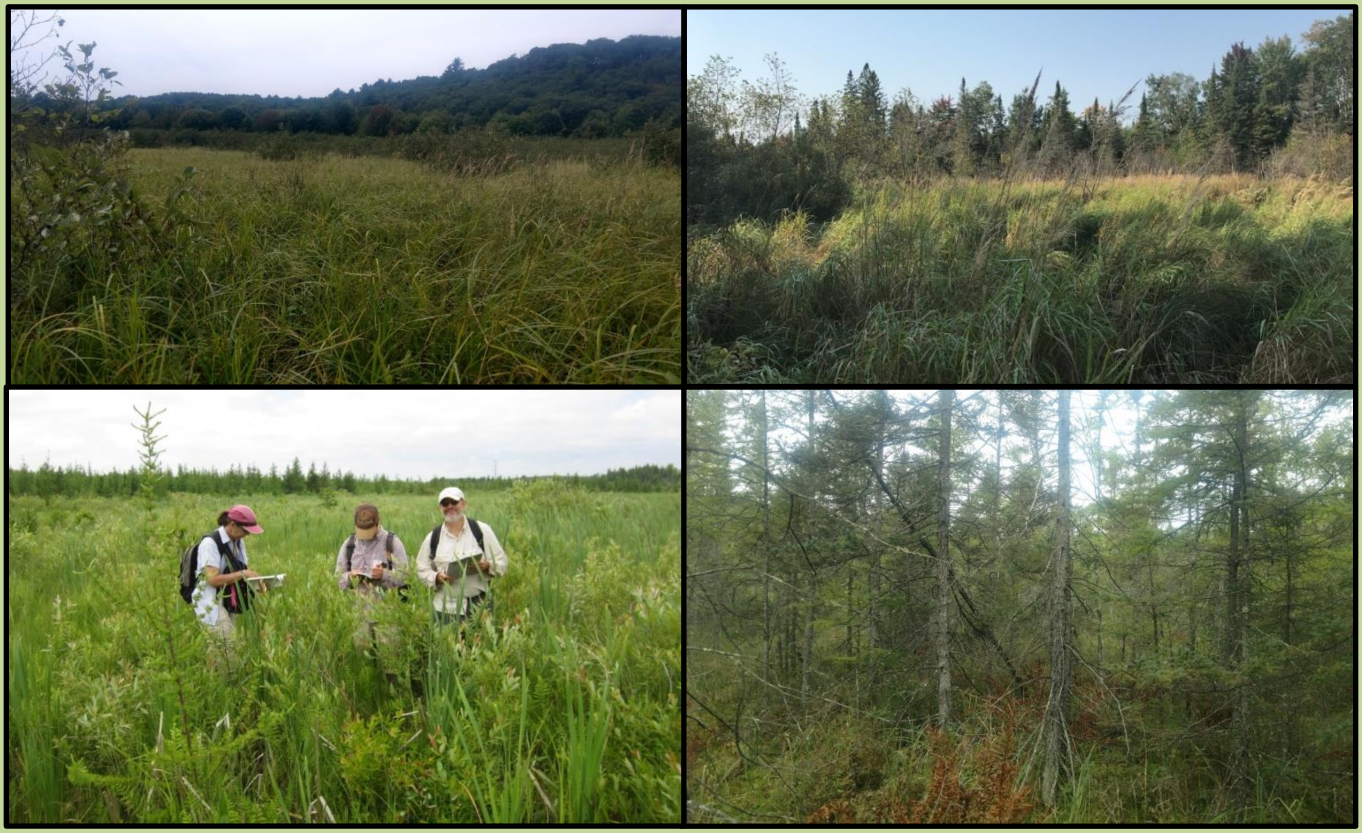
Provisional Wetland Floristic Quality Benchmarks for Wetland Monitoring and Assessment in Wisconsin



WISCONSIN
DEPT. OF NATURAL RESOURCES

Citation

Marti, A.M. and T.W. Bernthal. 2019. Provisional wetland Floristic Quality Benchmarks for wetland monitoring and assessment in Wisconsin. Final Report to US EPA Region V, Grants # CD00E01576 and #CD00E02075. Wisconsin Department of Natural Resources. EGAD # 3200-2020-01.

