine formed clay layers, in which confined aquifers are exposed (Amon et al. 2002). Alternatively, groundwater may flow on a horizontal path due to the presence of low permeability substrates (i.e. shale) or bedrock layers. Fens may occur in depressions and have upward flowing groundwater sources; or appear on slopes where the lateral movement of groundwater seeps out to exposed or eroded slopes; or fens may be located on the edge of lakes (Figure 5).

Unique characteristics that fens possess are limited low-concentrations of nitrogen and phosphorus (Bedford and Godwin 2003). An important component of fens, which facilitates these low concentrations, is the presence and influential effects of groundwater. Minerals found in groundwater (e.g. calcium bicarbonate [lime], calcium sulfate [gypsum], and iron) adsorb or precipitate phosphorus into unavailable forms (Stevenson 1986; Bedford and Godwin 2003). High levels of nitrogen and/or phosphorus in fen ecosystems indicate some kind of influence from external sources, may it be atmospheric deposition or anthropogenic activities (Bedford and Godwin 2003).

Assemblages of vascular flora have been researched and documented for many fen types (Stewart and Kantrud 1971, 1972; Stuckey and Denny 1981; Zimmerman 1983; Eggers and Reed 1977; Pearson and Leoschke 1992; Minnesota Department of Natural Resources 1995; Vitt and Chee 1990; Slack 1994; Anderson et al. 1995; Amon et al. 2002). Prairie Pothole fens have emergent vegetation mats forming on raised mounds of wet organic material (Stewart and Kantrud 1972). Species include: *Glyceria striata, Scirpus validus, Carex aquatilis, Salix interior, Salix candida, Cicuta maculata, Aster junciformis, Deschampsia caespitosa, Parnassia palustris, Muhlenbergia glomerata, Eriophorum angustifolium, Carex rostrata, Gentiana procera, Lobelia kalmii* (Stewart and Kantrud 1972). There is little information on vascular flora assemblages for eastern North Dakota wooded fens.

Classification schemes defining types of fen wetlands have been developed; however, there is not a definitive approach for classifying different types of fen wetlands. A report done on fen wetlands in the temperate zone of the United States (includes the states of Illinois, Wisconsin, Minnesota, and Eastern North Dakota) provides a foundation for classifying fen type wetlands (Amon et al. 2002).

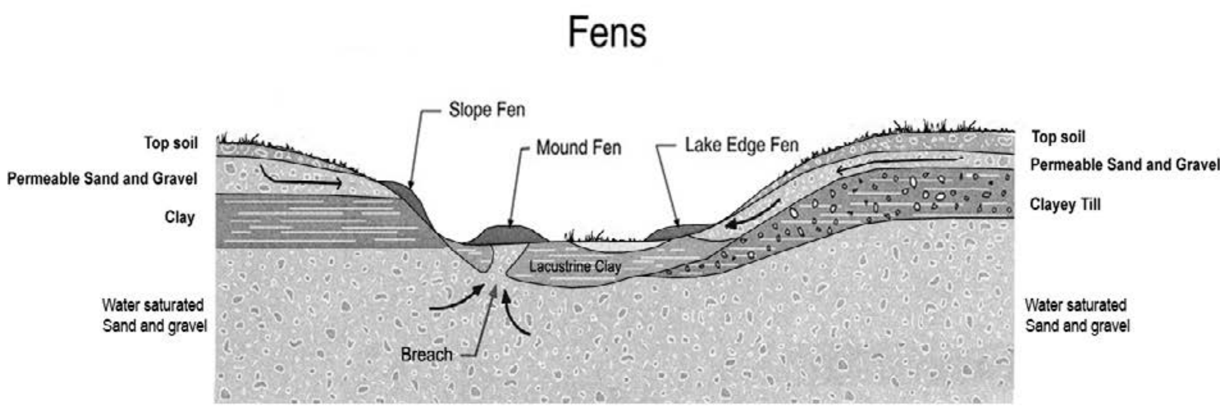

Figure 5. Illustration of underlying geology and hydrology for types of fens modified from Amon et al. 2004 pg. 305.

The Slope Fen is typically found on steep or gentle slopes in the landscape, or on hillsides, where less permeable soil or formations force groundwater to move latterly (Figure 5) (Amon et al. 2002). Slope Fens are typically found on the base of moraines, edges of sand and gravel outwash plains or terraces, and in areas of limestone bedrock or areas associated with sandstone or permeable deposits over a less permeable (i.e. shale) formations .

Discharge Mound Fens are described as wetlands with groundwater sourcing from a central discharge point(s) (Figure 5) (Amon et al. 2002). These types of wetlands may form over aquifer windows, or breeches in less permeable substrates that expose a confined aquifer. An example is a breach in lacustrine clay deposits overlain by sand and gravel deposits.

The last type of fen wetland depicted in Amon et al. (2002) study of fens in the temperate zone of the United States is Lake Edge Fens. These wetlands are characterized as having upward hydrologic gradients at the edges of lakes (Figure 5). Deposits of peat into the associated lake may create floating mats in the water body.

Another fen classification scheme developed by Bedford and Godwin (2003), classified fen types as: Poor Fens, Rich Fens, Calcareous Fens, or Extreme Rich/Marl Fens. Poor Fens receive water not only from ground water, but also from other sources. However, the groundwater that the fen does receive is poorly mineralized and buffered. This is due to the presence of low buffering soil materials such as sand or quartz. Poor fens occur atop of non-calcareous bedrock (i.e. sandstone, basalt, quartzite, granite). In addition, the attributes associated with poor fen's groundwater results in a slightly acidic pH. Plants associated with this type of fen are closely resembled to the plant associations with bogs (i.e. sphagnum mosses, Ericaceous shrubs).

Rich Fens have a larger and deeper recharge area for groundwater, which supplies a stable and consistent water level and keeps the plant rooting zone of the soil saturated (Bedford and Godwin 2003). Groundwater supplied to the rich fen is affluent in calcium and gypsum minerals, resulting in moderately alkaline pH levels. In the state of New York, rich fens occur atop of bedrock composed of limestone, dolostone, marble, or calcareous surficial deposits of glacially derived materials. Plant assemblages that indicate a rich fen include a dominate community of sedges, brown mosses of the Amblestegiaceae genus of Bryophytes, and Dicotyledonous herbaceous vegetation.

Calcareous Fens are described as having groundwater rich in calcium (Bedford and Godwin 2003). Groundwater inputs are more influential to the water budget than sources from precipitation or surface water. This type of fen supports unique calicole or calcifuge plant species. In the state of Wisconsin, calcareous fens occur in positions of the landscape with bedrock of limestone, dolomite, or sandstone containing dolomite and limestone. Extreme Rich/Marl Fens are distinguished from rich fen types by having strongly alkaline groundwater, in which carbonates precipitate to the surface. This reaction yields high concentrations of calcium and magnesium carbonate.

Other classification regimes that denote fen type wetlands provide limited descriptions to elucidate differences in fen wetland types. The hydrogeomorphic classification system (Brinson 1993) places fen wetlands into a Groundwater-Slope wetland class. Further, sub-classification splits the class into ombrotrophic peat bogs and fens/seeps. The CRAM classifies fen wetlands under a slope wetland class and further splits into two sub-classes (spring or seep and wet meadow) (Collins et al. 2008). The Ohio Rapid Assessment Method (ORAM) includes an extensive list of attributes associated with the fen wetland class; however, fen types are not denoted (Mack 2001). In the PPR of North Dakota, Stewart and Kantrud (1971, 1972) classified depressional type fens.

Slope Wetlands

Characteristics of slope wetlands are similar to fen wetlands, in result, some classification regimes have classified both of these wetlands under a similar class

(Brinson 1993; Collins et al. 2008). The California Rapid Assessment Method (CRAM) defines slope class wetlands characteristic of having groundwater as its primary source and occurring on a slope or base of a slope (Collins et al. 2008). Both fen wetlands and slope wetlands are associated within the CRAM's slope class.

Slope wetlands are attributed to having groundwater as its major source of water. Groundwater is supplied to slope wetlands by breaks, breaches, or stratigraphic changes in the underlying substrate or bedrock formations; therefore allowing groundwater to discharge to the land surface (Brinson et al. 1995; Stein et al. 2004). A constant seep of groundwater keeps the soil saturated in wetlands for prolonged periods in the growing season (Stein et al. 2004). The rate of groundwater flow is dependent on the length between recharge areas and discharge locations. Influential factors in groundwater delivery include the subsurface geology (i.e. non porous bedrock formations), soil features (i.e. eroded, alluvial, and colloidal soils), topography (degree of slope and relief) and land use.

The underlying geology is closely tied with hydrological attributes of slope wetlands. Stein et al. (2004) studied the relation of geologic formations within multiple slope wetlands located in California's semi-arid climates. They found that hydrologic and biogeochemical functions are dependent on a wetlands underlying geology. In result, the study produced a geologic subclass for classifying slope wetlands. Subclasses were defined by several attributes: retention of water, discharge of water, and retention or release of compounds such as organic matter, total nitrogen, phosphorous, and cation concentrations.

Plant communities associated with slope wetlands, studied by Stein et al. (2004), were observed to be Palustrine emergent communities attributed to alkali meadows or freshwater seeps (i.e. obligate alkali species, facultative alkali species). They found that topography, slope or relief, soil composition, or inflow and outflow structures did not affect the plant communities. Plant communities of slope wetlands in the Missouri Plateau sub-ecoregion of North Dakota have been described in ecological site descriptions as having species such as: *Spartina gracilis, S. pectinata, Puccinellia nuttalliana, and Pascopyron smitthii* (USDA-NRCS-ND,SD,MT 2003).

Forested Wetlands

In the state of North Dakota, forest type land cover makes up 4.4 percent (792,400 hectares or 1,958,000 acres) of the states total land area (Oduour and Kotchman 2007). The Turtle Mountains sub-ecoregion, located in north-central North Dakota, is a rich forested area (106,000 hectares or 262,000 acres), which supports a deciduous forest cover including *Quercus macrocarpa*, *Populus spp.*, *Fraxinus pennsylvanica, Betula papyrifera, Acer negundo, Amelanchier alnifolia, Symphoricarpos spp* (Kotchman 2010). The Turtle Mountains 240 meter (800 feet) elevation change from the surrounding northern black prairie sub-ecoregion, provides a greater annual rainfall aiding the forest type land cover. Another sub-ecoregion known for its forested landscape is the Pembina Gorge area (68,000 hectares or 168,000 acres). In this region, woodland communities are commonly made up of *Quercus macrocarpa*, *Populus tremuloides*, *Fraxinus pennsylvanica*, *Populus deltoides*, and *Ulmus americana*. Glacial activities that formed these areas have left behind certain topography and soils comprised of glacial till allowing for the occurrence of depressional-forested wetlands. This type of wetland is located in a topographic depression with a main water source from precipitation, and less from overland flow and groundwater (Brooks 2004).

Depressional forest wetland systems have been compared to the depressional PPR wetlands (Brooks and Hayashi 2002; Brooks 2004, 2005) because of similarities amongst wetland morphology, hydroperiods, and topographic location in depressions. Brooks (2009) classified depressional forested wetlands by a classification system (Stewart and Kantrud 1971) which separates depressional prairie wetlands into classes based on their hydroperiod and number of vegetation zones. This classification keyed out three classes of wetlands: 1) temporary – depressions holding water for short periods of time, 2) seasonal - holds water in a seasonal timeframe, 3) semipermanent – holds water over the duration of seasons (Brooks 2009).

However, depressional forested wetlands are unique, due to the influence that trees have on wetland attributes and characteristics (Williams 2005). The tree's leafs are an allochthonous source for depressional forest wetlands that stimulate microbial and micro-organism reactions in wetland's hydric soils. The decomposition of leaf detritus is done by associated fungi, bacteria, and detritivorous insects.

On the other hand, the occurrence of tree species in this habitat is dependent on the hydrological characteristics of the wetland (Williams 2005). Some tree species are more tolerant to flooding frequencies or longer durations of high water than other species. Certain tree species' adaptations, such as having truncated base or aerenchymatous roots, help some species occur in wetlands with longer hydroperiods. Brooks (2005) found that there are concentric zones of plant species that are dependent on flooding frequencies and duration of high water levels.

Wetlands occurring in these forested regions share some similarities with the northeastern United States ephemeral forested pools (Brooks 2009). Depressional forested wetlands located in the Turtle Mountains region may receive most of their waters from precipitation. In turn, inter and intra annual climate and weather events may affect forested depressional wetlands in the Turtle Mountains.

Forested wetlands provide both autochthonous (grasses, forbs, sedges) and allochthonous (tree leaf liter, tree branches) sources for decomposition and soil forming processes (Williams 2005). Larger and deeper wetlands should have longer hydroperiods, attributing to slower detritus decomposition rates and accumulation of organic matter (Brooks 2005).

Low-Gradient Riverine Wetlands

Riverine wetland systems have been defined by Brinson (1993) to be linear strips in the landscape with a unidirectional flow of water and having a hydroperiod that is short and flashy or long and steady, dependent on the stream order and surrounding landscape (Brinson 1993). The general sources of water for riverine wetlands derive from overbank flow or from subsurface groundwater inputs (Brinson et al. 1995). Surface water of these wetlands is lost through evapotranspiration, discharge into a larger channel or depressional waterbodies, or to deeper groundwater reservoirs. The frequency, velocity, and duration of water flow has an influence on the wetland system's soils and biotic assemblages, however, coincidently the soils and biotic assemblages have an influence on a riverine wetland's hydrodynamics.

Soils associated with riverine wetlands are predominately composed of transported sediments. Larger sized deposits, such as clay and silt, are related to low velocity water flow. Higher velocities of water flow deposit larger sized particles such as cobbles or sands (Hansen et al. 1995; Brinson et al. 1995). Riverine wetland soils are also characterized by an abundance of pore space (permeable soils), which provides for the storage and release of waters. An example of reference standard soils are coarse textured sandy loams, they have a high-flow through rate and conductivity (Brinson et al. 1995). The fluctuation between saturated anaerobic conditions and aerobic conditions in wetland soils, allows for pore spaces to be microhabitats for biogeochemical processes.

Plant assemblages of riverine wetland systems provide stream bank stabilization in high gradient streams and are key in nutrient cycling, providing organic matter for other biota, and in developing soils (USACOE 2010). Other benefits from vegetation include: converting solar radiation and carbon dioxide into complex organic compounds, which provide energy to food webs; providing habitat for nesting, resting, refuge, and escape cover for animals; creates roughness in wetland morphology to reduces the velocity of floodwaters. For the state of Montana, a classification system for riparian wetlands uses major plant assemblage types to define different riparian systems. Riparian habitat types are classified by dominant coniferous, deciduous, willow shrub, non-willow shrub, sedge, and non-sedge type species (Hansen et al. 1995).

Attributes of riverine wetlands such as flow velocities, substrate particle and pore size, underlying geologic or glaciated formations, and dominant vegetation cover have been used to classify and distinguish wetland types. The approach for classifying riverine systems by flow velocities reveals three general types: perennial, intermittent, and ephemeral. Perennial riverine wetlands are high gradient streams defined as having year round water flow with a saturated soil substrate composed of coarse sands or cobble sediments (Brinson 1993; USACOE 2010). These wetlands may flow-through or occur in the floodplains and riparian corridors associated with stream channels (Brinson et al. 1995).

Intermittent riverine wetlands sustain water flow for a long duration of the year and may show stagnant floodplains during dry periods (Brinson 1993; USACOE 2010). Stream flow is driven by groundwater during certain periods of a year, however runoff from rainfall is a secondary source (USACOE 2010). Soil substrate is composed of fine to coarse silts and sands. There also may be the emergence of point-bars that evidence prior flooding events (Brinson 1993). Disturbance dependent plant communities are found in the wetland evidencing intermittent water flow patterns.

Ephemeral riverine wetlands have low gradient flow velocities and fine sediments of silt or clay that are high in organic content (Brinson 1993). Low suspended sediment loads during flooding events allow for an increasing amount of light penetration. The runoff from precipitation events are the primary source of water, however groundwater is not a significant source of water for ephemeral streams since streambeds of ephemeral riverine wetlands are located above the water table year round (USACOE 2010).

In an unglaciated landscape, riverine wetlands have a developed and distinct low gradient drainage pattern. In glaciated regions, the landscape influences riverine wetlands drainage patterns, therefore attributing to a complex and variable hydrological processes (Brinson 1993). Forested wetlands have a mixed drainage pattern resembling characteristics of both riverine and depressional classes of wetlands.

In addition, forested riverine wetlands are referred by Jolley et al. (2009) as “kidneys” of streams and rivers because they function as filters for sediments and nutrients. Physical, biotic and hydrologic properties associated with forested riverine wetlands aid in the sequestration of carbon, nitrogen, and phosphorus from surface runoff sediments (Cavalcanti and Lockaby 2005). However, ephemeral forested riverine wetlands that have an increase in sedimentation from inorganic and sandy deposits can result in deficiencies of soil nitrogen and phosphorus (Jolley et al. 2009).

STUDY AREA

Sampled wetlands were located in the four ecoregions of North Dakota: Northwestern Great Plains, Northern Glaciated Plains, Northwestern Glaciated Plains, Lake Agassiz Plain (Figure 9) (Omnerick 1987). The Northwestern Great Plains situated in the southwest corner of North Dakota, is an old unglaciated and weathered landscape (Bluemle 1991). The Northwestern Glaciated Plains marks the western most advance of continental glaciation and is characterized as a transitional zone from dry semi-arid lands in the west and temperate rolling flat plains in the east (Wiken et al. 2011). The majority of depressional wetlands are found in the Northern Glaciated Plains, a landscape structured with glacial formations. The Lake Agassiz Plain is attributed to its flat lake topography caused by the proglacial Lake Agassiz.

Ecoregions

Northwestern Great Plains

Due south and west of the Missouri River is the semi-arid and undulating open plains characteristic of the Missouri Plateau sub-ecoregion (Bryce et al. 1998). The sub-ecoregion is attributed to a drainage pattern articulated by a composite of streams and surface and bedrock geology of sandstone and shale. Natural vegetation of the area includes mixed grasses such as: *Bouteloua gracilis, Pascopyrum smithii/Stipa viridula* association, *Schizachyrium scoparium, Calamovilfa longifolia*. Land-uses in the sub-ecoregion include dry land farming and cattle grazing. Spring wheat is the predominant crop with barley, oats, and sunflowers following.

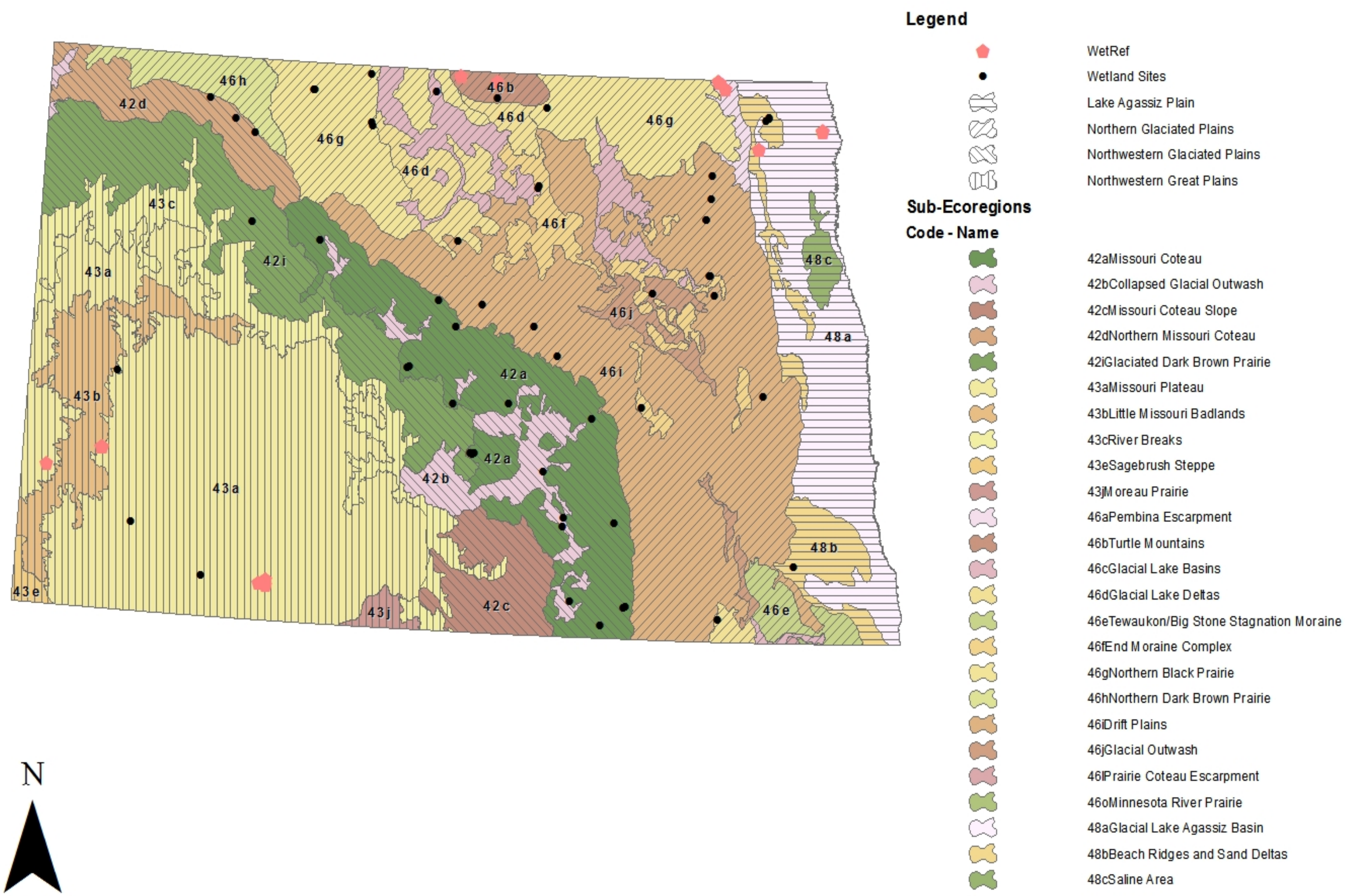

Figure 6. Map depicting ecoregions, sub-ecoregions, and wetlands sampled in the summer of 2011 and from DeKeyser and Hargiss (2011) reference condition data set.

Theodore Roosevelt National Park is a well-known point of interest in the Little Missouri Badlands sub-ecoregion. Many areas in this sub-ecoregion are Federal and State lands set aside for recreational, grazing, and wildlife purposes (Bryce et al. 1998; Sayler 2011). Erosion forces such as mast wasting and slumping, aided in sculpting the jagged and coarse landscape. Geologic surface material and bedrock include Paleocene sediments of the Bullion Creek and Sentinel Butte Formations (Bryce et al. 1998). The Little Missouri and other flowing streams are attributed to carrying heavy sediment loads. However, a majority of the streams in the White River Badlands are ephemeral. Dominant vegetation in the sub-ecoregion includes a mixed-grass prairie characteristic of: *Pascopyrum smithii*, *Bouteloua gracilis*, *Schizachyrium scoparium*, and *Calamovilfa longifolia*. Woody vascular plants include *Juniperous scopulorum* in draws and on north slopes and scattered cottonwood in riparian areas. Land-use in the region includes ranching, grazing, and occasional haying.

Northwestern Glaciated Plains

Set in the Northern Great Plains, the Northwestern Glaciated Plains ecoregion is characterized by its hilly and hummock topography and includes two concentrated sub-ecoregions: Missouri Coteau and Missouri Coteau Slope. Rugged and hummocky dead-ice moraines sculpt the landscape of the Missouri Coteau and Missouri Coteau Slope sub-ecoregions (Kantrud et al. 1989; Bluemle 1991; Bryce et al. 1998). The Missouri Coteau landscape has a simple drainage pattern and contains kettle lakes or semipermanent and seasonal depressional pothole wetlands (Bryce et al. 1998; Taylor 2011). However, the Missouri Coteau Slope has a more irregular topography that contains many wetlands and a low number of streams (Bryce et al. 1998). Native grasses in both areas include: *Pascopyrum smithii*, *Schizachyrium scoparium, Andropogon gerardii*, *Stipa comata*, and *Stipa viridula*. Dominant land-uses identified in the Missouri Coteau are dryland farming and livestock grazing (Taylor 2011). The flatter lands are tilled for agricultural practices such as harvesting corn and spring wheat (Bryce et al. 1998). Native prairie can be found scattered on unbroken rangelands. The Missouri Coteau Slope region has a fresh glacial moraine that suits more cropland and agriculture practices. Saline and steep sloped areas in this region are more attributed to grazing practices.