Provisional Wetland Floristic Quality Benchmarks for Wetland Monitoring and Assessment in Wisconsin

Wisconsin Department of Natural Resources
Final Report to USEPA- Region V
Wetland Program Development Grants # CD00E01576 and #CD00E02075
WDNR EGAD # 3200-2020-01 (Technical Report)
December 2019

Primary Authors

Aaron M. Marti[1]
Thomas W. Bernthal[2]

1 Wetland Assessment Research Scientist and Healthy Watersheds Monitoring Specialist, Water Resources Monitoring Section and Northern Region Water Resources Team, Bureau of Water Quality, Wisconsin Department of Natural Resources, Rhinelander, Wisconsin. E-Mail: aaron.marti@wisconsin.gov

2 Wetland Monitoring and Assessment Coordinator (Retired), Water Resources Monitoring Section, Bureau of Water Quality, Wisconsin Department of Natural Resources, Madison, Wisconsin.

Statement of Authorship and Contribution:

AMM conceptualized reporting and data analysis strategy, analyzed data, performed statistical analyses, conducted literature review and wrote the report; TWB conceptualized the study and its design, acquired funding, provided administrative oversight of project implementation and completion, and edited the report.

This report was prepared by the Wisconsin Department of Natural Resources under grants (#CD00E01576 and #CD00E02075) from the U.S. Environmental Protection Agency, Region 5. Points of view expressed in this report do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency. This report has not been subjected to the U.S. Environmental Protection Agency peer or administrative review processes. Any mention of trade names and commercial products does not constitute endorsement of their use.

Acknowledgements

We thank the following individuals and organizations, without whom, this work would have not been possible:

- U.S. Environmental Protection Agency, Region 5 Watersheds and Wetlands Branch, for providing financial and technical support during past and present phases of the development of Wisconsin Floristic Quality Assessment Methodology and the Wisconsin Wetland Floristic Quality Assessment Benchmarks
- Lake Superior Research Institute (Paul Hlina, Dr. Nick Danz, and their numerous technicians and students) for their efforts in methods development/testing and all work related to creation of wetland FQA Benchmarks for the Omernik Level III Northern Lakes and Forests Ecoregion of Wisconsin
- Ryan O'Connor and Kevin Doyle of the WDNR Natural Heritage Conservation Program, who conducted extensive fieldwork surveying many "least disturbed" sites for this project, assisted in development and refinement of the project design and the Disturbance Factor Checklist, and provided substantial suggested edits in their review of this technical report that vastly improved its content and clarity
- Christopher Noll and Melissa Gibson, who searched countless hours behind desktops and windshields for and surveyed a majority of the "most disturbed" sites throughout the three Ecoregions covered in this report. Corey Raimond (past WDNR employee) also assisted in these efforts.
- Pat Trochlell, retired WDNR wetland ecologist, contributed extensive field survey work, primarily in "least disturbed" wetlands in all 4 study ecoregions, played a key role in conceptualizing, funding and designing the study, helped design the Disturbance Factors Checklist and documented the timed-meander survey protocol.
- Past and retired WDNR Employees, including Elizabeth Haber (University of Utrecht, PhD Candidate) and Joanne Kline for their assistance in conceptualizing and helping to develop the initial stages of this project, as well as their assistance with fieldwork
- UW-Madison Herbarium (especially Mary Ann Feist) for their curation of voucher specimens and assistance in identification of unknown or difficult plant species
- Alison Mikulyuk, PhD (WDNR Lakes and Rivers Team Leader) for her consultation on questions regarding approach and troubleshooting of multivariate statistics included in this report

There are also other individuals and organizations that have helped along the way that we have unintentionally omitted from this list to whom we offer our sincere apology and utmost thanks.

Executive Summary

Over the past two decades, the Wisconsin Department of Natural Resources (WDNR) has developed and refined the Wisconsin Floristic Quality Assessment (WFQA or FQA) methodology to measure the biological condition or "health" of wetland plant communities. However, plant community metrics calculated as part of WFQA have lacked an overall framework for interpretation and comparison at both regional and statewide scales to utilize them effectively for meeting state and federal regulatory mandates to monitor, assess, and report on the condition of wetlands, to effectively enforce wetland-specific water quality standards that protect wetland health as well as functional values, and to inform wetland restoration, mitigation, and conservation efforts.