Northern Glaciated Plains

The undulating topography and thick glacial till of the Drift Plains sub-ecoregion houses a great number of temporary and seasonal wetlands. Glacial activity from the Wisconsin glaciation formed the regions washboard plains and ground moraine in the lower elevations and ice thrust topography in the steep higher elevations (Bluemle 1991). The region is historically a transitional blend of tall-grass and mixed-grass prairie, vegetation associations include: *Pascopyrum smithii*, *Schizachyrium scoparium, Andropogon gerardii*, *Panicum virgatum,* and *Sorghastrum nutans* (Bryce et al. 1998). Lands in the region are tilled for spring wheat, sunflower, and alfalfa.

Proglacial Lake Souris and Devils Lake, which formed from ice blocking their stream drainages or valleys, formed the smooth and flat topography of the Glacial Lake Basins sub-ecoregion. The region is low in wetland density; however, at the center of the glaciated lake plains, large remnant basins may contain large water bodies (Bluemle

1991). Vegetation associations occurring in the region include: *Pascopyrum smithii*, *Stipa comata*, *Boutellua gracilis*, and *Stipa viridula* (Bryce et al. 1998). Most land-use is tilled for spring wheat, sunflower, and flax.

The high hill-like elevations of the Turtle Mountains sub-ecoregion are resultant of large amounts of rock and sediment being forced upward into the glacier; and as the glacier receded, the new glacial sediment atop insulated the ice and produced a large mound deposit of debris (Bluemle 1991). The woodland cover in the Turtle Mountains is attributed to the regions several inches or more of precipitation each year. The lakes and wetlands in the area are settled in depressions in the collapsed topography and were historically filled by precipitation rather than glacial melt water. Vegetation within this region is mainly woody species, such as: *Quercus macrocarpa*, *Populus spp.*, *Ulmus Americana, Rhus spp.*, and *Amelanchier spp.* (Bryce et al. 1998). Land-uses in the region include native woodlands with some clearings for pastures; however, hay and small grains are harvested on gentler soils.

The Pembina Escarpment sub-ecoregion is characterized by its eroded and steep topography, a result from modification by glacial ice that flowed through the Red River Valley (Bluemle 1991). Seeps of groundwater or springs are prevalent in the escarpment. High gradient perennial streams are prevalent in the region. Vegetation associations tied with the region include an overstory of *Quercus macrocarpa*, *Populus spp.,* and *Betula papyrifera* (Bryce et al. 1998). The understory may be composed of *Corylus cornuta*, *Amelanchier spp.*, and *Cornus sericea*. Land practices include cropping of sunflower or flax on flatter cleared areas, and woodland pastures on steep areas.

Lake Agassiz Plains

The last proglacial lake to fill the Red River Valley shaped the ecoregions landscape leaving behind thick fertile lacustrine sediments (Bluemle 1991; Bryce et al. 1998). The shorelines and beaches of the proglacial lake left behind sand and gravel deposits characteristic of areas such as the Sheyenne River Delta (Bluemle 1991; Bryce et al. 1998). The deeper depths of the proglacial lake are characterized as lacustrine silt and clay deposits with a thick glacial till beneath. The lake pan left behind by the proglacial lake has left the area with an extremely flat and low gradient topography (Bluemle 1991; Bryce et al. 1998). In result, lands near the Red River of the North area are at risk for seasonal flooding, especially if lands are located in the flood plain (Bryce et al. 1998). A smaller part of the ecoregion is the Saline Areas sub-ecoregion, an effect caused from salty ground water seeping through the lacustrine and glacial till. Outside of the flood plain streams channel through the landscape with thin buffer strips of *Populus deltoides*, *Fraxinus pennsylvanica, Ulmus americana,* and *Sallix spp*. Historically, the Lake Agassiz Plains were characterized by a tall grass prairie (e.g. *Schizachyrium scoparium, Andropogon gerardii*, *Panicum virgatum,* and *Sorghastrum nutans*). Land-use practices mainly are associated with row crop agriculture. Other land-uses include grazing practices on sandy deltas and beaches, urban development, and on saline soils, grazing and agricultural production of sugarbeets and potatoes wherever tolerated (Bryce et al.

1998). Wetlands in the area are mostly drained or tilled, and influenced by agricultural practices (Bryce et al. 1998).

<u>Soils</u>

Anaerobiosis induced features that are found amongst wetlands soils are key indicators in delineating wetland's hydric soils (USDA-NRCS 2010). Hydric soils are defined as being formed under some condition of saturation during the growing season, in order to develop anaerobic conditions (Federal Register 1994). When soils are saturated or inundated for lengths of time, anaerobic processes amongst wetlands' biological, geological, and chemical elements produce features or indicators of hydric soils. Examples of hydric soils indicators are: the accumulation or loss of iron, manganese, sulfur or carbon compounds (i.e. organic matter) (USDA-NRCS 2010). Another feature, resultant of anaerobiosis, is the production and release of hydrogen sulfide (H_2S) and methane (CH_4) (Richardson et al. 1994; Richardson and Vepraskas 2001).

As noted above, the importance of having an anaerobic environment in wetlands soils for some length of time, allows for biogeochemical reactions and process to occur and develop hydric soils. The characteristics of hydric soils are generally a function of a wetlands hydrology (Richardson and Vepraskas 2001). A wetlands hydrology presents information on a wetlands water budget, primary sources of water input (i.e. precipitation, surface runoff, groundwater subsurface flow), and retention time of water in the soils. Water not only provides a saturated anaerobic soil environment, but also provides minerals and chemicals via specific water sources (i.e. groundwater and alkaline materials, surface runoff and nitrogen and phosphorus fertilizers).

Depressional PPR Wetlands

The hydrology and landscape of depressional PPR wetlands factors in the development of hydric soil features. Soils in the PPR and Northern Glaciated Plains ecoregion are glaciolacustrine (clay and silt) and glaciofluvial (sand and clay), therefore attributing to the shallow groundwater flow systems (van der Kamp and Hayashi 2009). Recharge wetlands are described as smaller sized depressional wetlands (i.e. vernal pools, temporary wetlands) located at higher elevations in the landscape; and are characteristic of Typic Argiaquolls and Cumulic Haplaquolls with a thick A horizon (Lissey 1971; Arndt and Richardson 1988). Recharge wetlands provide a groundwater recharge to wetlands lower in the landscape (Lissey 1971). The soils of these recharge wetlands are non-saline, and free of carbonates and other highly soluble ions (i.e. calcite and gypsum) (Arndt and Richardson 1989).

The flow-through wetlands are typically found in mid-landscape positions with coarser soils than recharge wetlands such as Typic Calciaquolls and Cumulic Haplaquolls (calcareous) (Lissey 1971; Arndt and Richardson 1988). Flow-through wetlands have higher salinity levels than those of recharge wetlands; due to the influence of groundwater as water source and also the presence of calcite and gypsum in the soils (Arndt and Richardson 1989). Waters from flow-through wetlands may leach and be delivered to lower in the landscape, large discharge basins (Lissey 1971).

Discharge basins receive most of their water from groundwater inputs and have poorly developed soils such as Mollic Fluvaquents and Fluvaquentic Haplaquolls (Arndt and Richardson 1988). The presence and high concentrations of sodium (Na^{+}) magnesium (Mg^{2+}) and sulfate (SO_4^{2-}) allow for the precipitation of calcite and gypsum resulting in alkaline conditions and higher salinities (Arndt and Richardson 1989).

Temporary type depressional wetlands are found throughout the PPR, and are characteristic of Argiabolls and Tonka or Tetonka series soils with thick A horizons (Arndt and Richardson 1989; Gilbert et al. 2006). Seasonal wetlands are defined by having a wet meadow zone with Argiaquolls that are Parnell or Worthing series soils. In the center of the seasonal wetland, fine textured and non-calcareous Cumulic Endoaquolls may be present. Around the delineated edge between the upland and wet meadow zone of seasonal wetlands Vallers series soils may be present (Gilbert et al. 2006).

Semi-permanent wetlands (otherwise classified as Lacustrine fringe wetlands in open water lake systems) have soils with distinct features due to wave action and physiochemical processes (Figure 7) (Richardson and Vepraskas 2001). The wave-cut terrace of a semi-permanent wetland is an area of the wetland where the waves actually strike. This geomorphic feature is composed of coarse textured beach sediments of sand and gravel. Erosional deposition filtering through the wave-cut terrace beach sediments builds in an area characterized as the wave-built terrace. This area of the semi-permanent wetland is made of rather fine sands or silts, and accompanied by clays. The offshore region of the wetland is towards the center of the water body and has silty and clay like soils.

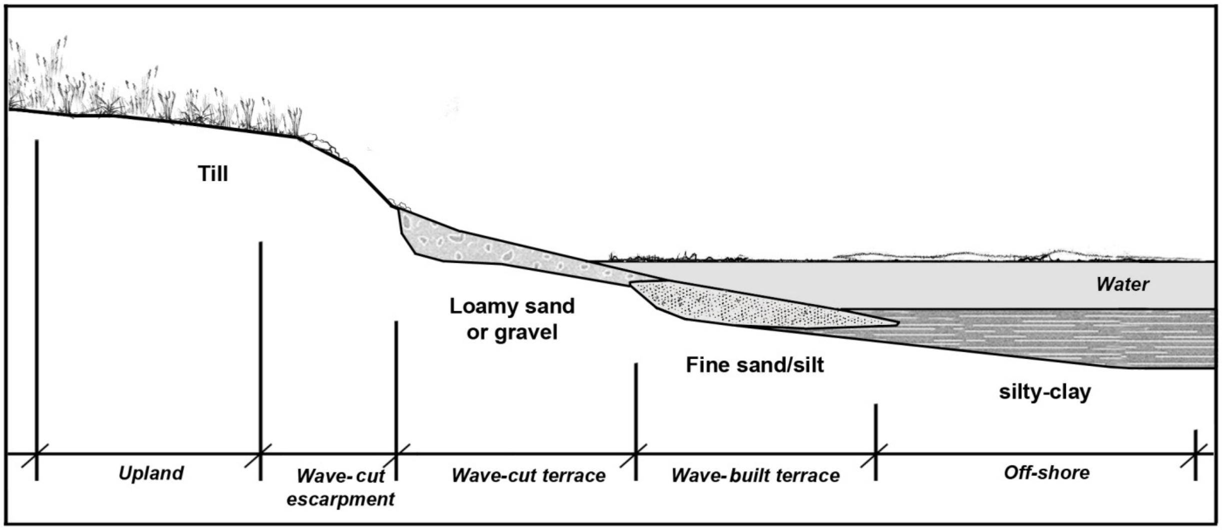

Figure 7. Illustration of the soils related to semi-permanent or lacustrine fringe wetlands modified from Richardson and Vepraskas 2001 pg. 56.

Slope Wetlands

Soils developed in this wetland class are tied to the topographic and geologic location of the wetland in the landscape. Richardson and Vepraskas (2001) differentiate slope wetlands by two types: 1) topographic slope wetlands and 2) stratigraphic slope wetlands. Topographic slope wetlands occur at the convergence of slopes or in coves, draws, or hollows (Figure 8). Soils at the head (upslope) of the wetland are characterized as thick and deep having high infiltration and percolation rates. Below these soils is an Epiaquic or dense till that is impermeable. Surface and subsurface water feeds through soils at the head of the wetland and leach out, or recharge soils located down-slope. Soils located at the head of the wetland tend to be characterized as mineral soils.

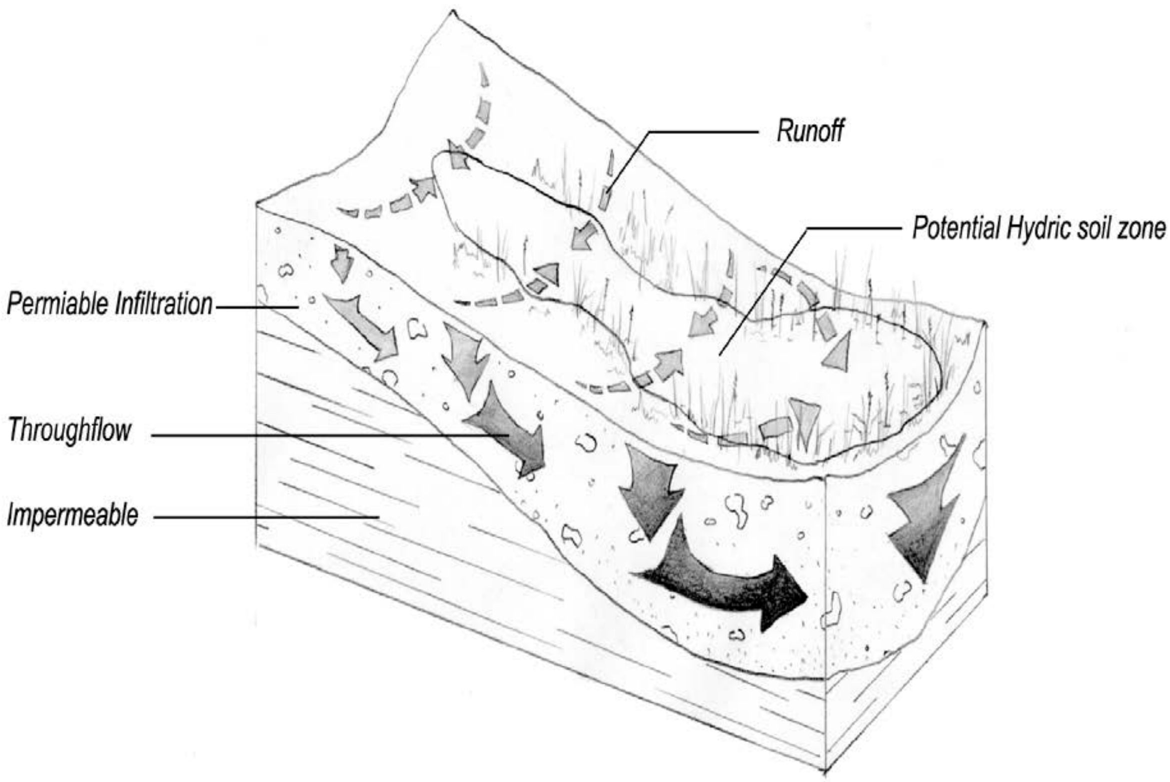

Figure 8. Illustration depicting general soil morphology of topographic slope wetlands modified from Richardson and Vepraskas 2001 pg. 223.

Soils on the down-slope may be Histosols depending on the wetland hydrology (i.e. water permanence, secondary water sources, and hydroperiods) (Richardson and Vepraskas 2001). Stratigraphic slope wetlands occur in the landscape where impermeable subsurface formations force groundwater to move laterally and intersect the land surface (Figure 9). Groundwater is the major source of water for the stratigraphic slope wetlands. In effect, wetland soils are rich in dissolved ions and nutrients, especially alkaline compounds.

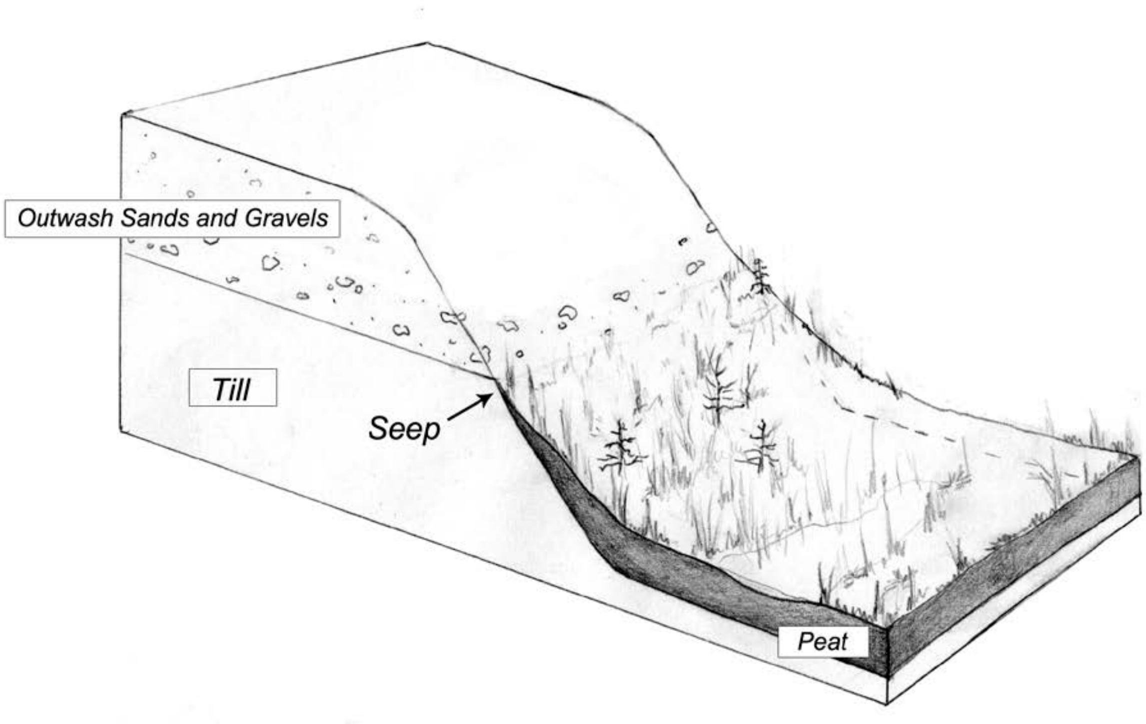

Figure 9. General morphology of stratigraphic slope wetlands modified from Richardson and Vepraskas 2001 pg. 225.

Fen Wetlands

The unique structure and soils associated with fen wetland systems are critical in providing habitats for rare and unique species of flora, and in most fens the soils are high in organic matter. Fen wetland systems can be classified by several types: 1) slope fens, 2) discharge mound fens, 3) lake edge fens, 4) poor fens, 5) rich fens, 6) calcareous fens and 7) extreme rich/marl fens.

Slope Fens are typically found on the base of moraines, the edges of sand and gravel outwash plains or terraces, and in areas with limestone bedrock or areas associated with permeable deposits (i.e. sandstone) over a less permeable (i.e. shale) formations (Amon et al. 2002). Discharge Mound Fens are described as wetlands with groundwater sourcing from a central discharge point(s). These types of wetlands may form over aquifer windows, or breeches in less permeable substrates that expose a confined aquifer. An example is a breach in lacustrine clay deposits overlain by sand and gravel deposits. Lake edge fens are characterized as having upward hydrologic gradients at the edges of lakes. Deposits of peat into the associated lake may create floating mats in the water body (see Figure 5 for illustrative detail).

Poor Fens have low or poor mineralized and buffering soil materials such as sand or quartz (Bedford and Godwin 2003). Poor fens occur atop of non-calcareous bedrock (i.e. sandstone, basalt, quartzite, granite). In addition, the attributes associated with poor fen’s groundwater results in a slightly acidic pH. Rich fens have a consistent saturation of soils in the plant rooting zone. A characteristic of these soils is the presence of calcium and gypsum minerals; this results a moderately alkaline pH. In the state of New York rich fens occur atop of bedrock composed of limestone, dolostone, marble, or calcareous surficial deposits of glacially derived materials. Calcareous fens are rich in calcium deposits. In the state of Wisconsin, calcareous fens occur in positions of the landscape with bedrock of limestone, dolomite, or sandstone containing dolomite and limestone. Extreme Rich/Marl fens are distinguished from rich fen types by their high concentrations of calcium and magnesium carbonate.

Forested Depressional Wetlands

Occurring in forests, these wetland systems are attributed to Alfisols class soils (Bryce et al. 1998). However, the Turtle Mountains sub-ecoregion was created by Wisconsinian Glacial activities that left behind certain topography and soils characterizing

Mollisols. For the most part the Turtle Mountains forested depressional wetlands are comprised of clay, loam, and glacial till (Bluemle 1991; Bryce et al. 1998). The Pembina Gorge area was carved out from melting Wisconsinian glaciers retreating and flowing north out of the Red river valley and also has depressional wetlands in forest settings with Alfisol soils (Bluemle 1991; Bryce et al. 1998).

However, depressional forested wetlands are unique, due to the fact that the trees have an influence on wetland attributes and characteristics; and, on the other hand, characteristics and attributes of a wetland influence the presence of tree species (Williams 2005). Leaves are an allochthonous source for depressional forest wetlands that stimulate microbial and micro-organism reactions in wetland's hydric soils. The decomposition of leave detritus in wetlands is done by associated fungi, bacteria, and detritivorous insects under conditions that allow for decomposition.

Riverine wetlands

The frequency, velocity, and duration of water flow have an influence on the wetland system's soils and biotic assemblages, however, coincidently the soils and biotic assemblages have an influence on a riverine wetland's hydrodynamics (Brinson et al. 1995). Riverine wetland soils are predominately made up of transported sediments. Larger sized deposits, such as clay and silt, are related to low velocity water flow. Higher velocities of water flow deposit larger sized particles such as cobbles or sands (Hansen et al. 1995; Brinson et al. 1995). Riverine wetland soils are also characterized by an abundance of pore space (permeable soils), which provides for the storage and release of waters. An example of reference standard soils are coarse textured sandy loams, they have a high-flow through rate and conductivity (Brinson et al. 1995). The fluctuation between saturated anaerobic conditions and aerobic conditions in wetland soils, allows for pore spaces to be microhabitats for biogeochemical processes.

METHODS

In 2011, during the months of June, July, and August, 55 wetlands were sampled throughout North Dakota (Figure 6). The sample set was determined from the 2011 National Wetland Condition Assessment (NWCA) protocol. The sampled sites were selected by first selecting wetlands from the U.S. Fish and Wildlife's Status and Trends survey. In the next step, the wetlands selected were filtered through a Generalized Random Tessellation Stratified (GRTS) survey design (Stevens and Olsen 2004). Through the GRTS, wetland sample sites were selected in order to represent a population of wetlands from their ecoregion (USEPA 2011). Each wetland selected through the GRTS was given a point from where the assessment area would be delineated. Sample sites were located within the Northwestern Great Plains, Northwestern Glaciated Plains, and Northern Glaciated Plains ecoregions of North Dakota (see Appendix A for a detailed list for each wetland site). Different wetland classes were encountered throughout the various sub-ecoregions in North Dakota. In the Beach Ridges and Sand Deltas sub-ecoregion, 1 fen and 2 riparian-forested wetland types were sampled. A forested seasonal wetland was sampled in the Turtle Mountain sub-ecoregion. A Lacustrine open water wetland was sampled in the Missouri Coteau sub-ecoregion. In the Missouri Plateau sub-ecoregion, slope wetlands were sampled. In the PPR, depressional semi-permanent, seasonal, and temporary wetlands were sampled. This dataset will be referred as the "55 NWCA dataset" throughout the rest of the paper.

Additionally, another set of 40 wetlands, sampled June through August 2009 and July 2010, that were part of a reference condition study for 4 unique regions in North Dakota, were combined with the 2011 field season data (DeKeyser and Hargiss 2011). In the reference condition study, per each region studied 10 *a priori* reference wetlands were sampled. Included in the study were 10 wetlands in the Pembina Escarpment sub-ecoregion, 10 wetlands in the Turtle Mountains sub-ecoregion, 10 wetlands in the Missouri Plateau sub-ecoregion, and 10 wetlands in the Glacial Lake Agassiz Basin sub-ecoregion. This dataset will be referred as the “40 ecoregion reference dataset” throughout the rest of the paper.

Initially, upon arriving at each sampling site, each wetland was delineated to determine its wetland class (i.e. depressional, riparian, forest, fen, slope), wetland zones based on present vegetation and hydro periods (i.e. low prairie, wet meadow, shallow marsh, deep marsh, open water) (Stewart and Kantrud 1971), wetland type (i.e. temporary, seasonal, semi-permanent, open water) (Stewart and Kantrud 1971), and hydrological position (i.e. recharge, flow-through, discharge) (Richardson and Vepraskas 2001).

Quadrat Sampling

At each wetland sampled, data for vascular species were determined by a quadrat method similarly adapted to the methods of DeKeyser (2000). DeKeyser (2000) determined that this modified quadrat method generates vegetation data adequate for a vegetative-based IBI. Per each wetland, 1m^2 quadrats were spaced evenly throughout the wetland’s zones, 8 in the low prairie, 7 in the wet meadow, 5 in the shallow marsh, and

5 in the deep marsh (Stewart and Kantrud 1971). For some wetlands, such as lacustrine fringe class wetlands, wetland's zones were too large to sample. In order to resolve these sampling conflicts amongst large lacustrine fringe wetlands and long riparian wetlands, quadrats were evenly set in each zone, but within 250 meters on either side of the NWCA assessment area point (USEPA 2011). 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. Wetlands that were classified as temporary had a total of 15 sampled quadrats, seasonal wetlands had 20, and semi-permanent wetlands had 25 sampled quadrats.

In each $1m^2$ quadrat, all plant species were identified and recorded on a list of primary species and given a relative percent aerial cover ranging from 0 – 100%. Other measurements taken within the quadrat include: litter thickness, percent litter, percent open water, water depth, percent bare ground, and percent standing dead. Other plant species that were found outside the $1m^2$ quadrats, but within wetland's zones, was also recorded in a secondary species list (DeKeyser et al. 2003).

Index of Plant Community Integrity

Vegetation data was assessed using the IPCI metric system developed by DeKeyser et al. (2003). The IPCI is an intensive assessment developed for temporary, seasonal, and semi-permanent depressional wetlands in the NWGP and NGP ecoregions (Hargiss et al. 2008). The IPCI analyzes wetland vegetation communities by a multimetric system (DeKeyser et al. 2003). Each metric defines some attribute of a plant community that responds to a disturbance gradient. Hargiss et al. (2008) adjusted the metric ranges previously set by DeKeyser et al. (2003) in order to better depict temporal and spatial changes in plant communities. A complete list of the metrics can be found in Appendix B. Using a wetland's primary and secondary species list data, IPCI metrics are assigned raw scores. Each metric's raw score is then subjected to a rank score (0, 4, 7, 11) based on the range of values acceptable for each rank score. In Appendix B, the ranges for each ranking score are illustrated. Then, the overall condition score for each wetland is determined by adding each metric's ranking scores together. In Appendix B, condition categories are displayed with their condition description and range of acceptable scores. The first five IPCI metrics depend on the species richness plant assemblages found in the wetland and the last four metrics depend on Coefficients of Conservatism values (C-Values) taken from the Northern Great Plains Floristic Quality Assessment Panel (2001). C-Values range from 0 to 10, a value of 0 indicates that a plant species has a 0% chance of being found in a remnant natural area, and a value of 5 indicates a 50% chance (NGPFQAP 2001).

Hydrogeomorphic Model

In addition, sampled wetlands were assessed by the HGM model developed for the PPR (Gilbert et al. 2006). Combining field data and GIS derived data from the office, FCI scores could be calculated from specific mathematical equations. Since some of the wetlands in the sample set did not fit the classification requirements of the PPR HGM assessment, field measurements such as the length of the wetlands parameter and area of the catchment basin were done in the office with ArcMAP v. 10.0 tools rather than being done in the field. Downloading aerial imagery of the wetland into ArcMAP, the parameter could be calculated through digitizing editing tools. The area of a wetland's catchment basin was determined by using raster elevation imagery in ArcMAP. Another modification to the data collection process of the HGM assessment method includes the determination of a sub-index score for Soil Recharge Potential. The score was subjectively assigned to wetlands that were not temporary or seasonal depressional wetlands located in the PPR. Model variables measured and FCI mathematical equations can be found in Appendix C.

North Dakota Rapid Assessment

The NDRAM protocol developed by (Hargiss 2009) was also conducted on sampled wetland sites. The protocol has been developed to be a rapid, on-site, assessment of wetland attributes (hydrology, hydric soils and hydrophytic vegetation). The protocol was developed for a specific area of the Missouri Coteau ecoregion of North Dakota, however, its transferability to the PPR of North Dakota, South Dakota, and Montana was proven and tested by Hargiss (2008). The NDRAM evaluates a wetland's physical and biological characteristics, and present stressors, in order to predict a wetland's condition in its current state. See Appendix D for the NDRAM protocol.

The NDRAM evaluates a wetlands condition by assessing three metrics: 1) wetland buffer and surrounding land-use, 2) hydrology, habitat alteration, and development and 3) vegetation composition. Each metric is scored by a set of sub-metrics, which are measured through observation and Best Professional Judgment (BPJ). Additional information included in the NDRAM is a general site description and wetland classification, land owner and land-use information, and an illustrative site map. This information is documented for future visits in order to determine trends and changes.

For each sub-metric there is a list of descriptive narratives that illustrate the range of the sub-metric from native conditions to severely disturbed. Based off of this disturbance range, each narrative is assigned a numerical score. In order to determine the potential condition of a wetland, sub-metric scores are added together to get a metric score. The total scores for each metric are added together to produce an overall condition score. The overall condition score is ranked into a condition class of either Good, Fair High, Fair Low, or Poor. The NDRAM assumes that condition category reflects the impact of stressors impairing wetland attributes (hydrology, hydric soils, hydrophytic plant communities).

Validation

Nonmetric Multidimensional Scaling (NMS) was used to analyze the transferability of the IPCI, HGM, and NDRAM protocols towards wetlands outside of their jurisdictions. Using NMS reduces, or ordinates, multivariate data by performing a rank ordering of data points onto various axes that reflect the dissimilarity amongst the data (McCune and Grace 2002). The rankings that are provided in the output axes reflect the minimum amount of stress or ordinated distance between data points in comparison to the distance predicted by regression. NMS was utilized with PC-ORD program v. 6.0 (MjM Software 2011).

Options that were utilized for NMS analysis include: 1) appropriate distance measure dependent on the dissimilarity matrix, 2) a random starting point, 3) autopilot with the “slow and thorough” selection. Output axes were selected best-fit if: 1) axis p-value was ≤ 0.05 when comparing the Monte Carlo randomization dataset’s stress to the stress from the real data, 2) final solution had a stress of < 20, number of iterations < 150, and a final instability < 0.0005., 3) axis represented (r^2) $\geq 60\%$ variation of the dataset and adding a subsequent axes reduces stress > 5 (McCune and Grace 2002). The axes generated from NMS were rotated so that the principle axes were statistically independent. In result, axes are then ordered with the first axis explaining the most variation.

This analysis for each assessment method was done by evaluating each methods final, or overall data, and also subset data collected by each method. The IPCI was analyzed in NMS by using the raw metric scores from the 55 NWCA and 40 ecoregion reference datasets. The NDRAM was analyzed by first examining the scores for the three metrics, then by examining the scores for each of the sub-metrics. The HGM was analyzed in 3 steps: 1) examining the dataset’s scores for all 6 FCIs; 2) analyze the dataset’s scores for the model variables found in each FCI’s equation (see Appendix C Table 1); and 3) analyze the dataset’s scores for vegetation, hydrology, soils, and landscape model variables (see Appendix C Table 2). Variables tested with NMS were considered significant drivers of the ordination results if their Sigma 1 (relation of the axis’ rank to the main dataset) had a Pearsons correlation coefficient ≥ 0.5 and ≤ -0.5 respectively.

The raw metric scores from the IPCI and sub-metric and metric scores from the NDRAM were analyzed with NMS using a Relative Euclidean distance measure in order to compare scores across sampled wetlands (McCune and Grace 2002). Functional capacity indices and model variables found in each FCI equation were analyzed in NMS with a Relative Euclidean distance measure in order to compare and seek out measures that best represent all wetlands sampled, and provide significant axes with rankings in order to compare to other condition assessment methods. Vegetation, hydrology, soils, and landscape model variables from the HGM were first relativized by their average standard deviation (by column) and then analyzed in NMS by the Relative Euclidean distance measure, in order to bridge HGM measures across all wetlands sampled.

Next, the Kendall coefficient of concordance was used to compare the ranks of each assessment method. The test used the Kendall *W* program (Legendre 2004) with 9,999 permutations of the data along with a procedure to correct for ties. The null hypothesis of the Kendall coefficient of concordance test is that each assessment method is independent from each other. The alternative hypothesis denotes that the assessment methods' ranks are similar with each other (accepted if p-value < 0.05). This analysis process was done in order to compare methods and see if they ranked wetland classes similarly or dissimilarly. The NMS ordination was used as a tool to indicate if any elements from the three assessment methods were transferable amongst wetland types or classes.

The 55 NWCA and 40 ecoregion reference dataset were used to indicate whether assessments were concordant of each other. The first analysis was done using both the 55 NWCA and 40 ecoregion reference datasets. Assessments were compared in Kendall's *W* using two judges in the input file. Therefore, the NDRAM final scores were compared to the HGM's first axis, generated from the NMS analysis done with the HGM functional capacity index scores; NDRAM compared to IPCI final scores; and HGM compared to IPCI. The second analysis was done using only the 40 reference ecoregion dataset and compared, again, the NDRAM to the HGM, NDRAM to the IPCI, and the HGM to the IPCI.

Plant species data collected from the IPCI and quadrat sampling methods were also analyzed with NMS. For each wetland sampled, primary plant species' abundances were averaged, and secondary species were given a value of 0.01. Each wetland zone was analyzed separate from each other (low prairie, wet meadow zone, shallow marsh, deep marsh). Using NMS, plant species abundance vs. sample site was analyzed with Sorenson (Bray-Curtis) distance measure (McCune and Grace 2002).

RESULTS AND DISSCUSION

Index of Plant Community Integrity Analysis

The NMS analysis on the IPCI's raw metric scores from the 55 NWCA dataset resulted in two axes. The first axis explained almost all the variability 92.3%, with the second axis, 5.7%, explaining only a small portion of the variability. Final stress of the ordination was 7.22811 with a final instability of 0.00000, 57 iterations were diagnosed. The low stress indicates an ordination that provides valid inferences. Pearson correlation coefficients calculated between the ordination axes and different IPCI metrics indicated that all 9 metrics had significant correlations (≥ 0.5 and ≤ -0.5) with axis 1 from the NMS ordination (Table 2). The metric measuring the percentage of the total species list that are annual, biennial, and introduced had an exclusive positive correlation to axis 1. On the other hand, the other metrics were negatively correlated to axis 1 (Table 2).

A NMS analysis of the raw IPCI metric scores from the 55 NWCA and the 40 ecoregion reference dataset resulted in an NMS ordination with two axes. The first axis represented 86.9% of the variability; the second axis represented 11.2% of the variability. Final stress for the two axes solution was 7.32406 with a final instability of 0.00000, 72 iterations were drawn. The low final stress indicated that the ordination provides valid inferences. Pearson correlation coefficients calculated between the ordination axes and different IPCI metrics suggested that all the metrics, except for the metric measuring the number of grass and grass-like species, were significantly correlated with axis 1 from the NMS ordination (Table 3). Again, the metric measuring the percentage of species that are annual, biennial, and introduced in the wetland's total species list, was the only metric with a positive correlation to axis 1.

Table 2. Pearson correlation coefficients for IPCI metrics calculated between the NMS ordination axes, and the data from the 55 NWCA dataset.

	Pearson Correlation Coefficient	
Metrics	Axis 1	Axis 2
Sp. Rich (a)	-.686	-.068
# Genera (b)	-.667	.017
Grass-like (c)	-.561	-.190
% of intro. (d)	.838	.109
# Nat. in WMZ (e)	-.649	.307
# C = 5 (f)	-.605	-.193
# C = 4 in WMZ (g)	-.625	.173
Avg. C (h)	-.808	-.129
FQI (i)	-.673	-.254

[a] Species richness of native perennial plant species.
[b] Number of genera of native perennial plant species.
[c] Number of grass and grasslike species (Poaceae, Juncaceae, Cyperaceae).
[d] Percentage of the total species list that are annual, biennial, and introduced.
[e] Number of native perennial plant species found in the wet meadow zone.
[f] Number of plant species with a C-Value ≥ 5.
[g] Number of plant species with a C-Value ≥ 4 found in the wet meadow zone.
[h] Average C-Value of all species present.
[l] Floristic Quality Index = Average C-Value multiplied by the square root of the total number of species.

Overall, the NMS results from both IPCI metric analyses concluded that the IPCI method was able to assess a range of condition amongst different wetland types; and additionally, that IPCI metrics dealing with vegetation species richness and coefficients of conservatism (C-Values) were transferable amongst different wetlands. The Pearson correlation coefficients calculated from the 55 NWCA dataset indicated that all 9 IPCI metrics were significantly correlated to the NMS ordination (Table 2). In addition, the metric measuring the percentage of total species that are annual, biennial, and introduced had the strongest positive correlation with axis 1, and the metric measuring the average C-Value had the strongest negative correlation with axis 1 (Table 2).

Table 3. Pearson correlation coefficients for IPCI metrics calculated between the NMS ordination axes, and the data from the 55 NWCA dataset and 40 ecoregion reference dataset.

	Pearson Correlation Coefficient	
Metrics	**Axis 1**	**Axis 2**
Sp. Rich (a)	-.665	-.257
# Genera (b)	-.649	-.324
Grass-like (c)	-.382	-.087
% of intro. (d)	.848	-.148
# Nat. in WMZ (e)	-.575	.285
# C = 5 (f)	-.542	-.582
# C = 4 in WMZ (g)	-.589	-.035
Avg. C (h)	-.626	-.640
FQI (i)	-.603	-.597

[a] Species richness of native perennial plant species.
[b] Number of genera of native perennial plant species.
[c] Number of grass and grasslike species (Poaceae, Juncaceae, Cyperaceae).
[d] Percentage of the total species list that are annual, biennial, and introduced.
[e] Number of native perennial plant species found in the wet meadow zone.
[f] Number of plant species with a C-Value ≥ 5.
[g] Number of plant species with a C-Value ≥ 4 found in the wet meadow zone.
[h] Average C-Value of all species present.
[I] Floristic Quality Index = Average C-Value multiplied by the square root of the total number of species.

Observing the relation of % annual, biennial, and introduced species metric scores from the 55 NWCA dataset to axis 1, all sampled wetlands with a low score were located to the right of the 0 value on axis 1 and are illustrated as larger sized triangles (Figure 10). On the other hand, the ordination of the 55 NWCA dataset placed wetlands with high average C-Values, represented as larger sized triangles, to the left of the 0 value on axis 1 (Figure 11). In essence, this ordination infers that wetlands from the dataset with higher average C-Values will have lower percentages of annuals, biennials, and introduced species and, on the other hand, wetlands with higher percentages of annual, biennial and introduced species have lower average C-Values. This ordination also infers that the IPCI method and metrics measuring percentage annual, biennial, and introduced species and average C-Value have the ability to assess a range of wetland types based off of the vegetation assemblages found throughout the wetland.

The additional NMS analysis including both the 55 NWCA dataset and the 40 ecoregion reference dataset inferred similar results. However, this NMS ordination indicated that the IPCI method and its metric scoring should be curtailed to specific wetland regional reference standards. The Pearson correlation coefficients calculated for each IPCI metric indicated that all IPCI metrics, except for the metric measuring the number of grass and grass-like species, were significantly correlated with axis 1 from the NMS ordination (Table 3). However the metric with the strongest positive correlation coefficient with axis 1 was the percentage of annual, biennial, and introduced species (0.848). Therefore, wetlands that were ordinated to the right of the 0 value on axis 1 had a higher percentage of annual, biennial, and introduced species, these wetlands are denoted as having larger sized triangles (Figure 12).

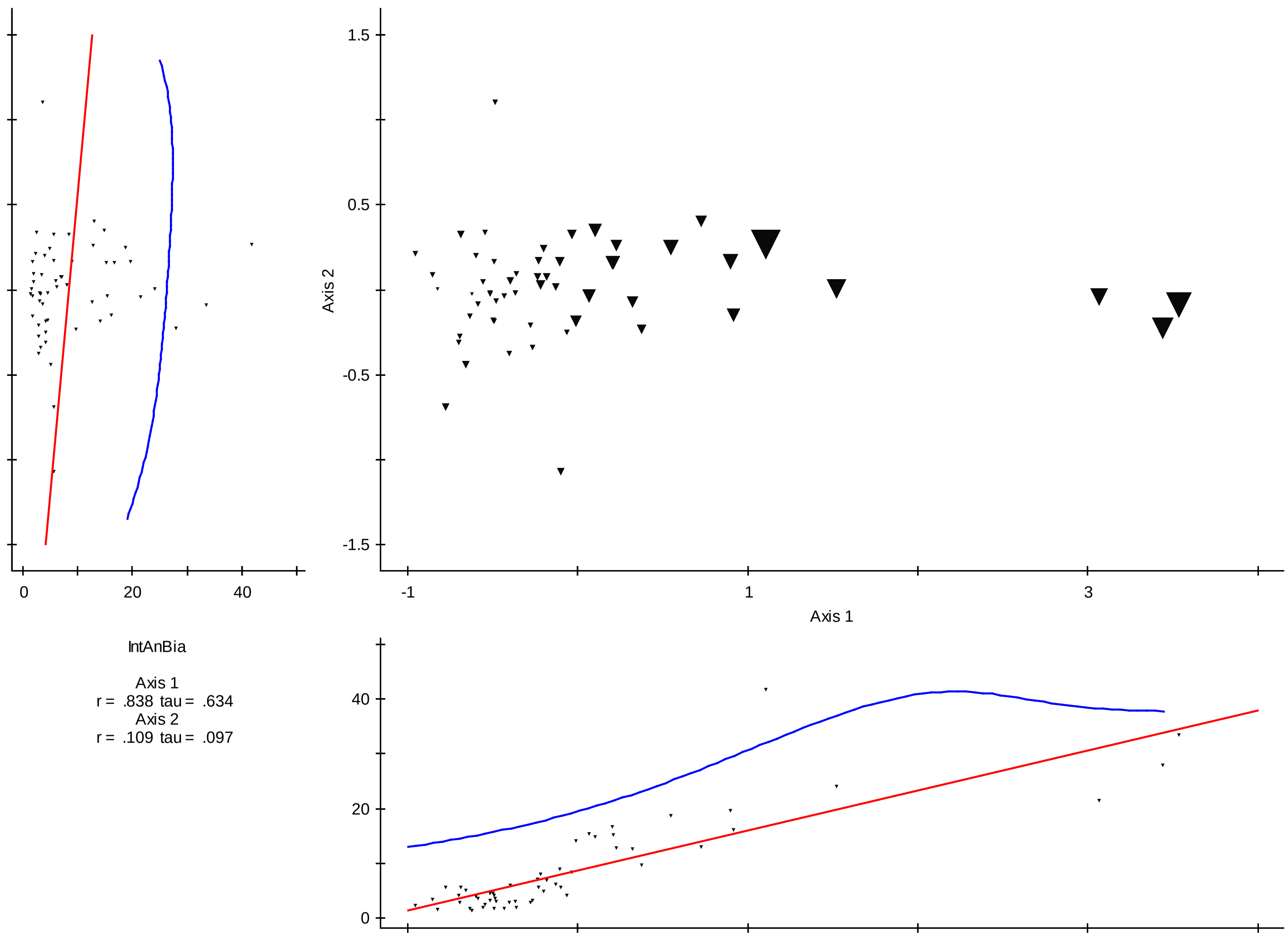

Figure 10. NMS scatterplot of the % annual, biennial, and introduced species metric scores from the 55 NWCA dataset, in relation to the two ordination axes.   Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the metric's score.

The strongest negative correlation with axis 1 was represented by metrics that measure the number of native perennial species in the wetland's plant species list. These metrics include: species richness of native perennial plant species, number of genera of native perennial plant species, average C-Value of all species present, and FQI. In this ordination, however, the metric measuring the average C-Value not only had a significant Pearson correlation coefficient with axis 1, but also had the strongest negative coefficient for axis 2 (Table 3). Observing the ordination of the datasets against axis 1, wetlands that had a higher average C-Value were located to the left of the 0 value and denoted by larger sized triangles (Figure 13).

The scatterplot from this ordination illustrates that wetlands positioned to the left of the 0 value on axis 1 have higher metric scores for measures on the number of native perennials and a lower score for the metric measuring percentage of annual, biennial, and introduced species (Figure 14). The wetlands from the 40 ecoregion reference dataset are highlighted by different color triangles on this scatterplot (Figure 14). Reference wetlands from the Missouri Plateau and Red River Valley ecoregions were ordinated to the right of the 0 value on axis 1, indicating that these wetlands had higher metric scores for percentage annual, biennial, and introduced species and lower numbers of native perennial species (Figure 14). The Turtle Mountains reference wetlands were positioned to the left of the 0 value on axis 1, indicating that these wetlands had higher numbers of native perennial species and had a lower percentage of annual, biennial, and introduced species in the wetland (Figure 13).

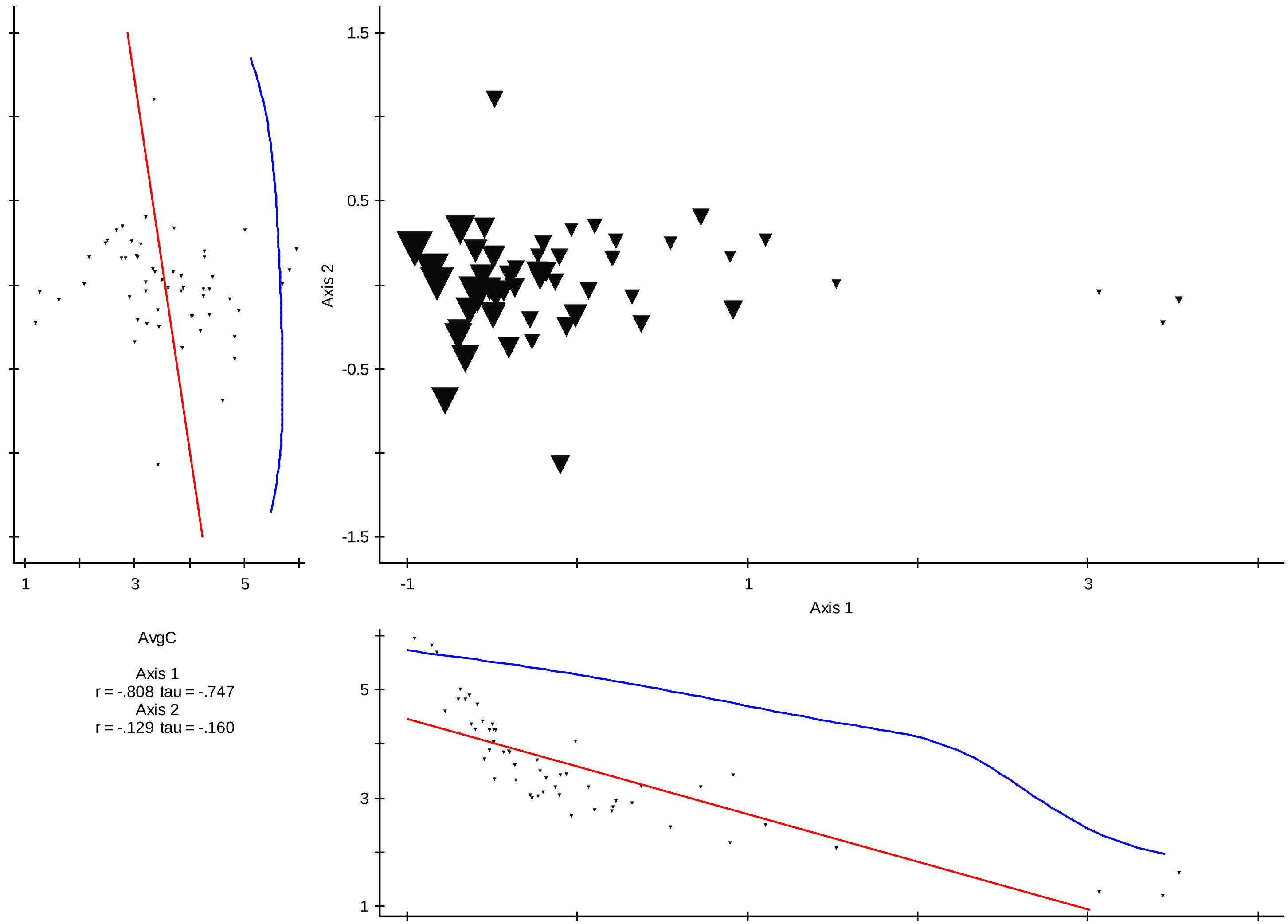

Figure 11. NMS scatterplot of the average C-Value metric scores from the 55 NWCA dataset, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the metric's score.