To adapt the WFQA method as a comprehensive, quantitative, and repeatable method for intensive, site-level monitoring and assessment of wetland condition, WDNR engaged with partners in 2011 to develop Floristic Quality Assessment Benchmarks for all common wetland community types across Wisconsin, known as the Wisconsin Floristic Quality Assessment Benchmarks Project. Since 2012, WDNR and partners have surveyed nearly 1,100 wetland assessment areas statewide towards this effort. FQA Benchmarks consist of numeric, statistically-derived ranges of FQA scores for a given wetland community type, with each range corresponding to a narrative ranking category (e.g. "Excellent" to "Very Poor") along a gradient of ecosystem disturbance—generally following the Biological Condition Gradient approach promoted by the U.S. Environmental Protection Agency (US EPA).

During an earlier phase of the project, FQA Benchmarks were created for the US EPA Omernik Level III Northern Lakes and Forests Ecoregion, which is detailed in a separate report, *Northern Lakes and Forests Inland Wetland Survey: Relationships between Floristic Quality Assessment and Anthropogenic Stressors – 2012- 2014* by Hlina et al. (2015) of the Lake Superior Research Institute. The current study used a consistent statistical methodology similar to Hlina et al. to generate FQA Benchmarks from timed-meander survey data for the 3 remaining primary Omernik Level III Ecoregions of Wisconsin: North Central Hardwood Forests, Southeast Wisconsin Till Plains, and the Driftless Area. Tables 5, 8, and 11 (respectively) at the end of the Executive Summary contain the resulting suggested provisional Benchmarks based on cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores, including narrative condition rankings, for common wetland plant communities for each Ecoregion.

Based on both Hlina et al. (2015) and information gathered through this study, Benchmarks based on $w\overline{C}$ scores from timed-meander surveys were found to be the most appropriate FQA metric for Benchmark development because of their ability to discriminate the ecological condition of sites along a gradient of human disturbance, whereas other metrics that include measures of species richness in their calculation such as the Floristic

Quality Index (*FQI*) and cover-weighted Floristic Quality Index (*wFQI*) were not. Community diversity and the effects of overall cover of individual plant species are captured using $w\overline{C}$, resulting in a more ecologically and statistically defensible assessment metric and corresponding set of Benchmark criteria for comparison. Based on these factors, we suggest that $w\overline{C}$ Benchmark criteria are used as the primary provisional Benchmarks whenever possible when attempting to apply Benchmark criteria for a project. Additionally, Benchmarks are based on use of the WDNR Timed-Meander Survey Protocol (Trochlell 2015), thus this protocol is recommended for wetland plant community survey efforts. However, in the instance that only limited data from plant inventories are available (i.e. a plant species list without cover percentage estimates), preliminary $\overline{C}$ Benchmarks based on Overall Disturbance (Tables II, VII, and XIV in Appendix 2) may be applied with the understanding of their potential limitations.

Benchmarks have numerous potential applications to meet the objectives of the Clean Water Act, including:

- the creation of numeric Tiered Aquatic Life Use criteria to formulate numeric water quality standards as either stand alone or additional/supportive criteria;
- the assessment of the natural quality of sites;
- the assessment of plant community response to restoration, management, and permitting actions;
- aiding in elucidating the relationship between wetland condition and wetland ecosystem functions.

It is emphasized that provisional FQA Benchmarks are an initial step towards evaluating wetland ecosystem condition for Wisconsin and there are a number of associated caveats and limitations for their full implementation:

- Wetland condition and function are two different concepts. Users should realize that even a wetland with in poor plant community condition may still provide some ecosystem functions and services dependent upon the context in which they are considered (e.g. landscape, watershed, wetland complex).
- Plant communities are one biotic community present in wetland ecosystems. FQA-based condition metrics are a promising start towards more complete wetland ecological assessment, but further work is needed. Other biotic and abiotic components (i.e. diatom communities, bryophyte communities, water chemistry, soil physicochemsitry, and soil microbial communities/enzyme activity) may deserve further consideration as indicators to assess ecosystem condition in relationship to anthropogenic stress.