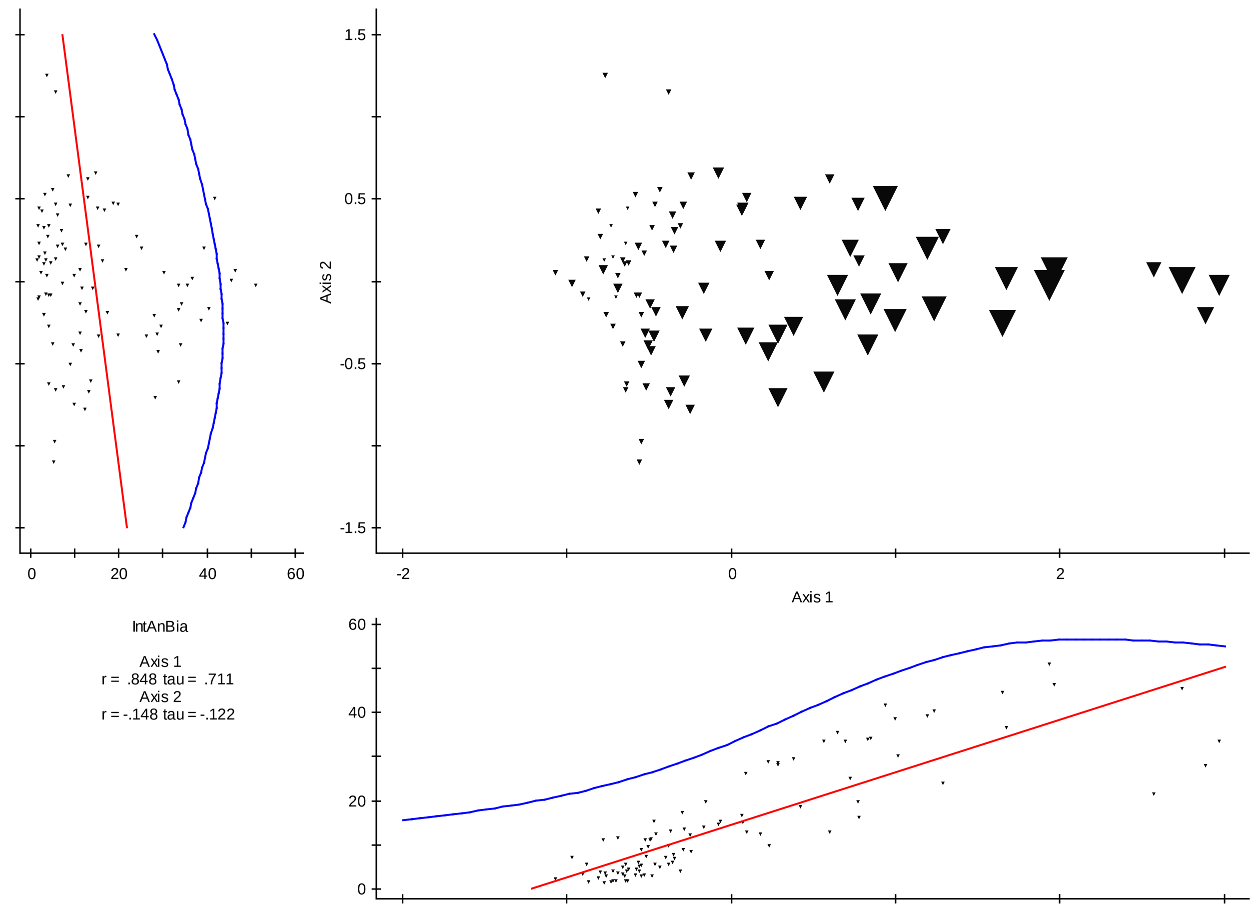

Figure 12. NMS scatterplot of the % annual, biennial, and introduced species metric scores from the 55 NWCA and 40 ecoregion reference datasets, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the metric's score.

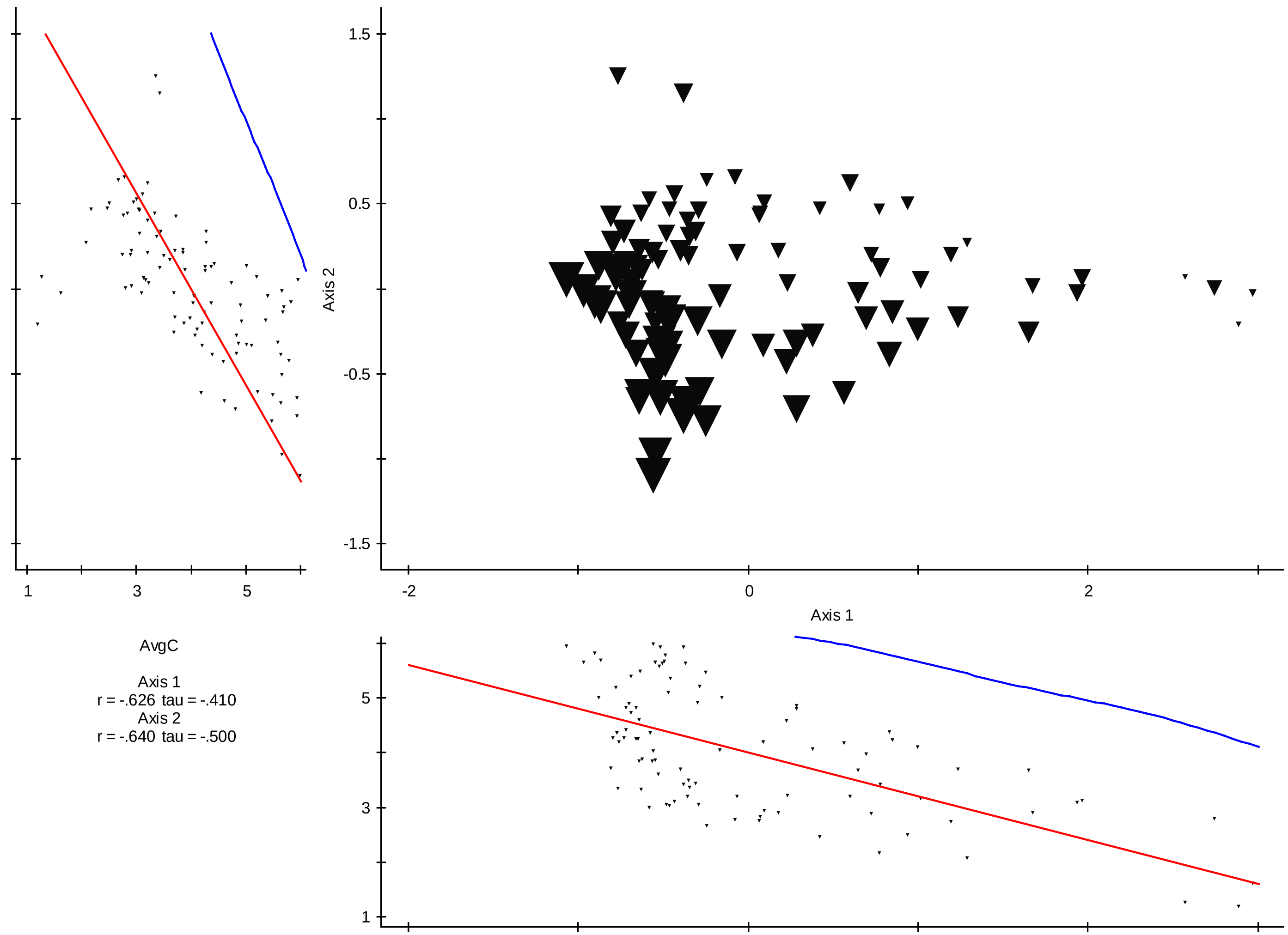

Figure 13. NMS scatterplot of the average C-Value metric scores from the 55 NWCA and 40 ecoregion reference datasets, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the metric's score.

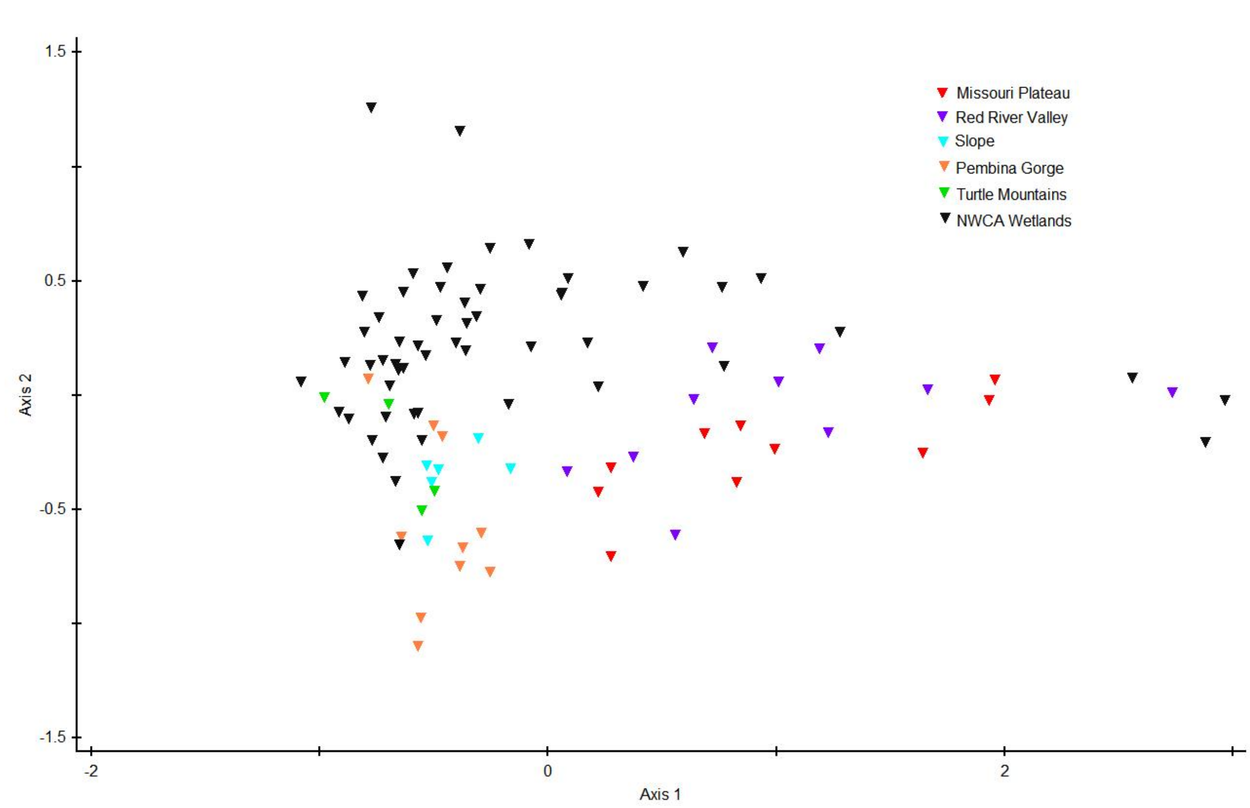

Figure 14. Scatterplot diagram of wetlands from the 55 NWCA and 40 ecoregion reference datasets based on NMS ordination of IPCI raw metrics' scores. Distances amongst the triangles approximate the dissimilarity in IPCI metrics' scores.

The goal of the IPCI assessment is to detect changes in PPR depressional type wetland's plant community in order to evaluate the condition of the wetland. Many other IBI assessments developed for other wetland types also utilize plant community assemblages in order to indicate condition (Mack 2007). Vegetation is a consistent biotic indicator that can be found in most, if not all, wetland types. Effective biotic indicators for IBI's are required to show a change in composition over a gradient of disturbance (Karr and Chu 1997). The results from the NMS analysis of IPCI metric scores spatially depict the range of condition for the multiple wetland classes sampled throughout the state of North Dakota (Figure 14). Wetlands with abundant introduced annual and biennial species and plant communities with low average C-Value are distributed to the right of the 0 value on axis 1 (Figure 14).

IPCI metrics that are transferable amongst wetland types found throughout North Dakota measure the number of introduced annual and biennial species throughout the wetland, and also measure the average C-Value based on all the plant species found within the wetland (Table 2 and Table 3). However, the ordination of the ecoregion reference wetlands illustrated that wetlands from different ecoregions have different regional ecological processes that justify their positions along axis 1 and also their relation to higher or lower metric scores for % annual, biennial, and introduced species and number of native perennial species.

An effective IBI protocol is able to detect a divergence of biological integrity from regional ecological processes (Karr 1999). In the NMS results, the IPCI metrics were shown to detect a divergence in biological integrity however, regional ecological processes were not (Figure 14). Depressional type wetlands located in the Red River Valley (RRV) have been heavily impacted with high urban development and agricultural land uses (Kantrud and Newton 1996). This is best illustrated by the position of the reference wetlands from the RRV in Figure 14. Kantrud and Newton (1996) had to omit RRV depressional wetlands in their test for vegetative indicators of wetland quality in the PPR and RRV. The reason for omitting RRV wetlands was that they did not span a gradient of disturbance, instead the wetlands would only represent the disturbed side of the gradient.

The regional influence and magnitude of anthropogenic land use in the RRV has certainly changed this regions biological community. Urban development and agricultural land uses have an adverse effect on plant community composition decreasing species richness and increasing the occurrence of exotic species and introduced species (Stewart and Kantrud 1971, 1972; Kantrud and Newton 1996; Houlahan et al. 2006). The IPCI method should have its metrics calibrated for the “best attainable” regional reference conditions represented by the 10 RRV depressional wetlands sampled by DeKeyser and Hargiss (2011) (Stoddard et al. 2006). This is mainly due to the rarity of natural remnant areas in this region and the inevitable influence of anthropogenic stressors on these wetlands within this ecoregion.

Wetlands located in the Missouri Plateau ecoregion were also illustrated by NMS to have regionally specific ecological process (Figure 14). Reference wetlands from the Missouri Plateau region were located in a position on axis 1 that indicated that these wetlands have lower average C-Values and a higher % of annuals, biennials, and introduced species (Figure 14). Wetlands located in the Missouri Plateau are characterized by their saline tolerant wetland species, due to their hydrological and geological position. These wetlands could be considered saline slope lowland type wetlands, which naturally have lower species diversity (USDA-NRCS-ND, SD, MT 2003). Historical climax plant communities within these wetlands are saline tolerant with moderate C-Values (*Spartina gracilis (C-Value = 6), S. pectinata (C-Value = 5), Puccinellia nuttalliana (C-Value = 4) , and Pascopyron smitthii (C-Value = 4)*). Other grasses that are prevalent in this wetland type include: *Elymus trachycaulus*, *Distichlis* *spicata*, and *Hordeum jubatum*. The unique plant community assemblages for these wetlands in the Missouri Plateau ecoregion would require IPCI metrics to be calibrated to regional reference standards for this ecoregion. Further research on slope wetlands in this region would also help in creating valid assessments for these wetland types.

Wetlands located in the Turtle Mountains were also segregated from other regional reference wetlands on the NMS scatterplot (Figure 14). The wetlands sampled in this region were characterized as having higher species richness metric scores and a lower % annual, biennial, and introduced species (Figure 14). Even though the forested wetlands in the Turtle Mountains were more closely related to remnant natural PPR wetlands, the incidence of higher C-Values and species richness might be an indicator of disturbance. Mack (2009) had found that metrics dealing with plant species diversity may not be suitable for assessing the condition of forest type wetlands. Moreover, the increase in species richness and C-Values could be the cause of native full-sun plant species establishing themselves in disturbed forested wetland sites. Mack (2009) adjusted Ohio's V-IBI for forested wetlands in order to consider a metric that measures the abundance of dependent shade tolerant forested plant species, and also the abundance of full-sun plant species occurring within the wetland. Haeussler et al. (2004) found that forested depressional, riparian, and fen/bog type wetlands may have higher species richness. However, the lack of a metric measuring shade tolerant species and regional natural species diversity, indicates that the IPCI method should be adjusted in order to assess forested type wetlands. There is also the need for further research on forested wetlands in this region.

Likewise, the reference wetlands sampled from the Pembina Gorge region demonstrated lower % annual, biennial, and introduced species metric scores and higher species richness scores (Figure 14). Fen wetland systems are known for their unique diversity of rare, threatened, or endangered plant species (Bedford and Godwin 2003). However, similar to forested wetlands, an increase in species diversity may be an adverse effect of disturbance (Haeussler et al. 2004). Considering this probable effect, the IPCI is not fully developed to accommodate the regional ecological processes of wetlands in the Pembina Gorge area, and suggests the need for further research of wetland types found in this region.

Developing or partitioning a statewide IBI assessment by wetland type and ecoregion could reduce the variation amongst these wetland types. Having calibrated metric and metric scoring protocols for these regions or wetland types would accommodate plant community assemblages that are signature to the environmental and ecological processes exhibited by these wetlands. Calibration of the IPCI would need to be referenced against regional reference standards for each ecoregion or wetland type. This would allow the IPCI assessment to represent similar scores to wetlands of different classes, but with a comparative level of human impacts (Fennessy et al. 2007).

North Dakota Rapid Assessment Analysis

A NMS analysis of the NDRAM's metric scores from the 55 NWCA dataset resulted in a NMS ordination with 2 axes. The first axis represented 69.8% of the variability. The second axis represented 30.2% of the variability. In total both axes represented 100% of the variability. Final stress from the 2 axis solution was 0.09581 with a final instability of

0.00000, 76 iterations were drawn. The low final stress indicated that the ordination provides valid inferences.

Table 4. Pearson correlation coefficients for NDRAM metrics calculated between the NMS ordination axes, and the data from the 55 NWCA dataset.

	Pearson Correlation Coefficient (r)	
Metrics	**Axis 1**	**Axis 2**
Buff. and Land.[a]	-.837	.072
Habitat alt. and dev.[b]	-.457	-.270
Veg.[c]	-.535	-.601

[a] Buffers and surrounding land use.
[b] Hydrology, habitat alteration, and development.
[c] Vegetation.

Pearson correlation coefficients calculated between the different axes and the metrics found that the metric measuring the buffer and surrounding landuse had a significant negative correlation (-0.837) with the first axis (Table 5, Figure 15). Points with an ordination to the left of the 0 value on axis 1, indicated as larger sized triangles, have higher metric scores; therefore signifying that the buffer and surrounding land use for these wetlands are closer to native conditions (Figure 15). The Pearson correlation coefficients for the NDRAM vegetation metric had significant coefficients for both axis 1 (-0.535) and axis 2 (-0.601). Since 100% of the variability in the NMS ordination was represented by both axis 1 and axis 2, analyzing the vegetation metric involved inferring patterns found between both axes. The significant negative correlations with axis 1 and axis 2 infer that points positioned with negative values, for both axes, have metric scores related more to native conditions (Figure 16). Another inference based off of the Pearson correlation coefficients for axis 1 is that the buffer and land use metric is partially correlated with the vegetation metric (Table 4). However, the significant Pearson correlation coefficient with axis 2 for the vegetation metric indicates that the metric is semi-independent of the buffer and land use metric.

These inferences can be observed in the two separate ordination scatterplots for each metric (Figure 15 and Figure 16). The larger triangles indicate wetlands representing higher scores. Larger triangle sizes in the buffer and surrounding land use ordination plot are positioned to the left of the 0 value on axis 1 (Figure 15). The positions of the larger sized triangles for the vegetation metric are plotted differently. They are generally ordinated below the 0 value on axis 2 and also to the left of the 0 value on axis 1 (Figure 16).

A NMS analysis of the sub-metric scores from the 55 NWCA dataset resulted in a NMS ordination with 2 axes. The first axis represented 83.9% of the variability, the second axis represented 13.9% of the variability. Final stress for the two axes solution was 7.80106 with a final instability of 0.00000, 45 iterations were drawn. The low final stress indicated that the ordination provides valid inferences.

Pearson correlation coefficients calculated between the different axes and the sub-metrics found that the sub-metric measuring plant community and habitat development had a significant positive correlation with axis 1 (Table 5). All other sub-metrics, excluding the sub-metric measuring modifications to natural hydrologic regime, had a significant negative correlation with axis 1 (Table 5).

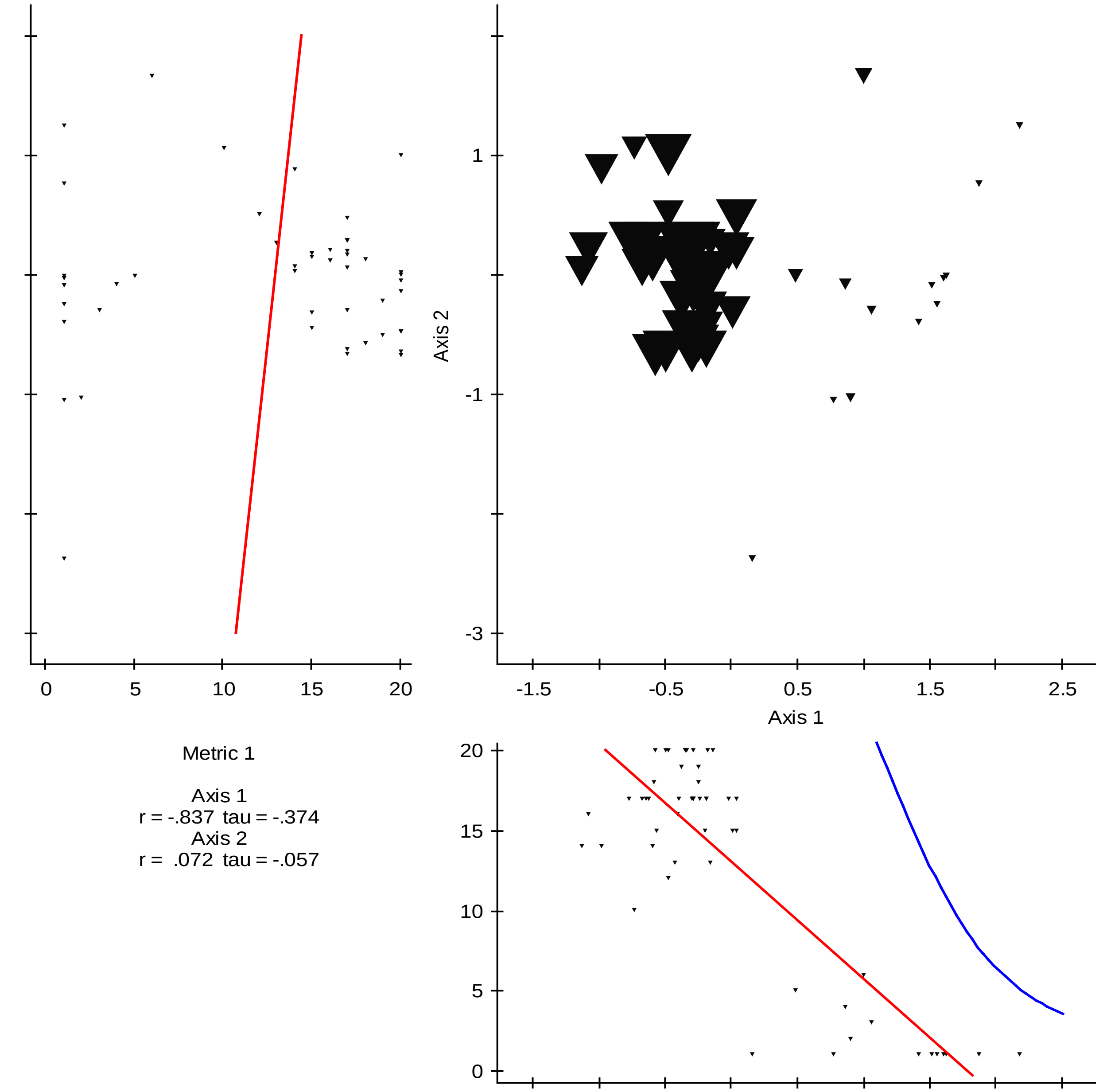

Figure 15. NMS scatterplot of the buffers and surrounding land use metric scores from the 55 NWCA dataset, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the metric's score.

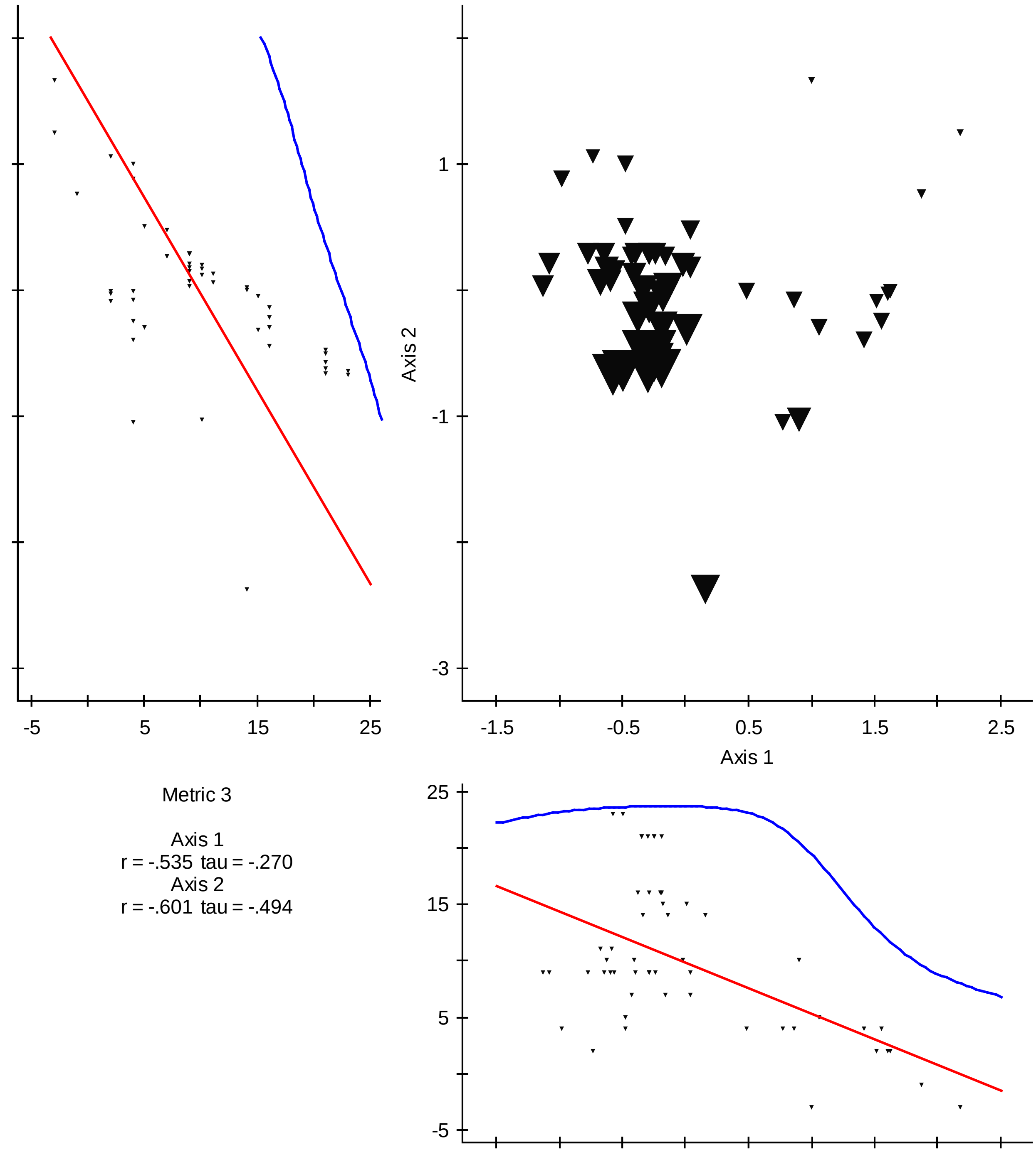

Figure 16. NMS scatterplot of the vegetation use metric scores from the 55 NWCA dataset, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the metric's score.

Table 5. Pearson correlation coefficients for NDRAM sub-metrics calculated between the NMS ordination axes, and the data from the 55 NWCA dataset.

	Pearson Correlation Coefficient (r)	
Sub-Metrics	**Axis 1**	**Axis 2**
Avg. buff. width[a]	-.759	.494
Land.[b]	-.773	.374
Sub/Soil Dist.[c]	-.731	.053
Plants and Dev.[d]	.674	-.235
Alt. and Recover[e]	-.689	.026
Mgmt[f]	-.677	.285
Mod. to Hydro.[g]	.338	.167
Native Potential[h]	-.662	-.155
Invs. Spp.[i]	-.563	-.150
Veg. Cond.[j]	-.776	-.238

[a] Calculate average buffer width.
[b] Intensity of surrounding land use.
[c] Substrate/Soil disturbance.
[d] Plant community and habitat development.
[e] Habitat alteration and recovery from current and past disturbances.
[f] Management.
[g] Modifications to natural hydrologic regime.
[h] Potential of wetland to reach reference (native) condition for the area.
[i] Invasive species.
[j] Overall condition of wetland based on plant species.

The sub-metric measuring plant community and habitat development had the only significant positive correlation with the axis 1 ordination and therefore can be inferred as independent of the other sub-metrics with negative coefficients. Therefore, sub-metrics with significant negative Pearson correlation coefficients for axis 1, are contingent to each other based off their ordination on axis 1. For example if a lower score is recorded for the sub-metric measuring intensity of surrounding landuse, one could predict that the sub-metric score for overall condition of wetland based on plant species will also have a lower score.

An overall analysis of the NDRAM method requires looking at the significant metrics from the NMS ordination and further analyzing the subset data from the NDRAM's sub-metric NMS results. The NMS analysis for the NDRAM metrics indicated that metrics measuring buffer and surrounding land use and vegetation were significant to the 55 NWCA dataset. The sub-metrics that compose each of these metrics were subject to the NMS analysis and resulted in the Pearson correlation coefficient scores shown in Table 5**.** Significant Pearson correlation coefficients for sub-metrics under the buffer and surrounding land use metric include both the sub-metric calculating the average buffer width and the sub-metric measuring the intensity of the surrounding land use (Table 5). Significant sub-metrics for the vegetation metric include both the sub-metric measuring invasive species and the sub-metric measuring the overall condition of wetland based on plant species (Table 5). This eludes that the NDRAM method's most transferable elements are measures of a wetland's buffer condition and buffer width, and measurements on the richness of the buffer and wetland's vegetation community.

Hydrogeomorphic Model Analysis

A NMS analysis of the 6 FCI scores from the 55 NWCA dataset and 40 ecoregion reference dataset, resulted in a NMS ordination with 2 axes. The first axis represented 84.9% of the variability, and the second axis represented 13.3% of the variability. Final stress from the 2 axis solution was 7.74145 with a final instability of 0.00000, 93 iterations were drawn. The low final stress indicated that the ordination provides valid inferences.

Table 6. Pearson correlation coefficients for the HGM's FCIs calculated between the NMS ordination axes, and the data from the 55 NWCA dataset and 40 ecoregion reference dataset.

	Pearson Correlation Coefficient (r)	
FCIs	**Axis 1**	**Axis 2**
Water Storage	-.274	-.161
Groundwater Retention	.260	-.263
Retention of Particulates	-.805	.229
Remove, Convert and Sequester Dissolved Substances	.328	.472
Plant Community Resilience and Structure	.278	.438
Provide Faunal Habitat	.203	.303

Pearson correlation coefficients calculated between the different axes and the FCIs found that the "Retention of Particulates" (capacity of a wetland to physically remove and retain inorganic and organic particulates > 0.45 µm from the water column) FCI has a significant negative correlation (-0.805) with the axis 1. Other FCIs were insignificantly correlated with the axis 1 (Table 6). This analysis infers that the Retention of Particulates FCI has the ability to be transferable; however, further investigation of the Retention of Particulates equation, using model variables sub-index scores, may elude elements of this method that are transferable to other wetlands types in different ecoregions.

The HGM assessment for the PPR (Gilbert et al. 2006) uses an equation including Vsed, Vupuse, Vgrasscont, Vgrasswidth, Vvegcomp, Vout, and Vsubout model variables to mathematically equate the functional capacity index for retention of particulates function of PPR depressional wetlands. Using a NMS analysis, these model variable sub-index scores taken from the 55 NWCA dataset and 40 ecoregion reference dataset resulted in a NMS ordination with two axes. The first axis explained almost all (91.8%) of the variability. The second axis explained a small portion of the variability (6%). Final stress was 6.09299 with a final instability of 0.00000, 63 iterations were drawn. The low final stress indicated that the ordination provides valid inferences.

Table 7. Pearson correlation coefficients for model variables in the retention of particulates FCI equation calculated between the NMS ordination axes, and the data from the 55 NWCA dataset and 40 ecoregion reference dataset.

	Pearson Correlation Coefficient (r)	
Ret. Par. Mod. Var.[a]	**Axis 1**	**Axis 2**
Vupuse	-.750	-.131
Vgrasscont	-.903	.240
Vgrasswidth	-.912	.123
Vvegcomp	-.549	-.500
Vsed	.591	.515
Vout	.024	-.323
Vsubout	-.010	-.559

[a] Retention of Particulates model variables equation = $((V_{SED} \times ((V_{UPUSE} + V_{GRASSCONT} + V_{GRASSWIDTH})/3) + (((V_{VEGCOMP} + (\text{Minimum of } V_{OUT}, V_{SUBOUT}))/2))/2)^{1/2}$.

Pearson correlation coefficients calculated between the different axes and the model variables found that Vgrasswidth (width of grassland perpendicular to the wetland) and Vgrasscont (continuity of grassland adjacent to the wetland), were the dominant significant negative correlations (-0.912 and -0.903) with the first axis (Table 7). Other model variables had significant Pearson correlation coefficients, however, their coefficients were not as close to values of -1 or 1 as much as Vgrasswidth and

Vgrasscont were.   The other model variables with significant Pearson correlation coefficients include Vupuse (land use within the catchment), Vvegcomp (vegetation composition), and Vsed (sediment deposition in the wetland).

Further analysis on the transferability of the HGM assessment required looking into the sub-index scores for the vegetation based model variables: Vgrasswidth, Vgrasscont, and Vvegcomp.   A NMS analysis of these model variables scores from the 55 NWCA dataset and 40 ecoregion reference dataset resulted in a NMS ordination with two axes. The first axis represented almost all (95.8%) the variability; the second axis represented only a small portion (4.1%) of the variability.   Final stress for the 2 axes solution was 0.14526 with a final instability of 0.00000, 102 iterations were drawn.   The low final stress indicated that the ordination provides valid inferences.

Table 8. Pearson correlation coefficients for HGM vegetation model variables calculated between the NMS ordination axes, and the data from the 55 NWCA dataset and 40 ecoregion reference dataset.

	Pearson Correlation Coefficient (r)	
Veg. mod. var.[a]	**Axis 1**	**Axis 2**
Vgrasscont	.842	-.295
Vgrasswidth	.873	.174
Vvegcomp	.182	.087

[a] HGM Vegetation model variables

The Pearson correlation coefficients calculated between the different axes and the model variables found that the Vgrasswidth model variable had a significant positive correlation (0.842) with the first axis (Table 8, Figure 17).   The Vgrasscont model variable also had a significant positive correlation (0.842) with the first axis (Table 8, Figure 18).   These coefficients explain the ordination of the wetland sites based on axis 1.   Larger sized triangles in the ordination scatterplots indicate wetlands that have higher sub-index scores for both model variables measuring the width of grassland perpendicular to the wetland and measuring the continuity of grassland adjacent to the wetland (Figure 17 and Figure 18). Smaller sized triangles represent wetlands with lower sub-index scores for these model variables.

The HGM assessment is designed to be regionally specific for a certain set of hydrogeomorphically similar classification of wetlands in order to evaluate the capacity or performance of associated biological, chemical, hydrologic, and physical functions (Brinson 1993; Smith et al. 1995). The HGM assessment that was utilized in this research was designed for assessing wetlands that are: prairie potholes, low permeability substrate, temporary and seasonal hydroperiods, depressions (Gilbert et al. 2006). Some of the wetlands sampled were classified under this regime, however, other wetlands were not.

The transferability of the HGM assessment to wetlands out of its classified jurisdiction was investigated in order to find common measures of wetland function for wetland types found throughout the state of North Dakota. A similar approach for evaluating the transferability of an HGM guidebook was done by Cole et al. (2008) in the Upper Juanita watershed in Pennsylvania. In their study, transferability was tested in order to expedite the creation of HGM protocols for other regions by discovering similar model variables that bridged between different wetland types.

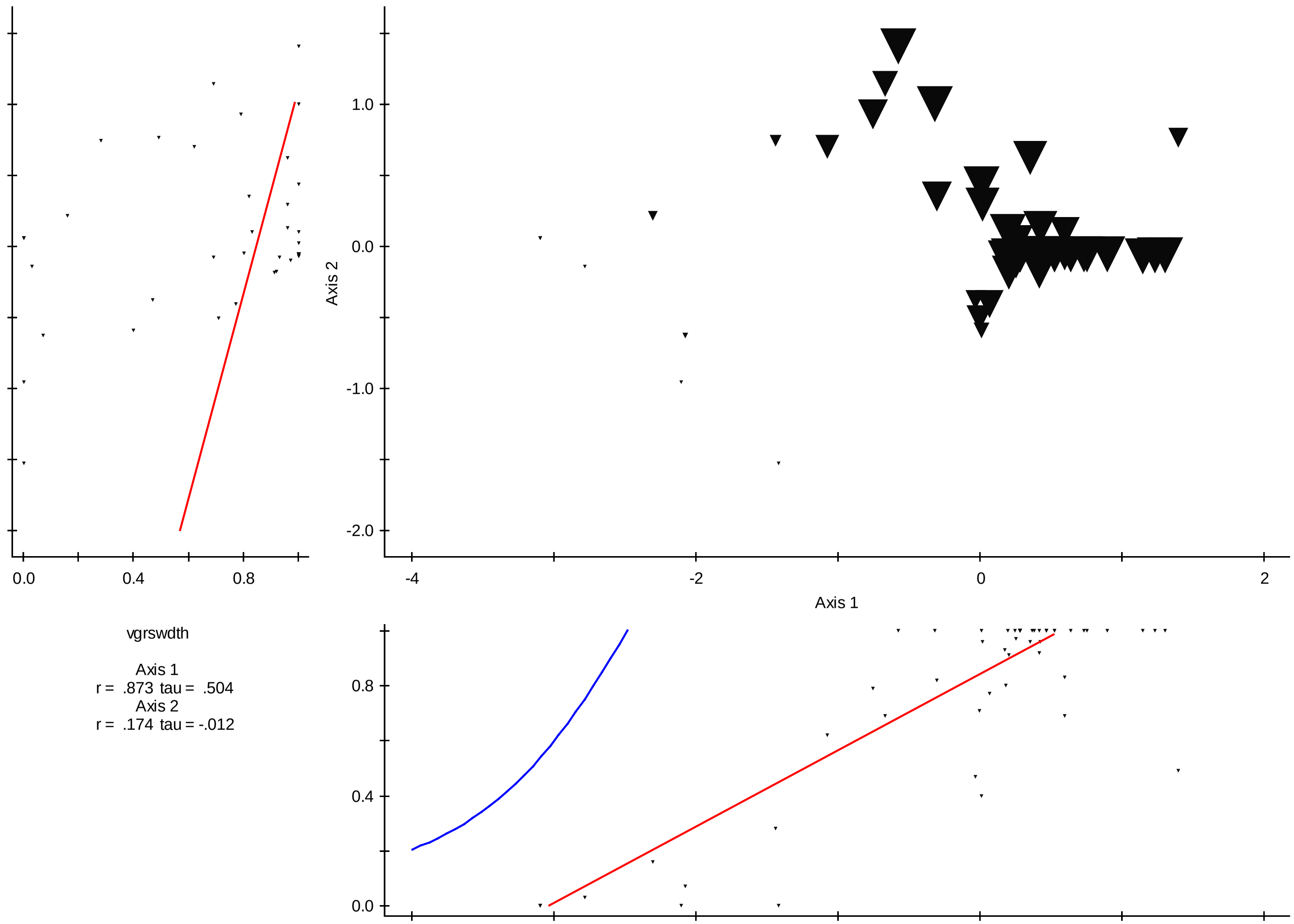

Figure 17. NMS scatterplot of the HGM model variable Vgrasswidth scores from the 55 NWCA and 40 ecoregion reference datasets, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the model variable's score.

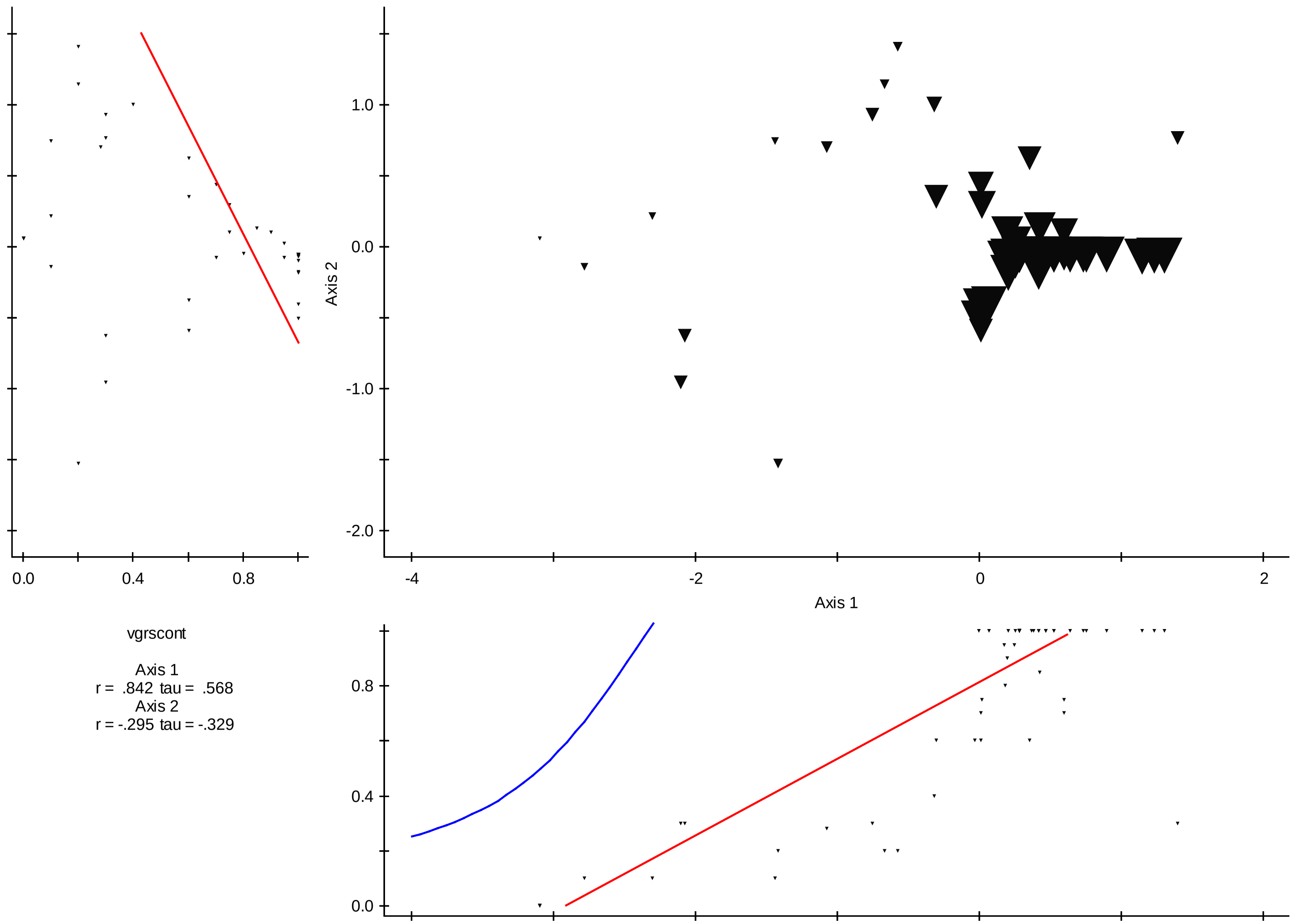

Figure 18. NMS scatterplot of the HGM model variable Vgrasscont scores from the 55 NWCA and 40 ecoregion reference datasets, in relation to the two ordination axes. Each triangle represents a wetland sampled from the dataset, the size of the triangle is proportional to the model variable's score.

Overall, this analysis on the transferability of the HGM assessment concluded that the Retention of Particulates FCI has transferability to other wetland types; however, further investigation of the subset data revealed that Vsed, Vupuse, Vgrasscont, Vgrasswidth, Vvegcomp model variables had contingent elements in representing different wetland types from different ecoregions. Dominant model variables with the most significant Pearson correlation coefficients were measurements on the width of grassland perpendicular to the wetland and measurements on the continuity of grassland adjacent to the wetland. Aspects of the HGM that showed transferability to other wetland types from different ecoregions were measurements made on the buffer width (Vgrasswidth) and vegetation quality (Vgrasscont and Vvegcomp), and the type of land use in the upland or surrounding area (Vupuse). Prior researchers have indicated that the land use and disturbance levels in the surrounding buffer, or low prairie zone of wetlands, is indicative of the plant species composition of PPR depressional wetlands (DeKeyser et al. 2009; Peterson-Smith et al. 2009). The cumulative impacts of surrounding land uses have an influence on plant community composition in wetlands. Wetlands found within natural remnant or native landscapes trend to have less invasion by introduced and exotic species than wetlands within anthropogenic settings (Houlahan et al. 2006). Goebel et al. (2006) found that the plant community compositions in riparian areas are reflective of local environmental conditions and land uses such as agricultural land and urban development.

Results from this investigation of transferability deduce that any HGM assessment method should include in its guidebook, some measurement that deals with indicating buffer vegetation quality, condition, and width and the surrounding land uses in the local vicinity. The HGM guide book developed for Inter-montane depressional wetlands in Montana includes model variables that consider these factors, however no measurement on the buffer width is noted: Vupuse, Vedgeuse, Vwetuse (Hauer et al. 2002). In accordance with the results, Vgrasscont and Vgrasswidth were statistically proven to measure vegetation and buffer attributes of different wetland classes amongst the state of North Dakota. These aspects of the HGM model developed for the PPR can be used in other alternative research in order to provide insight on the average continuity of grassland around the perimeter of a wetland, and the average width of grassland adjacent to a wetland's edge. For example, Jordan et al. (2007) used certain FCI variables to understand how a wetland's function correlates with other measures such as soil composition and nitrogen processing.

Kendall's Test of Concordance

Using the 55 NWCA dataset and the 40 ecoregion reference dataset, the Kendall's *W* program calculated a 64.5% similarity with a p-value of 0.00 between the NMS generated axis 1 for the HGM's FCI scores, and the final scores from the IPCI. The Kendall's *W* program calculated a 73.8% similarity with a p-value of 0.00 between the NMS generated axis 1 for the HGM's FCI scores and the final scores from the NDRAM. The Kendall's concordance test for the IPCI and NDRAM final scores calculated an 81.388% similarity with a p-value = 0.00. Overall, the concordance tests between each of the assessments infers that each assessment is concordant with each other ($p\text{-value} < 0.05$), when using the 55 NWCA wetland dataset and 40 reference ecoregion dataset.

On the other hand, the concordance tests between the three assessments using only the 40 reference ecoregion dataset, produced results inferring that the assessments are not concordant with each other. The Kendall's *W* program calculated 50.7% similarity with a p-value of 0.46 when comparing the NDRAM and IPCI final scores. Between the HGM's axis 1 from NMS and the IPCI finial scores the Kendall's *W* program calculated a 43.3% similarity with a p-value of 0.79 . In addition, the Kendall's *W* program calculated 59% similarity with a p-value of 0.13 between the HGM's axis 1 from NMS and the NDRAM final scores.

From these results a few inferences can be made. The NDRAM, IPCI, and HGM assessments evaluate a wetland by different criteria. The NDRAM evaluates PPR depression type wetlands by inspecting the composition of the vegetation and by identifying stressors in the surrounding landscape that can affect the condition of the wetland. The IPCI assess PPR depression type wetlands by metrics specific to the plant species present throughout the wetland. The HGM evaluates the functional ability of PPR depressional type wetlands to operate. Hargiss (2009) indicated that the overall evaluations, from each of these assessments, are concordant amongst each other when assessing PPR depressional type wetlands. On the other hand, our concordance tests done with the 40 ecoregion reference dataset indicate that, overall, the three assessments are not concordant with each other when evaluating wetlands outside of the PPR depression types.

The concordance results from the 40 ecoregion dataset defend the reason for Brinson's (1991) Hydrogeomorphic and Cowardin et al.'s (1971) classification schemes, which identify wetlands under separate classes and types. Although they are still considered wetlands, differences amongst hydrologic, soil, vegetation, and geomorphic characteristics set them apart from one another. However, from a hierarchal classification standpoint, there are broad categories that group a variety of wetlands by similar basic features, such as the ability to store water for a portion of the growing season. Moreover, the concordance tests done with the 40 ecoregion reference dataset may additionally infer that although the overall evaluation is non-concordant, there may be subset measures within the NDRAM, IPCI and HGM assessments, which can be used in creating assessment methods for different wetland types in North Dakota.

DEVELOPMENT OF STATEWIDE RAPID ASSESSMENT SUB-METRICS

An important aspect in validating and calibrating RAM's is to use level 3 data to adjust and modify a RAM's framework or methodology (USEPA 2006). Level 3 assessment methods for North Dakota would include the IPCI and HGM assessments. The NMS results from both of these assessments inferred that the assessment of different wetland types found throughout the state, should be done by measuring wetlands' buffer width and quality, and the richness of the wetland's plant species in terms of number of native perennials, % of annual, biennial, and introduced species, and the wetlands average C-Value or Floristic Quality Index.

The results from the NMS analysis on the IPCI concluded that wetlands with higher metric scores for average C-Value and number of native perennials have a lower metric score for % annual, biennial, and introduced plant species. The analysis of the HGM revealed that any wetland type from any ecoregion would have a higher sub-index score for buffer width and quality if the vegetation community in the wetland has a higher FQI score and the surrounding landscape is not severely disturbed by anthropogenic disturbances.

However, the analysis done on the NDRAM metrics indicated that wetlands with native or close to native vegetation communities need some kind of disturbance in the buffer. Higher scores for the buffer and surrounding land use metric did not always mean that the vegetation metric was going to score high. This observation from the NMS ordination could be a result of the NDRAM's scope, which is focused on characterizing the condition of depressional wetlands in the PPR (Hargiss 2009). Plant communities and wetlands in the PPR are characteristic to specific disturbances that have occurred naturally over time (grazing, fire) (Kantrud et al. 1989, Kantrud and Newton 1996, DeKeyser 2000, Hargiss 2009). The NDRAM's buffer and land use, and vegetation metrics indicate that these characteristic disturbances explain better plant communities, however these disturbances may not have the same effect on other plant communities for other wetland classes found in different eco-regions throughout North Dakota (Fennessy et al. 2004).

Multiple states have designed robust RAMs in order to assess the condition of different classified wetlands occurring statewide (Fennessy et al. 2004; Collins et al. 2008). These RAMs have a protocol evaluating a wetland's form and structure separate from present stressors. By evaluating the stressors separately, a RAM's score can better explain how stressors affect the condition of a wetland (Sutula et al. 2006). To better the transferability of the NDRAM for statewide applicability, metrics and sub-metrics should evaluate the form and structure of a wetland separate from specific stressors. This would provide a robust evaluation for any wetland class and create a NDRAM indifferent to wetland class and intra-inter annual seasonality (Fennessy et al. 2004; Collins et al. 2008).

Sub-metrics to be added into the present NDRAM version assess the condition of a wetland's buffer by analyzing the extent and quality of the vegetation cover and condition of the substrate and amount of human disturbance in the buffer area. The other sub-metric evaluates the cover and quality of wetland vegetation communities present in the wetland. By evaluating aspects such as the plant communities present, interspersion or continuity of vegetation, and relative cover of plant species, an interpretation can be provided for explaining the range and structure of wetland's vegetation. This evaluation can also indicate or interpret factors that shape a wetland in its landscape (Bedford 1996; Fennessy et al. 2004).

Table 9 and Table 10 are the sub-metrics scorecards. Tables 11, 12, 13, and 14 are supplemental narrative descriptions for assessing the sub-metric scorecard in Table 10. The narrative descriptions for both sub-metrics were developed from NMS results and inferences from the analysis of the IPCI and the HGM . Consideration for these sub-metrics were also guided from reviewing the Ohio Rapid Assessment Method (ORAM) v. 5.0 (Mack 2001) and the CRAM field books (Collins et al. 2008). The sub-metric in Table 9 assigns a numerical score in order to differentiate higher conditions (score of 7) from lower conditions (score of 1). The other sub-metric measuring vegetation communities and interspersion assigns alpha-numerical values (A,B,C, or D) for vegetation communities present. Not providing a numerical score to this sub-metric provides an un-biased approach in assessing multiple wetland types with different vegetation communities present. Therefore, this sub-metric acts as a report card providing an illustration of the quality and cover of the vegetation community (or communities) present. A report card can evaluate the plant or ecological systems present and provide insight for management and monitoring programs (CNHP and The Nature Conservancy 2008).

Table 9. Buffer condition sub-metric for the buffer and landscape setting metric in a statewide Rapid Assessment Method.

Buffer condition: Derived from extent and quality of vegetation cover and present condition of the substrate and the amount of anthropogenic influence on the buffer area (wetland border or low prairie zone).	
Score	Narrative description of the buffer condition
7	Area is dominated by native vegetation, characterized by undisturbed soils **and** is subject to little or no anthropogenic influence.
5	Area has an intermediate mix of native and non-native vegetation (25-75%), characterized by undisturbed soils, **and/or** subject to little or no anthropogenic influence. **-OR-** Area is dominated by native vegetation, **but** soils are characterized by some disturbance/compaction, **and** subject to minimal or low anthropogenic influence.
3	Area is substantially characterized by non-native vegetation (>75%), soils are characterized by ≥ moderate disturbance/compaction, **and/or** ≥ moderate anthropogenic influence.
1	Area is characterized by bare ground **and/or** highly disturbed/compacted soils, **and/or** intense anthropogenic influence.
	Other:

Table 10. Wetland vegetation communities and interspersion scorecard for a statewide Rapid Assessment Method.

Wetland Vegetation Communities/Interspersion: Indicates the presence or absence of wetland vegetation communities, their relative cover, and quality.	
Wetland vegetation community	Cover/Quality of vegetation community[1]
Aquatic Bed	
Emergent	
Shrub	
Forest	
Mudflats[2]	
Open water[2]	
Other__________	

[1]See Table 11 for narrative descriptions and scoring.
[2]See Table 13 for narrative descriptions and scoring.

Table 11. Narrative descriptions and score values for assessing the wetland vegetation communities and interspersion scorecard.

Cover scale for wetland vegetation communities	
Score/Value	Narrative description
A	Present: makes up a large part of the area and is of high quality[1].
B	Present: makes up a small part of the area and is of high quality[1] **-or-** makes up a large part of the area and is of intermediate quality[1].
C	Present: makes up a small part of the area and is of intermediate quality[1] **-or-** makes up a large part of the area and is of low quality[1].
D	Absent or <0.1ha
N/A	Not applicable to wetland

[1]See Table 12 for narrative descriptions determining quality.

Table 12. Supplemental quality scale for assessing the quality of wetland vegetation communities in the wetland vegetation communities and interspersion scorecard.

Quality scale for vegetation communities	
Score	Quality descriptions
High	High species diversity, dominated by native species, absent or virtually absent non-native or native disturbance tolerant species.
Intermediate	Intermediate species diversity, native species are a dominant component, some non-native or native disturbance tolerant species.
Low	Low species diversity **and/or** dominance of non-native or disturbance tolerant native species.

Table 13. Narrative descriptions and score values for assessing open water and mudflat vegetation communities for the wetland vegetation communities and interspersion scorecard.

Mudflat and Open water cover/quality scale for vegetation communities	
Score	Narrative Description
A	High (≥4 hectare)
B	Intermediate (1 to < 4 hectare)
C	Low (0.1 to < 1 hectare)
D	Absent
N/A	Not applicable to wetland

Inferences from the IPCI indicate that higher species richness and C-Values are negatively correlated to % annuals, biennials, and introduced species throughout the wetland. The HGM results reveal that a statewide assessment needs to measure a wetland's buffer extent, quality and also the cover and quality of its vegetation community.

The NMS ordination scatterplot from analysis of HGM vegetation model variables also provides a grouping pattern that aids in developing narrative descriptions for both sub-metric scorecards (Figure 20).

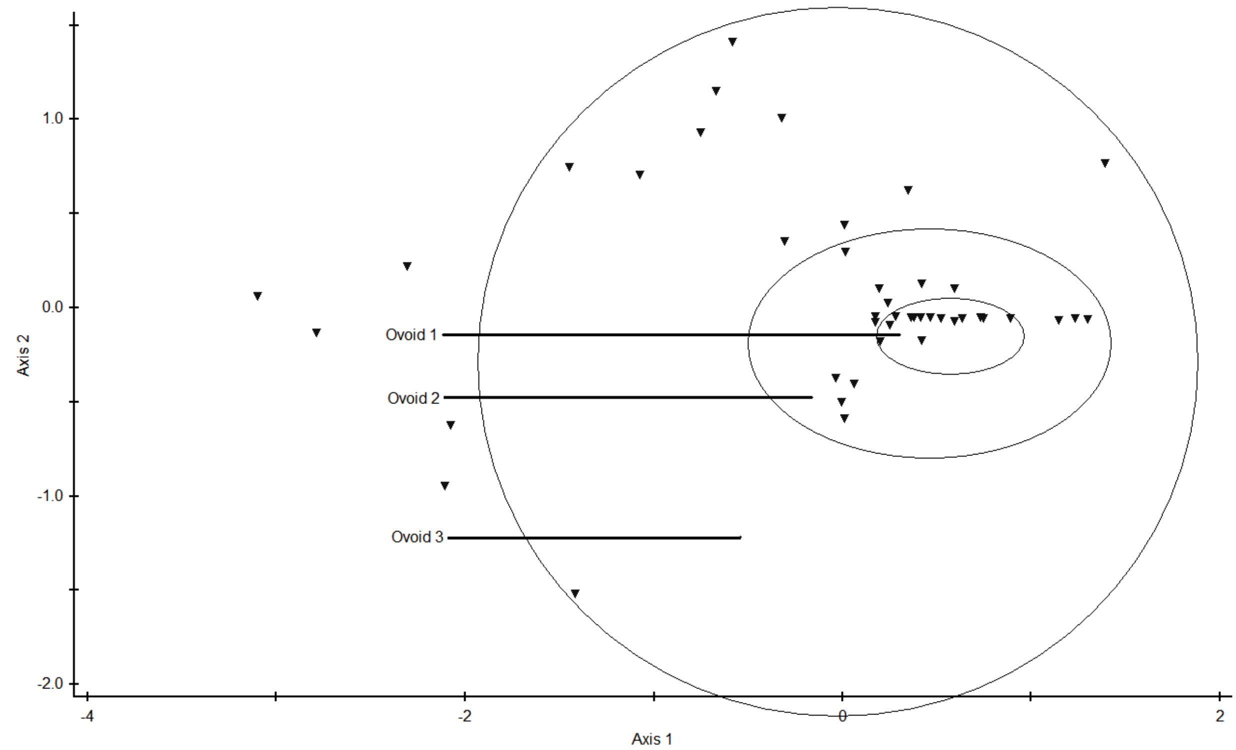

Figure 19. Scatterplot diagram of wetlands from the 55 NWCA and 40 ecoregion reference datasets based on NMS ordination of HGM vegetation model variables' scores. Distances amongst the triangles approximate the dissimilarity in HGM model variables' scores.

The ordination of the 55 NWCA dataset and 40 ecoregion reference dataset in Figure 19 displays a unique ordination; it presents a grouping pattern (shown as ovoid 1, 2, and 3) based on surrounding land use, buffer quality and condition, and plant species and community composition. Wetlands ordinated in ovoid 1 are all wetland types from different regions that represent remnant natural areas with native grassland, intact forests, and no sign of anthropogenic disturbances. The buffer areas and wetland vegetation of these wetlands are representative of native perennial forbs, grasses, and grass-like species and wetland sites have scarce amounts of invasive or exotic species. Moving away from ovoid 1, wetlands sites have increases in the magnitude of anthropogenic disturbance and a decrease in native perennial grasses and forbs.

Wetlands within the ovoid 2 have a buffer with low magnitude disturbances (i.e. hay, idle) effecting the plant community composition slightly. These wetlands have high C-Values and abundant with native perennial forbs and some grasses. Ovoid 3 has wetlands with mixed buffers with some native plant communities. However, disturbances in the uplands result in the introduction of low C-Value plant species. Outliers beyond ovoid 3 were sampled wetlands characterized as plowed through wetlands or wetlands heavily disturbed by anthropogenic disturbances. The buffer area around the wetland is either row crop or tilled, and the vegetation community is represented by annuals, biennials, introduced or exotic invasive species, cropland weeds, or bare ground. Wetland vegetation in this group is similarly depicted as in Stewart and Kantrud's (1971) drawdown cropland tillage phase.

Tutorial on Filling Out New Sub-metrics

The buffer condition sub-metric is filled out via a field visit and done with BPJ. If the wetland exemplifies one of the narrative descriptions for the buffer condition sub-metric than it is awarded the coinciding score. However, in cases where the wetland does not exemplify one of the narrative descriptions, the scorer can provide an alternative in the "Other" narrative description category and award it a score using BPJ.

The scorecard assessing the vegetation communities and interspersion is done via a field visit and filled out using BPJ. The left column provides a list of vegetation communities. The cover and quality of the vegetation community is scored by an alphanumerical value from examining the narrative descriptions in Table 11. If a vegetation community is not applicable to the wetland type being assessed then **N/A** is assigned in the cover and quality column for the scorecard (Table 14).

Table 14. Tutorial example for assigning N/A in the wetland vegetation communities and interspersion scorecard.

Wetland Vegetation Communities/Interspersion: Indicates the presence or absence of wetland vegetation communities, their relative cover, and quality.	
Wetland vegetation community	Cover/Quality of vegetation community[1]
Aquatic Bed	**N/A**
Emergent	
Shrub	**N/A**
Forest	
Mudflats[2]	**N/A**
Open water[2]	
Other__________	

[1]See Table 11 for narrative descriptions and scoring.
[2]See Table 13 for narrative descriptions and scoring.

However, if the vegetation community is typical of the wetland type in normal conditions, than a value is recorded in the cover and quality column. Table 11 provides narrative descriptions in order to guide scoring the scorecard. Additionally Table 12 provides descriptions for the nomenclature used to describe the quality (High, Intermediate, and Low). The supplemental table for describing the level of quality is to reduce the variability or error amongst different scorers using this assessment. If the scorer decides a vegetation community cover and quality demonstrates one of the narrative descriptions in Table 11 then the value is recorded in the scorecard (Table 15).

Table 15. Tutorial example for assigning an alphanumeric value in the wetland vegetation communities and interspersion scorecard.

Wetland Vegetation Communities/Interspersion: Indicates the presence or absence of wetland vegetation communities, their relative cover, and quality.	
Wetland vegetation community	Cover/Quality of vegetation community[1]
Aquatic Bed	N/A
Emergent	**B**
Shrub	N/A
Forest	
Mudflats[2]	N/A
Open water[2]	
Other__________	

[1]See Table 11 for narrative descriptions and scoring.
[2]See Table 13 for narrative descriptions and scoring.

The scorer continues to fill out the scorecard in order to depict the vegetation communities of the wetland type under normal conditions. However, if a vegetation community is absent, but shouldn't be, the scorer reports the value found in Table 11 for absent vegetation communities (Table 16). An additional narrative description table is provided for mudflats and open water vegetation communities. If the wetland has a mudflat or open water vegetation community that is in accord with the narrative descriptions in Table 13, then the scorer records the value in the scorecard (Table 16). In this example, the forested type wetland has an intermediate quality emergent vegetation community, however, the forest vegetation community is absent or less than 0.1 ha of the wetland and there is 0.1 to < 1 ha of open water vegetation. Furthermore, if a wetland type has a vegetation community not described in the scorecard, then the scorer can fill out the "Other" field in the first column of the scorecard (Table 17).

Table 16. Tutorial example for assigning an alphanumeric value for an open water or mudflats vegetation community in the wetland vegetation communities and interspersion scorecard.

Wetland Vegetation Communities/Interspersion: Indicates the presence or absence of wetland vegetation communities, their relative cover, and quality.	
Wetland vegetation community	Cover/Quality of vegetation community[1]
Aquatic Bed	N/A
Emergent	B
Shrub	N/A
Forest	D
Mudflats[2]	N/A
Open water[2]	**C**
Other__________	

[1]See Table 11 for narrative descriptions and scoring.
[2]See Table 13 for narrative descriptions and scoring.

Table 17. Tutorial example for assigning the other wetland vegetation community option in the wetland vegetation communities and interspersion scorecard.

Wetland Vegetation Communities/Interspersion: Indicates the presence or absence of wetland vegetation communities, their relative cover, and quality.	
Wetland vegetation community	Cover/Quality of vegetation community[1]
Aquatic Bed	N/A
Emergent	A
Shrub	N/A
Forest	N/A
Mudflats[2]	N/A
Open water[2]	N/A
Other _**Emergent Saline**_	**B**

[1]See Table 11 for narrative descriptions and scoring.
[2]See Table 13 for narrative descriptions and scoring.

In this case the scorer added an emergent saline vegetation community. The "Other" category is for the scorer to insert a vegetation community description that is missing or more descriptive. Additionally, in the comments section, the scorer may want to write reasons why the "Other" category was used. The comments section can also be used to describe the wetland's vegetation communities in more in-detail.

Adding the sub-metric in Table 9 to the NDRAM would result in removing the current sub-metric 1b (intensity of surrounding land-use). The point categories for the current sub-metric would transfer to the new sub-metric in Table 9. By installing the sub-metric in Table 9 in the present NDRAM version, would allow a more uniform assessment amongst all ecoregions and different wetland classes found in North Dakota. Adding the scorecard in Table 10 to the NDRAM would not result in adjusting the scores in order to keep the final score of the assessment 100 points.

MANAGEMENT IMPLICATIONS

There is a possibility of a statewide assessment for North Dakota wetlands. However, current regional methods have to be designed to accommodate regional differences in plant communities, reference standards, and hydrogeomorphic processes. The IPCI would need to be calibrated to different wetland classes by incorporating metrics that represent regional ecological processes, and relate the condition of a wetland in accordance with the regional reference standards.

The NDRAM has the possibility of being sensitive to all wetland classes in North Dakota if sub-metrics and metrics were an evaluation on wetland form and structure, and noted stressors on a separate checklist. The HGM method would be transferable to all wetlands in North Dakota if more regional guide-books were developed in order to evaluate the different hydrogeomorphic classes of wetlands found throughout the state. A statewide wetland assessment would be beneficial not only to the scientific community, but also to government agencies, private industries, and the general public. The application of a statewide assessment method would allow proper indexing of wetland condition for management, mitigation, monitoring, conservation, and protection of wetlands, now and for the future.

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APPENDIX A. DETAILED DESCRIPTIONS FOR WETLANDS SAMPLED IN THE 55 NWCA AND 40 ECOREGION REFERENCE DATASETS

Table A1. List of wetlands from the 55 NWCA 40 ecoregion reference datasets depicting site i.d., Cowardin et al. 1971 classification, wetland type, county, latitude and longitude.

Site #	Wetland Type[a]	County	Latitude	Longitude	HGM Land Use Code[b]
5001	Seasonal Depressional	Stutsman	47.199866	-98.787754	79a
5003	Semi Permenant Depressional (Lacustrine Fringe)	Sheridan	47.602358	-100.408356	79a
5004	Temporary Depressional	Bottineau	48.879718	-100.663489	98, 79a, 69b
5006	Semi Permenant Depressional (Lacustrine Fringe)	Nelson	47.825361	-98.173759	69b
5007	Riparian (Oxbow/Saline) Temporary	Billings	47.244844	-103.289167	Grazed 69b
5008	Seasonal Depressional	Renville	48.853747	-101.734305	79a
5010	Seasonal Depressional	Ransom	46.354189	-97.468212	98, 75
5011	Permenant Depressional (Lacustrine)	Burleigh	47.184499	-100.401375	Grazed 69b
5012	Semi Permenant Depressional (Lacustrine Fringe)	Burke	48.769736	-102.644221	69b
5013	Semi Permenant Depressional (Lacustrine Fringe)	Pierce	48.38973	-99.730017	69b
5015	Low Land Saline (Riparian) Temporary	Adams	46.168993	-102.465416	Grazed 79a
5016	Riparian Semi Permenant	Pembina	48.798334	-97.733043	69b, 61
5017	Seasonal Depressional	Walsh	48.351826	-98.228343	69s
5018	Seasonal Depressional	Bottineau	48.955488	-101.23654	Grazed 69b
5019	Semi Permenant Depressional (Lacustrine Fringe)	Nelson	47.931093	-98.221209	79a, 69a
5021	Semi Permenant Depressional (Lacustrine Fringe)	Dickey	46.108727	-98.896921	69b
5023	Semi Permenant Depressional (Lacustrine Fringe)	Burleigh	46.915981	-100.200047	79a
5027	Seasonal Depressional	Slope	46.426751	-103.089604	79a, 79b, 69a

Table A1. (Continued)

Site #	Wetland Type[a]	County	Latitude	Longitude	HGM Land Use Code[b]
5030	Seasonal Depressional	Walsh	48.236622	-98.262384	69b
5032	Seasonal Depressional	Bottineau	48.688003	-101.220021	Grazed 69b
5034	Seasonal Depressional	Steele	47.273933	-97.749742	69b
5037	Semi Permenant Depressional (Lacustrine Fringe)	Mclean	47.367658	-100.80623	69b
5040	Semi Permenant Depressional (Lacustrine Fringe)	Rolette	48.817798	-99.685235	79a
5042	Seasonal Depressional	Mchenry	48.071318	-100.419674	69b
5043	Semi Permenant Depressional (Lacustrine Fringe)	Logan	46.536591	-99.429962	71, 72b
5046	Seasonal Depressional	Burleigh	46.917062	-100.237146	Grazed 69b
5048	Semi Permenant Depressional (Lacustrine Fringe)	Ward	48.029477	-101.611066	75a, 61
5049	Semi Permenant Depressional (Lacustrine Fringe)	Mcintosh	46.008085	-99.087701	Grazed 69b
5052	Semi Permenant Depressional (Lacustrine Fringe)	Dickey	46.118288	-98.876435	61
5055	Semi Permenant Depressional (Lacustrine Fringe)	Pierce	48.378733	-99.737211	75, 61
5056	Semi Permenant Depressional (Lacustrine Fringe)	Logan	46.589206	-99.42079	90, 75, 69b
5059	Seasonal Depressional	Walsh	48.475155	-98.217563	75
5062	Semi Permenant Depressional (Lacustrine Fringe)	Ward	48.592716	-102.23213	Grazed 75, 61
5065	Semi Permenant Depressional (Lacustrine Fringe)	Kidder	47.197185	-99.924721	98, 69b
5066	Seasonal Depressional	Renville	48.851731	-101.740764	72b
5067	Semi Permenant Depressional (Lacustrine Fringe)	Mcintosh	46.137029	-99.34873	Grazed 75, 61

Table A1. (Continued)

Site #	Wetland Type[a]	County	Latitude	Longitude	HGM Land Use Code[b]
5068	Fen Temporary	Pembina	48.78548	-97.757942	Grazed 61
5069	Seasonal Depressional	Stutsman	47.131597	-99.208903	Grazed 74a
5072	Semi Permenant Depressional (Lacustrine Fringe)	Mountrail	48.110772	-102.209249	98, 75, 69a
5073	Seasonal Depressional	Burleigh	46.912737	-100.223631	98, 69a
5075	Semi Permenant Depressional (Lacustrine Fringe)	La Moure	46.565028	-98.989472	69b
5077	Seasonal Depressional	Dickey	46.060652	-98.099341	79a
5078	Seasonal Depressional	Bottineau	48.672473	-101.207191	79a
5079	Seasonal Depressional	Wells	47.466397	-99.524628	69b
5082	Riparian Semi Permenant	Pembina	48.797818	-97.736775	61
5083	Semi Permenant Depressional (Lacustrine Fringe)	Nelson	47.822517	-98.17961	79a, 75, 69a
5084	Seasonal Depressional	Kidder	46.83646	-99.60636	Grazed 98, 69b
5085	Semi Permenant Depressional (Lacustrine Fringe)	Sheridan	47.739127	-100.563759	75
5089	Seasonal Depressional	Mclean	47.374251	-100.79192	69b
5091	Seasonal Depressional	Wells	47.621626	-99.735634	75
5093	Semi Permenant Depressional (Lacustrine Fringe)	Nelson	47.930465	-98.226496	98, 75, 69a
5094	Seasonal Depressional	Sheridan	47.724992	-100.185961	79a
5095	Semi Permenant Depressional (Lacustrine Fringe)	Walsh	48.235145	-98.269298	90, 69a, 69b
BotRef	Depressional Forested Seasonal		48.858	-100.1277	69b
LwRef	Semi Permenant Depressional (Lacustrine Fringe)		48.668477	-102.403441	69b
SMP1	Seasonal Riverine	Grant	46.149201	-101.9301119	61

Table A1. (Continued)

Site #	Wetland Type[a]	County	Latitude	Longitude	HGM Land Use Code[b]
TMP2	Temporary Linear	Grant	46.166471	-101.921676	61
TMP3	Temporary Linear	Grant	46.166706	-101.921362	61
TMP4	Temporary Linear	Grant	46.163931	-101.923025	61
SMP5	Seasonal	Billings	46.818478	-103.369999	Grazed 61
SMP6	Seasonal	Billings	46.819033	-103.378281	61
SMP7	Seasonal	Golden Valley	46.702661	-103.830245	Grazed 61
TMP8	Temporary	Billings	46.817776	-103.37232	61
TMP9	Temporary	Billings	46.818478	-103.369999	Grazed 61
SMP10	Seasonal	Grant	46.13702033	-101.9163849	Grazed 61
SPG1	Seasonal	Cavalier	48.954257	-98.122957	61
TPG2	Temporary	Cavalier	48.953164	-98.121695	61
SPG3	Seasonal	Cavalier	48.952956	-98.121786	61
SPG4	Seasonal Seep	Cavalier	48.987232	-98.174273	61
SPG5	Seasonal Forest	Cavalier	48.987237	-98.174654	61
TPG6	Temporary	Cavalier	48.986942	-98.174606	Grazed 61
SPG7	Seasonal	Cavalier	48.987616	-98.173876	61
TPG8	Temporary	Cavalier	48.987634	-98.173782	61
TPG9	Temporary Seep	Cavalier	48.992586	-98.183484	61
TPG10	Temporary Forest	Cavalier	48.987937	-98.175107	61
STMPP1	Seasonal Forest	Rolette	48.94706	-100.129157	61
STMPP2	Seasonal	Bottineau	48.966854	-100.45679	61
TTMPP3	Temporary Forest	Bottineau	48.968611	-100.453619	61
TTMPP4	Temporary	Bottineau	48.971198	-100.457729	61
SRRV1	Seasonal Depressional	Pembina	48.625156	-97.820322	61
SRRV2	Seasonal Depressional	Pembina	-97.8202	48.626253	61
TRRV3	Temporary Depressional	Pembina	-97.820926	48.626277	61

Table A1. (Continued)

Site #	Wetland Type[a]	County	Latitude	Longitude	HGM Land Use Code[b]
TRRV4	Temporary Depressional	Pembina	48.627342	-97.819946	Grazed 61
SRRV5	Seasonal Depressional	Pembina	48.624091	-97.819813	Grazed 61
TRRV6	Temporary Depressional	Pembina	48.623291	-97.819716	Grazed 61
SRRV7	Seasonal Depressional	Pembina	48.729882	-97.263105	61
TRRV8	Temporary Depressional	Pembina	48.730247	-97.261985	61
SRRV9	Seasonal Depressional	Pembina	48.730735	-97.261942	61
TRRV10	Temporary Depressional	Pembina	48.730116	-97.261853	61
SSL1	Seasonal Forest				61
TSL2	Temporary Forest				61
SSL3	Seasonal				61
TSL4	Temporary				61
TSL5	Temporary				61
SSL6	Seasonal				61

[a] Wetland Classification based off of Stewart and Kantrud 1971 and field observations.
[b] HGM Vupuse codes:

98 = Urban, semi-pervious, or impervious surface.
90 = Feed Lot.
79 = Conventional tillage row crop.
77 = No-till row crop/high residue crops.
72 = Rowcrop – contoured and terraced.
75 = Conventional tillage small grain.
73 = No-till small grain/high residue crops.
71 = Small grain – contoured and terraced.
72 = Minimum till in a grass/legume rotation.
74 = Farmsteads.
69 = Permanent hay land.
79 = Rangeland - Native species, overgrazed, high amount of bare ground, low plant vigor and evidence of soil erosion (e.g., gullies, rills, etc.).
74 = Rangeland - Native or non-native species, often overgrazed, some bare ground, low plant vigor.
69 = Rangeland dominated by non-native species under some type of management; -OR- Rangeland – native species with fair grazing management such as season-long grazing at slight or moderate intensity; -OR- Rangeland – idle grassland cover (Includes idle native range and CRP).
61 = Native prairie that allows for adequate plant recovery time between vegetation removal.

Table A2. List of wetlands from the 55 NWCA and 40 ecoregion reference datasets depicting site i.d., USEPA sub-ecoregion, and level 1, 2, 3 ecoregion.

Site #	**Sub-Ecoregion**	**Level 3 Ecoregion**	**Level 2 Ecoregion**	**Level 1 Ecoregion**
5001	46f End Moraine Complex	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5003	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5004	46c Glacial Lake Basins	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5006	46j Glacial Outwash	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5007	43b Little Missouri Badlands	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5008	46g Northern Black Prairie	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5010	48b Beach Ridges and Sand Deltas	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
5011	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5012	42d Northern Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5013	46f End Moraine Complex	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5015	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5016	48b Beach Ridges and Sand Deltas	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
5017	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5018	46g Northern Black Prairie	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5019	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5021	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5023	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5027	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5030	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5032	46g Northern Black Prairie	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5034	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5037	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5040	46g Northern Black Prairie	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5042	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS

Table A2. (Continued)

Site #	Sub-Ecoregion	Level 3 Ecoregion	Level 2 Ecoregion	Level 1 Ecoregion
5043	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5046	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5048	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5049	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5052	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5055	46f End Moraine Complex	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5056	42b Collapsed Glacial Outwash	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5059	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5062	42d Northern Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5065	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5066	46g Northern Black Prairie	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5067	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5068	48b Beach Ridges and Sand Deltas	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
5069	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5072	42i Glaciated Dark Brown Prairie	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5073	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5075	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5077	46d Glacial Lake Deltas	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5078	46g Northern Black Prairie	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5079	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5082	48b Beach Ridges and Sand Deltas	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
5083	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5084	42b Collapsed Glacial Outwash	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5085	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS

Table A2. (Continued)

Site #	Sub-Ecoregion	Level 3 Ecoregion	Level 2 Ecoregion	Level 1 Ecoregion
5089	42a Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
5091	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5093	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5094	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
5095	46i Drift Plains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
BotRef	46b Turtle Mountains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
LwRef	42d Northern Missouri Coteau	42 Northwestern Glaciated Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SMP1	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TMP2	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TMP3	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TMP4	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SMP5	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SMP6	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SMP7	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TMP8	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TMP9	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SMP10	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SPG1	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
TPG2	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
SPG3	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
SPG4	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
SPG5	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
TPG6	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
SPG7	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS

Table A2. (Continued)

Site #	Sub-Ecoregion	Level 3 Ecoregion	Level 2 Ecoregion	Level 1 Ecoregion
TPG8	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
TPG9	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
TPG10	46a Pembina Escarpment	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
STMPP1	46b Turtle Mountains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
STMPP2	46b Turtle Mountains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
TTMPP3	46b Turtle Mountains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
TTMPP4	46b Turtle Mountains	46 Northern Glaciated Plains	TEMPERATE PRAIRIES	GREAT PLAINS
SRRV1	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
SRRV2	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
TRRV3	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
TRRV4	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
SRRV5	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
TRRV6	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
SRRV7	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
TRRV8	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
SRRV9	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
TRRV10	48a Glacial Lake Agassiz Basin	48 Lake Agassiz Plain	TEMPERATE PRAIRIES	GREAT PLAINS
SSL1	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TSL2	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SSL3	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TSL4	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
TSL5	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS
SSL6	43a Missouri Plateau	43 Northwestern Great Plains	WEST-CENTRAL SEMI-ARID PRAIRIES	GREAT PLAINS

APPENDIX B. INDEX OF PLANT COMMUNITY INTEGRITY METRIC DESCRIPTIONS, VALUES, AND SCORE RANGES FOR TEMPORARY, SEASONAL, AND SEMI-PERMANENT WETLANDS

Table B1. Index of Plant Community Integrity metrics value and score ranges for temporary depressional wetlands modified from Hargiss 2009.

Temporary Depressional Wetlands				
Metrics	Value range for 0	Value range for 4	Value range for 7	Value range for 11
Sp. Rich (a)	0–16	17–23	24–40	41+
# Genera (b)	0–11	12–19	20–26	27+
Grass-like (c)	0–8	9–10	11–15	16+
% of intro. (d)	41.1+	35.1–41.0	27.1–35.0	0.0–27.0
# Nat. in WMZ (e)	0–7	8–10	11–13	14+
# C = 5 (f)	0–4	5–11	12–16	17+
# C = 4 in WMZ (g)	0–3	4–9	10–12	13+
Avg. C (h)	0.00–2.50	2.51–3.57	3.58–4.58	4.59+
FQI (i)	0.00–13.60	13.61–21.70	21.71–27.20	27.21+

Table B2. Index of Plant Community Integrity metrics value and score ranges for seasonal depressional wetlands modified from Hargiss 2009.

Seasonal Depressional Wetlands				
Metrics	Value range for 0	Value range for 4	Value range for 7	Value range for 11
Sp. Rich (a)	0–19	20–31	32–41	42+
# Genera (b)	0–14	15–24	25–32	33+
Grass-like (c)	0–6	7–10	11–17	18+
% of intro. (d)	41.1+	30.8–41.0	21.1–30.7	0.0–21.0
# Nat. in WMZ (e)	0–8	9–16	17–24	25+
# C = 5 (f)	0–7	8–17	18–26	27+
# C = 4 in WMZ (g)	0–4	5–9	10–16	17+
Avg. C (h)	0.00–2.60	2.61–3.12	3.13–3.52	3.53+
FQI (i)	0.00–10.00	10.01–16.11	16.12–22.99	23.00+

Table B3. Index of Plant Community Integrity metrics value and score ranges for semi-permanent depressional wetlands modified from Hargiss 2009.

Semi-Permanent Wetlands				
Metrics	Value range for 0	Value range for 4	Value range for 7	Value range for 11
Sp. Rich (a)	0–44	45–60	61–71	72+
# Genera (b)	0–34	35–39	40–54	55+
Grass-like (c)	0–8	9–18	19–31	32+
% of intro. (d)	37.2+	34.1–37.1	29.1–34.0	0.0–29.0
# Nat. in WMZ (e)	0–21	22–31	32–44	45+
# C = 5 (f)	0–12	13–18	19–23	24+
# C = 4 in WMZ (g)	0–9	10–14	15–25	26+
Avg. C (h)	0–3.15	3.16–3.57	3.58–3.89	3.90+
FQI (i)	0–22.30	22.31–30.49	30.50–37.09	37.10+

a -Species richness of native perennial plant species.
b -Number of genera of native perennial plant species.
c -Number of grass and grass-like species (Poaceae, Juncaceae, and Cyperaceae).
d -Percentage of the total species list that are annual, biennial, and introduced.
e -Number of native perennial plant species found in the wet meadow zone.
f -Number of plant species with a C-Value = 5 (C-Value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP, 2001)).
g -Number of plant species with a C-Value = 4 found in the wet meadow zone (C-Value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP, 2001)).
h -Average C-Value of all species present (C-Value assigned by the Northern Great Plains Floristic Quality Assessment Panel (TNGPFQAP, 2001)).
i -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)).

Table B4. Index of Plant Community Integrity condition categories for seasonal wetlands modified from Hargiss 2009.

Condition Description	**Total Score**
Very Poor	0-19
Poor	20-39
Fair	40-59
Good	60-79
Very Good	80-99

Table B5. Index of Plant Community Integrity conditional categories for temporary and semi-permanent wetlands modified from Hargiss 2009.

Condition	Total Score
Poor	0-32
Fair	35-65
Good	66-99

APPENDIX C. EQUATIONS FOR THE 6 FUNCTIONAL CAPACITY INDICES, AND DESCRIPTIONS FOR MODEL VARIABLES IN THE PRAIRIE POTHOLE REGION HYDROGEMORPHIC MODEL MODIFIED FROM GILBERT ET AL. 2006

Table C1. Equations and explanations of the 6 functional capacity indices from the Prairie Pothole Region hydrogeomorphic model modified from Gilbert et al. 2006.

Function	Functional Capacity Equation and Definition
Water Storage	FCI = ((Minimum of V_{OUT}, V_{SUBOUT}) x ((V_{SED} + ((V_{SOURCE} + V_{UPUSE})/2)/2))$^{1/2}$
	Capacity of a prairie pothole wetland to collect and retain inflowing surface water, direct precipitation, and discharging groundwater as standing water above the soil surface, pore water in the saturated zone, or soil moisture in the unsaturated zone.
Groundwater Recharge	FCI = ((Minimum of V_{OUT}, V_{SUBOUT}) x (($V_{RECHARGE}$ + V_{EDGE}+ $V_{CATCHWET}$)/3)/2 + ((V_{SQI} + V_{SOM})/2)/2))$^{1/2}$
	Capacity of a prairie pothole wetland to move surface water downward into local or regional groundwater flow paths.
Retain Particulates	FCI = ((V_{SED} x ((V_{UPUSE} + $V_{GRASSCONT}$ + $V_{GRASSWIDTH}$)/3) + ((($V_{VEGCOMP}$ + (Minimum of V_{OUT}, V_{SUBOUT}))/2))/2)$^{1/2}$
	Capacity of a wetland to physically remove and retain inorganic and organic particulates > 0.45µm from the water column.
Remove, Convert, and Sequester Dissolved Substances	FCI = (((Minimum of V_{OUT}, V_{SUBOUT}) x (($V_{GRASSWIDTH}$ + $V_{GRASSCONT}$)/2) + ((V_{SOURCE} + V_{UPUSE} + V_{SED})/3) + (($V_{VEGCOMP}$ + V_{SOM})/2))/3)$^{1/3}$
	Capacity of a wetland to remove and sequester imported nutrients, contaminants, and other elements and compounds.
Plant Community Resilience and Carbon Cycling	FCI = ((Minimum of V_{OUT}, V_{SUBOUT}) x ((V_{UPUSE} + $V_{GRASSCONT}$ + $V_{GRASSWIDTH}$)/3) + ((V_{SED} + V_{SOM})/2) + $V_{VEGCOMP}$)/3)$^{1/2}$
	Capacity of a pothole wetland to sustain native plant community patterns and rates of processes in response to the variability inherent in its natural disturbance regimes.
Provide Faunal Habitat	FCI = ((Minimum of V_{OUT}, V_{SUBOUT}) x (((V_{UPUSE} + V_{SED})/2) + (($V_{HABFRAG}$ x ((V_{BASINS} + $V_{WETAREA}$)/2))$^{1/2}$) + $V_{VEGCOMP}$)/3)$^{1/2}$
	Capacity of a prairie pothole to support aquatic and terrestrial vertebrate and invertebrate populations during some or part of their life cycle.

Table C2. Descriptions of the model variables from the Prairie Pothole Region hydrogeomorphic model modified from Gilbert et al. 2006.

Vegetation Model Variables	
Vgrasscont	Continuity of grassland adjacent to the wetland
Vgrasswidth	Width of grassland perpendicular to the wetland
Vvegcomp	Vegetation composition
Soils Model Variables	
Vrecharge	Estimated soil recharge potential
Vsed	Sediment deposition in the wetland
Vsqi	Soil quality index
Vsom	Soil organic matter
Hydrologic Model Variables	
Vout	Wetland surface outlet
Vsubout	Subsurface drainage
Vsource	Reduction or increase in catchment area
Vedge	Modified shoreline irregularity index
Vcatchwet	Ration of catchment area to wetland area
Land-use and landscape Model Variables	
Vupuse	Land-use within the catchment
Vwetprox	Proximity to nearest wetlands
Vwetarea	Wetland density in the landscape assessment area
Vbasins	Number of basins in the landscape assessment area
Vhabfrag	Sum of the length of roads and ditches in the landscape assessment area

APPENDIX D. NORTH DAKOTA RAPID ASSESSMENT FROM HARGISS 2009

North Dakota Rapid Assessment Method for Wetlands

Directions:

The NDRAM for wetlands was created to rapidly assess temporary, seasonal, and semi-permanent wetlands in the Prairie Pothole Region based on the plant communities present. Results of the NRDAM should indicate results similar to the Index of Plant Community Integrity (IPCI) (DeKeyser 2000, DeKeyser et al. 2003, Kirby and DeKeyser 2003, and Hargiss 2005).

Before conducting the NDRAM employees should complete the short NDRAM field training course. This course will teach them the methods involved in the NDRAM, how to identify significant characteristics of the wetland, and the basic plant community information needed to properly use the NDRAM. Additional training on the HGM Model and the IPCI may also be helpful, but not necessary, to complete the NDRAM. Another additional resource that may be helpful is Stewart and Kantrud (1971).

The NDRAM can be completed by anyone who has had the short field course. The NDRAM should be used as an indicator of wetland condition in an area. However, further investigation into plant communities present and land use practices will be helpful in making recommendations for management of an area. The NDRAM can be used every few years to indicate change in wetland condition. When combined with the IPCI over a larger area, regional wetland plant community trends can also be determined.

References:

DeKeyser, E.S., 2000. A vegetative classification of seasonal and temporary wetlands across a disturbance gradient using a multimetric approach. Ph.D. Dissertation. North Dakota State University, Fargo, ND.

DeKeyser, E.S., Kirby, D.R., Ell, M.J., 2003. An index of plant community integrity: development of the methodology for assessing prairie wetland plant communities. Ecological Indicators 3, 119-133.

Hargiss, C.L.M., E.S. DeKeyser, D.R. Kirby, and M.J. Ell. 2008. Regional assessment of wetland plant communities using the index of plant community integrity. Ecological Indicators 8:303-307.

Kirby, D.R., DeKeyser, E.S., 2003. Index of wetland biological integrity development and assessment of semi-permanent wetlands in the Missouri Coteau Region of North Dakota. Final Report for North Dakota Department of Health. Section 104[b](3) Wetland Grant funds.

Stewart, R.E., Kantrud, H.E., 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Fish and Wildlife Service. Resource Publication 92, 57 pp. Washington D.C.

North Dakota Rapid Assessment Method Form:

Site Name___________________________ **Date**____________________________

Land Ownership_____________________

Person(s) assessing wetland____

Legal Description____

County____

GPS Information:

Datum______________

N___________________

W___________________

General Site Description____

____

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____

Photo's

Photo Number	Direction Facing	Description

Use space below to draw a detailed picture of the wetland. Be sure to include different groups of vegetation and any distinct features. Create a legend for your map. Circle the % cover of the different types of plants on the right.

Sedges	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Cattails	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Grasses	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Rushes	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Forbs	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Shrubs	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Trees	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Other:_______	**0-25%**	**25-50%**	**50-75%**	**75-100%**

N

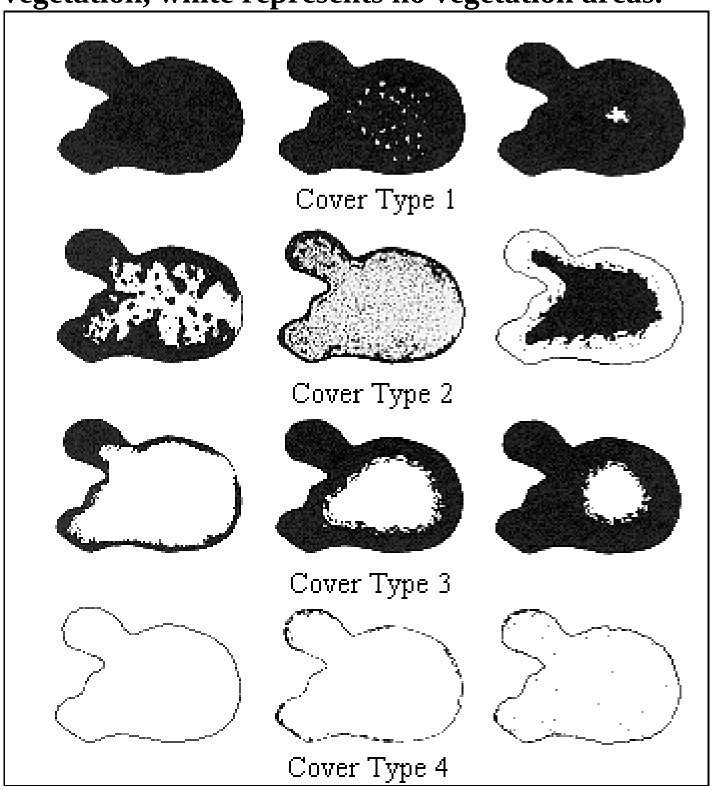
1 square = ____ m
Overall wetland is approximately ________m X ________m
Hydrologic classification (temporary, seasonal, etc.) ___________________________

Site Characterization:

Estimate amount of standing water:

Total wetland area covered by standing water	0	1-25	26-50	51-75	76-100
If water is present:					
Percentage of water <1 ft. deep	0	1-25	26-50	51-75	76-100
Percentage of water 1-3 ft. deep	0	1-25	26-50	51-75	76-100
Percentage of water >3 ft. deep	0	1-25	26-50	51-75	76-100

Estimate (by circling picture below) amount and distribution of cover. Black represents vegetation, white represents no vegetation areas.



Land use and disturbances (check all that apply):

	Dugout		Haying
	Road/prairie trail		Drought
	Cropping		Restored/Reclaimed
	Drain		Idle
	Grazed		Other__________________________

Wetland Classification:

Poor Condition: Poor condition wetlands are wetlands that are highly disturbed with low functioning (Example: cropped, drained, etc.).

Fair Condition: Fair condition wetlands are wetlands that have been disturbed in the past or are currently moderately disturbed. They perform many wetland functions, but are not at full potential compared to less disturbed native wetlands (Example: hayed, mowed, CRP, etc.).

Good Condition: Good condition wetlands are native properly functioning wetlands that are for the most part undisturbed (Example: grazed, native areas).

Preliminary Observations:

#	Question	Circle One	
1	Critical Habitat. Is the wetland in an area that has been designated by the U.S. Fish and Wildlife Service as "critcal habitat" for any threatened and endangered species?	Yes Wetland should be evaluated for possible Good condition status.	No
2	Critical Habitat. Is this wetland a fen or does it contain a fen?	Yes Wetland should be evaluated for possible Good condition status.	No
3	Threatened or Endangered Species. Is the wetland known to contain an individual of, or documented occurrences of, federal or state-listed threatened or endangered plant or animal species?	Yes Wetland should be evaluated for possible Good condition status.	No
4	Poor Condition Wetland. Is the wetland completely plowed through all zones on a regular basis and planted with a crop?	Yes Wetland is a poor condition wetland.	No
5	Good Condition Wetland. Is the wetland in an area that has never been disturbed other than light-moderate grazing, and contains mostly native perennial species?	Yes Wetland should be evaluated for possible Good condition status.	No

Metrics

Metric 1. Buffers and surrounding land use.

1a. Calculate Average Buffer Width

Score	Rating Description
	WIDE. Buffer averages 50m or more around wetland perimeter (10pts)
	MEDIUM. Buffer average 25m to <50m around wetland perimeter (7 pts)
	NARROW. Buffer averages 10m to <25m around wetland perimeter (4 pt)
	VERY NARROW. Buffer averages <10m around wetland perimeter (0 pts)
	OTHER.

1b. Intensity of Surrounding Land Use. Select one or more, average the scores.

Score	Rating Description
	VERY LOW. Native prairie, light to moderate grazing, etc. (10 pts)
	LOW. Hayed prairie area, CRP, etc. (7 pts)
	MODERATELY HIGH. Farm, conservation tillage, planted alfalfa (4 pts)
	HIGH. Urban, row cropping, etc (1 pt)
	OTHER.

	Total for Metric 1 (out of possible 20).

Metric 2. Hydrology, Habitat alteration, and Development.

2a. Substrate/Soil Disturbance. This metric evaluates physical disturbances to the soil and surface substrates of the wetland. The labels on the categories are intended to be descriptive but not controlling. Examples of disturbance include: filling, grading, plowing, hoove action, vehicle use, sedimentation, dredging, etc.

Score	Rating Description
	NONE. There are no disturbances, or beneficial disturbances Ex. light to moderate grazing and fire (7 pts).
	RECOVERED. The wetland appears to have recovered from past disturbances (5 pts).
	RECOVERING. The wetland appears to be in the process of recovering from past disturbances (3 pts).
	RECENT OR NO RECOVERY. Complete removal of vegetation and soil exposed, the disturbances have occurred recently, and/or the wetland has not recovered from past disturbances, and/or the disturbances are ongoing (1 pt).
	OTHER

2b. Plant Community and Habitat Development. This metric asks the rater to assign an overall rating of how well-developed the wetland is in comparison with other ecologically or hydrogeomorphically similar wetlands; based on the quality typical of the region.

Score	Rating Description
	EXCELLENT. Wetland appears to represent best of its type or class. Ex. the wetland is found on native prairie and appears to be diverse in native plant species. (12 pts)
	VERY GOOD. Wetland appears to be a very good example of its type or class but is lacking characteristics which would make it excellent. Ex. wetland may be on native prairie but is lacking diversity because of being left idle or herbicide application. (10 pts)
	GOOD. Wetland appears to be a good example of its type or class but because of past or present disturbances, successional state, or other reasons, it is not excellent. (8 pts)
	MODERATELY GOOD. Wetland appears to be a fair to good example of its type or class. Ex. wetland has past disturbances such as heavy grazing, restoration, or draining that have affected the area. (6 pts)
	FAIR. Wetland appears to be a moderately good example of its type or class, but because of past or present disturbances, successional state, etc. it is not good. Ex. a combination of native and non-native portions to the wetland with low diversity of plant species. (4 pts)
	POOR TO FAIR. Wetland appears to be a good to fair example of its type or class. Ex. wetland may be a monoculture of one plant species or may have native species in a buffer around the wetland, but outer zones are cropped. (2 pts)
	POOR. Wetland appears to not be a good example of its type or class because of past or present disturbances, successional state, etc. Ex. wetland may be completely cropped through with no perennial plant community present. (0 pt)

2c. Habitat Alteration and Recovery from Current and Past Disturbances. This metric evaluates the disturbance level of wetland habitat and the ability to recover from habitat alterations. Ideal management involves some form of disturbance such as moderate grazing or fire to maintain plant vigor and diversity. Leaving areas idle and haying can lead to a monoculture of species. Restored and CRP areas take time to become properly functioning communities and are often planted with at least partially non-native species.

Score	Rating Description
	MOST SUITABLE. The wetland appears to have recovered from past alterations and alterations have been beneficial to habitat. (10 pts).
	NONE OR NONE APPARENT. There are no alterations, or no alterations that are apparent to the rater (7 pts).
	RECOVERING. The wetland appears to be in the process of recovering from past alterations (4 pts).
	RECENT OR NO RECOVERY. The alterations have occurred recently, and/or the wetland has not recovered from past alterations, and/or the alterations are ongoing (1 pt).
	OTHER.

2d. Management.

	Fire or Moderate Grazing. If the area has been burned or is moderately grazed at proper intervals. (4 pts)
	Restored, CRP, Hayed, or Idle. If the area is restored, hayed, planted with CRP, left idle, or has large buffer before cropping begins. (2 pts)
	Cropped. If the wetland is cropped through or cropped with only a very narrow buffer. (0 pts)
	OTHER.

2e. Modifications to Natural Hydrologic Regime. This question asks the rater to identify alterations to the hydrologic regime of the wetland (ex. ditches, drains, etc.) and the amount of recovery from such alterations.

Score	Rating Description
	NONE. There are no modifications or non modifications that are apparent to the rater (12 pts).
	RECOVERED. The wetland appears to have recovered from past modifications to the fullest extent possible. Ex. long established road (8 pts).
	RECOVERING. The wetland appears to be in the process of recovering from past modifications (4 pts).
	RECENT OR NO RECOVERY. The modifications have occurred recently, and/or has not recovered from past modifications, and/or the modifications are ongoing (1 pt).
	OTHER.

2f. Potential of Wetland to Reach Reference (Native) Condition for the Area. This question asks the rater to use their best professional judgment and determine the condition of the wetland and whether it is trending in a positive or negative direction (questions 2a – 2e may help in this determination). In this metric reclamation refers to taking off soil and replacing with wetlands soils and seed bank (strip mining), restoration involves seeding and management of wetland area, management includes a management system such as light to moderate grazing and/or fire and may include spraying of unwanted species.

Score	Rating Description
	EXCELLENT. Wetland is at or near reference condition (12 pts).
	GOOD POTENTIAL. Wetland is disturbed in some way so not at reference condition, but could achieve reference condition easily over time (10 pts).
	MODERATE POTENTIAL. Wetlands is disturbed, but with proper management and time it could return to reference condition (7 pts).
	MODERATELY POOR POTENTIAL. Through proper management and potential restoration/reclamation the wetland may return to reference condition. (5 pts).
	POOR POTENTIAL. Minor potential for return to reference condition, but restoration/reclamation would be needed (2 pt).
	NO POTENTIAL. No potential for return to reference condition without extreme restoration/reclamation efforts (0 pts).

	Total for Metric 2 (out of possible 57).

Metric 3. Vegetation

3a. Invasive species (include in estimate of 3m buffer of low prairie zone). Amount of aerial plant covered by invasived species. Invasive species (native or non-native) include but are not limited to brome, reed canary, quack, kentucky blue, and crested wheat grasses, as well as canada thistle and leafy spurge. Annual crops and weeds should be considered invasives.

Score	Rating Description
	ABSENT. (3 pts)
	NEARLY ABSENT. <5% aerial cover of invasive species (1 pt)
	SPARSE. 5-25% aerial cover of invasive species (0 pt)
	MODERATE. 25-75% aerial cover of invasive species (-1 pts)
	EXTENSIVE. >75% aerial cover of invasive species (-3 pts)

3b. Overall condition of wetland based on plant species using best professional judgment from professional wetland botanist. Walk around wetland area making mental note of plant species present, variety, abundance, etc.

Score	Rating Description
	VERY GOOD (20 pts). Undisturbed native area with a variety of plant species throughout wetland (grasses, sedges, rushes, forbs, etc). Moderate grazing may be utilized. No major impairments to area.
	GOOD (15 pts). Area is still relatively native with a good variety of species. There is an impairment (road, haying, spraying, etc) that has affected the condition of the wetland.
	FAIR (10 pts). Area has been impaired either in the past and is recovering or is currently being impaired but not by something that would decimate the plant community. (CRP, haying, etc.)
	POOR (5 pts). Area is heavily disturbed but there are some plant species still intact. Plant community will consist mostly of non-native annual species, but there may be some native or perennials present. Large populations of invasive species may be present.
	VERY POOR (0 pt). Wetland is heavily disturbed (cropping, hayland, etc) and the plant community if one exists consists of mostly non-native annual species with very little variety. Invasive species may dominate the plant community.

	Total for Metric 3 (out of possible 23).

TOTAL.

Score	
	Total from Metric 1.
	Total from Metric 2.
	Total from Metric 3.
	Rapid Assessment Score

Total points possible is 100:

Condition Ratings are as follows:
Good = 69-100
Fair High = 53-68
Fair Low = 27-52
Poor = 0-26

Score	
	Total for entire wetland.
	Overall condition rating for wetland (Good, Fair, or Poor).

Comments____

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APPENDIX E. 2012 NORTH DAKOTA RAPID ASSESSMENT (NDRAM)

2012 North Dakota Rapid Assessment Method for Wetlands* (*Not Field Tested)

Directions:

NDRAM was created to rapidly assess temporary, seasonal, and semi-permanent wetlands in the Prairie Pothole Region based and additionally assess other wetland types found throughout North Dakota (Stasica 2012). Results of the NRDAM should indicate results similar to the Index of Plant Community Integrity (IPCI) (DeKeyser 2000, DeKeyser et al. 2003, Kirby and DeKeyser 2003, and Hargiss 2005).

Before conducting the NDRAM employees should complete the short NDRAM field training course. Additional training on the HGM Model and the IPCI may also be helpful, but not necessary, to complete the NDRAM. Another additional resource that may be helpful is Stewart and Kantrud (1971).

The NDRAM can be completed by anyone who has had the short field course. The NDRAM should be used as an indicator of wetland condition in an area. However, further investigation into plant communities present and land use practices will be helpful in making recommendations for management of an area. The NDRAM can be used every few years to indicate change in wetland condition. When combined with the IPCI over a larger area, regional wetland plant community trends can also be determined.

References:

DeKeyser, E.S., 2000. A vegetative classification of seasonal and temporary wetlands across a disturbance gradient using a multimetric approach. Ph.D. Dissertation. North Dakota State University, Fargo, ND.

DeKeyser, E.S., Kirby, D.R., Ell, M.J., 2003. An index of plant community integrity: development of the methodology for assessing prairie wetland plant communities. Ecological Indicators 3, 119-133.

Hargiss, C.L.M., E.S. DeKeyser, D.R. Kirby, and M.J. Ell. 2008. Regional assessment of wetland plant communities using the index of plant community integrity. Ecological Indicators 8:303-307.

Kirby, D.R., DeKeyser, E.S., 2003. Index of wetland biological integrity development and assessment of semi-permanent wetlands in the Missouri Coteau Region of North Dakota. Final Report for North Dakota Department of Health. Section 104[b](3) Wetland Grant funds.

Stasica, M.S., 2012. Transferability of regional and wetland specific assessment methods for a statewide approach. M.S. Dissertation North Dakota State University, Fargo, ND.

Stewart, R.E., Kantrud, H.E., 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Fish and Wildlife Service. Resource Publication 92, 57 pp. Washington D.C.

North Dakota Rapid Assessment Method Form:

Site Name__________________________ **Date**___________________________

Land Ownership_____________________

Person(s) assessing wetland____

Legal Description____

County____

GPS Information:

Datum______________

N__________________

W__________________

General Site Description____

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Photo's

Photo Number	Direction Facing	Description

Use space below to draw a detailed picture of the wetland. Be sure to include different groups of vegetation and any distinct features. Create a legend for your map. Circle the % cover of the different types of plants on the right.

Sedges	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Cattails	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Grasses	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Rushes	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Forbs	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Shrubs	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Trees	**0-25%**	**25-50%**	**50-75%**	**75-100%**
Other:_______	**0-25%**	**25-50%**	**50-75%**	**75-100%**

N ↑

1 square = ____ m

Overall wetland is approximately ________m X ________m

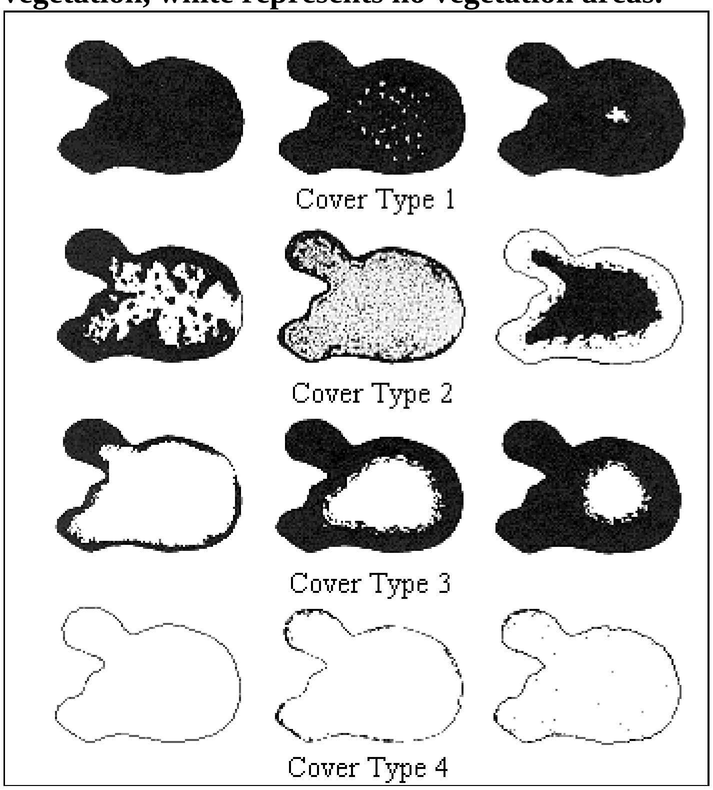
Hydrologic classification (temporary, seasonal, etc.) ___________________________

Site Characterization:

Estimate amount of standing water:

Total wetland area covered by standing water	0	1-25	26-50	51-75	76-100
If water is present:					
Percentage of water <1 ft. deep	0	1-25	26-50	51-75	76-100
Percentage of water 1-3 ft. deep	0	1-25	26-50	51-75	76-100
Percentage of water >3 ft. deep	0	1-25	26-50	51-75	76-100

Estimate (by circling picture below) amount and distribution of cover. Black represents vegetation, white represents no vegetation areas.



Land use and disturbances (check all that apply):

	Dugout		Haying
	Road/prairie trail		Drought
	Cropping		Restored/Reclaimed
	Drain		Idle
	Grazed		Other___________________________

Wetland Classification:

Poor Condition: Poor condition wetlands are wetlands that are highly disturbed with low functioning (Example: cropped, drained, etc.).

Fair Condition: Fair condition wetlands are wetlands that have been disturbed in the past or are currently moderately disturbed. They perform many wetland functions, but are not at full potential compared to less disturbed native wetlands (Example: hayed, mowed, CRP, etc.).

Good Condition: Good condition wetlands are native properly functioning wetlands that are for the most part undisturbed (Example: grazed, native areas).

Preliminary Observations:

#	Question	Circle One	
1	Critical Habitat. Is the wetland in an area that has been designated by the U.S. Fish and Wildlife Service as "critcal habitat" for any threatened and endangered species?	Yes Wetland should be evaluated for possible Good condition status.	No
2	Critical Habitat. Is this wetland a fen or does it contain a fen?	Yes Wetland should be evaluated for possible Good condition status.	No
3	Threatened or Endangered Species. Is the wetland known to contain an individual of, or documented occurrences of, federal or state-listed threatened or endangered plant or animal species?	Yes Wetland should be evaluated for possible Good condition status.	No
4	Poor Condition Wetland. Is the wetland completely plowed through all zones on a regular basis and planted with a crop?	Yes Wetland is a poor condition wetland.	No
5	Good Condition Wetland. Is the wetland in an area that has never been disturbed other than light-moderate grazing, and contains mostly native perennial species?	Yes Wetland should be evaluated for possible Good condition status.	No

Metrics

Metric 1. Buffers and surrounding land use.

1a. Calculate Average Buffer Width

Score	Rating Description
	WIDE. Buffer averages 50m or more around wetland perimeter (10pts)
	MEDIUM. Buffer average 25m to <50m around wetland perimeter (7 pts)
	NARROW. Buffer averages 10m to <25m around wetland perimeter (4 pt)
	VERY NARROW. Buffer averages <10m around wetland perimeter (0 pts)
	OTHER.

1b. Buffer Condition. Derived from the extent and quality of vegetation cover and present condition of the substrate and the amount of anthropogenic influence on the buffer area (wetland border or low prairie zone).

Score	Rating Description
	Area is dominated by native vegetation, characterized by undisturbed soils and is subject to little or no anthropogenic influence (10 pts)
	Area has an intermediate mix of native and non-native vegetation (25-75%), characterized by undisturbed soils, **and/or** subject to little or no anthropogenic influence. **-OR-** Area is dominated by native vegetation, **but** soils are characterized by some disturbance/compaction, **and** subject to minimal or low anthropogenic influence (7 pts)
	Area is substantially characterized by non-native vegetation (>75%), soils are characterized by ≥ moderate disturbance/compaction, **and/or** ≥ moderate anthropogenic influence (4 pts)
	Area is characterized by bare ground **and/or** highly disturbed/compacted soils **and/or** intense anthropogenic influence (1 pt)
	OTHER.

	Total for Metric 1 (out of possible 20).

Metric 2. Hydrology, Habitat alteration, and Development.

2a. Substrate/Soil Disturbance. This metric evaluates physical disturbances to the soil and surface substrates of the wetland. The labels on the categories are intended to be descriptive but not controlling. Examples of disturbance include: filling, grading, plowing, hoove action, vehicle use, sedimentation, dredging, etc.

Score	Rating Description
	NONE. There are no disturbances, or beneficial disturbances Ex. light to moderate grazing and fire (7 pts).
	RECOVERED. The wetland appears to have recovered from past disturbances (5 pts).
	RECOVERING. The wetland appears to be in the process of recovering from past disturbances (3 pts).
	RECENT OR NO RECOVERY. Complete removal of vegetation and soil exposed, the disturbances have occurred recently, and/or the wetland has not recovered from past disturbances, and/or the disturbances are ongoing (1 pt).
	OTHER

2b. Plant Community and Habitat Development. This metric asks the rater to assign an overall rating of how well-developed the wetland is in comparison with other ecologically or hydrogeomorphically similar wetlands; based on the quality typical of the region.

Score	Rating Description
	EXCELLENT. Wetland appears to represent best of its type or class. Ex. the wetland is found on native prairie and appears to be diverse in native plant species. (12 pts)
	VERY GOOD. Wetland appears to be a very good example of its type or class but is lacking characteristics which would make it excellent. Ex. wetland may be on native prairie but is lacking diversity because of being left idle or herbicide application. (10 pts)
	GOOD. Wetland appears to be a good example of its type or class but because of past or present disturbances, successional state, or other reasons, it is not excellent. (8 pts)
	MODERATELY GOOD. Wetland appears to be a fair to good example of its type or class. Ex. wetland has past disturbances such as heavy grazing, restoration, or draining that have affected the area. (6 pts)
	FAIR. Wetland appears to be a moderately good example of its type or class, but because of past or present disturbances, successional state, etc. it is not good. Ex. a combination of native and non-native portions to the wetland with low diversity of plant species. (4 pts)
	POOR TO FAIR. Wetland appears to be a good to fair example of its type or class. Ex. wetland may be a monoculture of one plant species or may have native species in a buffer around the wetland, but outer zones are cropped. (2 pts)
	POOR. Wetland appears to not be a good example of its type or class because of past or present disturbances, successional state, etc. Ex. wetland may be completely cropped through with no perennial plant community present. (0 pt)

2c. Habitat Alteration and Recovery from Current and Past Disturbances. This metric evaluates the disturbance level of wetland habitat and the ability to recover from habitat alterations. Ideal management involves some form of disturbance such as moderate grazing or fire to maintain plant vigor and diversity. Leaving areas idle and haying can lead to a monoculture of species. Restored and CRP areas take time to become properly functioning communities and are often planted with at least partially non-native species.

Score	Rating Description
	MOST SUITABLE. The wetland appears to have recovered from past alterations and alterations have been beneficial to habitat. (10 pts).
	NONE OR NONE APPARENT. There are no alterations, or no alterations that are apparent to the rater (7 pts).
	RECOVERING. The wetland appears to be in the process of recovering from past alterations (4 pts).
	RECENT OR NO RECOVERY. The alterations have occurred recently, and/or the wetland has not recovered from past alterations, and/or the alterations are ongoing (1 pt).
	OTHER.

2d. Management.

	Fire or Moderate Grazing. If the area has been burned or is moderately grazed at proper intervals. (4 pts)
	Restored, CRP, Hayed, or Idle. If the area is restored, hayed, planted with CRP, left idle, or has large buffer before cropping begins. (2 pts)
	Cropped. If the wetland is cropped through or cropped with only a very narrow buffer. (0 pts)
	OTHER.

2e. Modifications to Natural Hydrologic Regime. This question asks the rater to identify alterations to the hydrologic regime of the wetland (ex. ditches, drains, etc.) and the amount of recovery from such alterations.

Score	Rating Description
	NONE. There are no modifications or non modifications that are apparent to the rater (12 pts).
	RECOVERED. The wetland appears to have recovered from past modifications to the fullest extent possible. Ex. long established road (8 pts).
	RECOVERING. The wetland appears to be in the process of recovering from past modifications (4 pts).
	RECENT OR NO RECOVERY. The modifications have occurred recently, and/or has not recovered from past modifications, and/or the modifications are ongoing (1 pt).
	OTHER.

2f. Potential of Wetland to Reach Reference (Native) Condition for the Area. This question asks the rater to use their best professional judgment and determine the condition of the wetland and whether it is trending in a positive or negative direction (questions 2a – 2e may help in this determination). In this metric reclamation refers to taking off soil and replacing with wetlands soils and seed bank (strip mining), restoration involves seeding and management of wetland area, management includes a management system such as light to moderate grazing and/or fire and may include spraying of unwanted species.

Score	Rating Description
	EXCELLENT. Wetland is at or near reference condition (12 pts).
	GOOD POTENTIAL. Wetland is disturbed in some way so not at reference condition, but could achieve reference condition easily over time (10 pts).
	MODERATE POTENTIAL. Wetlands is disturbed, but with proper management and time it could return to reference condition (7 pts).
	MODERATELY POOR POTENTIAL. Through proper management and potential restoration/reclamation the wetland may return to reference condition. (5 pts).
	POOR POTENTIAL. Minor potential for return to reference condition, but restoration/reclamation would be needed (2 pt).
	NO POTENTIAL. No potential for return to reference condition without extreme restoration/reclamation efforts (0 pts).

	Total for Metric 2 (out of possible 57).

Metric 3. Vegetation

3a. Invasive species (include in estimate of 3m buffer of low prairie zone). Amount of aerial plant covered by invasived species. Invasive species (native or non-native) include but are not limited to brome, reed canary, quack, kentucky blue, and crested wheat grasses, as well as canada thistle and leafy spurge. Annual crops and weeds should be considered invasives.

Score	Rating Description
	ABSENT. (3 pts)
	NEARLY ABSENT. <5% aerial cover of invasive species (1 pt)
	SPARSE. 5-25% aerial cover of invasive species (0 pt)
	MODERATE. 25-75% aerial cover of invasive species (-1 pts)
	EXTENSIVE. >75% aerial cover of invasive species (-3 pts)

3b. Overall condition of wetland based on plant species using best professional judgment from professional wetland botanist. Walk around wetland area making mental note of plant species present, variety, abundance, etc.

Score	Rating Description
	VERY GOOD (20 pts). Undisturbed native area with a variety of plant species throughout wetland (grasses, sedges, rushes, forbs, etc). Moderate grazing may be utilized. No major impairments to area.
	GOOD (15 pts). Area is still relatively native with a good variety of species. There is an impairment (road, haying, spraying, etc) that has affected the condition of the wetland.
	FAIR (10 pts). Area has been impaired either in the past and is recovering or is currently being impaired but not by something that would decimate the plant community. (CRP, haying, etc.)
	POOR (5 pts). Area is heavily disturbed but there are some plant species still intact. Plant community will consist mostly of non-native annual species, but there may be some native or perennials present. Large populations of invasive species may be present.
	VERY POOR (0 pt). Wetland is heavily disturbed (cropping, hayland, etc) and the plant community if one exists consists of mostly non-native annual species with very little variety. Invasive species may dominate the plant community.

	Total for Metric 3 (out of possible 23).

TOTAL.

Score	
	Total from Metric 1.
	Total from Metric 2.
	Total from Metric 3.
	Rapid Assessment Score

Total points possible is 100:

Condition Ratings are as follows:
Good = 69-100
Fair High = 53-68
Fair Low = 27-52
Poor = 0-26

Score	
	Total for entire wetland.
	Overall condition rating for wetland (Good, Fair, or Poor).

Wetland vegetation communities and interspersion scorecard

Wetland vegetation community	Cover/Quality of vegetation community
Aquatic Bed	
Emergent	
Shrub	
Forest	
Muflats	
Open water	
Other	

Comments________________

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Cover scale for wetland vegetation communities	
Score/Value	Narrative description
A	Present: makes up a large part of the area and is of high quality1.
B	Present: makes up a small part of the area and is of high quality -or- makes up a large part of the area and is of intermediate quality.
C	Present: makes up a small part of the area and is of intermediate quality -or- makes up a large part of the area and is of low quality.
D	Absent or <0.1ha
N/A	Not applicable to wetland

Quality scale for vegetation communities	
Score	Quality descriptions
High	High species diversity, dominated by native species, absent or virtually absent non-native or native disturbance tolerant species.
Intermediate	Intermediate species diversity, native species are a dominant component, some non-native or native disturbance tolerant species.
Low	Low species diversity and/or dominance of non-native or disturbance tolerant native species.

Mudflat and Open water cover/quality scale for vegetation communities	
Score	Narrative Description
A	High (≥4 hectare)
B	Intermediate (1 to < 4 hectare)
C	Low (0.1 to < 1 hectare)
D	Absent
N/A	Not applicable to wetland