- The Benchmarks in this study and Hlina et al. (2015) should be considered *provisional*, but they may be immediately applied with the understanding that they may be improved over time. Further refinements and investigation strategies are detailed in "Discussion" section.
- FQA surveys using the WDNR Timed-Meander Survey Protocol require substantial taxonomic expertise, as surveys conducted by those with lesser expertise are likely to miss some species and misidentify some species. One option for WDNR to build capacity for implementation could be to use state and regional aquatic monitoring funds to hire wetland assessment experts (e.g. Regional Wetland Ecologists or Wetland Botanists) that could specialize in FQA in addition to other wetland ecology-specific needs.
- Some wetland community types had no or limited Benchmarks. These communities may require more fieldwork efforts and/or data analyses or may require alternative statistical approaches.

Fieldwork and data from this study, combined with that of Hlina et al. (2015), have also generated a number of other valuable applications, including generation of a wetland reference network for Wisconsin for long-term wetland monitoring and assessment (O'Connor and Doyle 2017). This study was also able to statistically evaluate the "distinctness" of a select number of wetland communities as classified by the WDNR Natural Heritage Conservation Program. Furthermore, the plant community and disturbance data gathered for 1,100 wetland assessment areas will surely have many future applications for wetland monitoring and assessment. These data will also support the creation of target species planting lists based on the community composition to inform wetland restoration and mitigation efforts.

The provisional Benchmarks constitute a solid starting point for application of the WFQA as a statistically-valid, cost-effective, repeatable approach that will allow for relative comparisons across sites and time at most scales of interest. Understanding and documenting wetland condition, as well as the stressors likely driving condition, will allow for enhanced management and restoration opportunities of wetlands while also allowing for protection of wetlands already in excellent condition.

Table 5. Provisional Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)*	---	---	---	---	---
Black Spruce Swamp (BSS)*	---	---	---	---	---
Central Poor Fen (CPF)*	---	---	---	---	---
Emergent Marsh (EM)	> 6.6	5.2- 6.6	3.1 - 5.1	0.8 - 3.0	< 0.8
Northern Hardwood Swamp (NHS)	> 6.1	5.0 - 6.1	2.7 - 4.9	2.5 - 2.6	< 2.5
Northern Sedge Meadow (NSM)	> 7.0	5.9 - 7.0	2.8 - 5.8	1.4 - 2.7	< 1.4
Northern Tamarack Swamp (NTS)	> 7.1	6.7 - 7.1	5.7 - 6.6	4.5 - 5.6	< 4.5
Northern Wet Mesic Forest (NWMF)**	> 7.1		6.8 - 7.1	< 6.8	
Shrub Carr (SC)	> 5.7	4.9 - 5.7	2 - 4.8	1.6 - 1.9	< 1.6
Southern Sedge Meadow (SSM)	> 6.0	5.0 - 6.0	2.7 - 4.9	1.9 - 2.6	< 1.9

*Type did not have significant inverse relationship with Overall Disturbance; no benchmarks currently suggested

**Tiers calculated using Least Disturbed 75th and 25th %

Table 8. Provisional Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Calcareous Fen (CF)	> 7.0	6.2 - 7.0	3.6 - 6.1	2.2 - 3.5	< 2.2
Emergent Marsh (EM)	> 5.7	4.1 - 5.7	2.1 - 4.0	1.0 - 2.0	< 1.0
Floodplain Forest (FF)	> 4.0	3.4 - 4.0	2.3 - 3.3	2.2	< 2.2
Northern Hardwood Swamp (NHS)	> 6.2	5.4 - 6.2	3.6 - 5.3	3.4 - 3.5	< 3.4
Northern Wet Mesic Forest (NWMF)	> 6.5	6.5	5.8 - 6.4	5.3 - 5.7	< 5.3
Shrub Carr (SC)	> 5.1	4.7 - 5.1	3.2 - 4.6	2.3 - 3.1	< 2.3
Southern Hardwood Swamp (SHS)	> 4.7	4.0 - 4.7	2.9 - 3.9	2.0 - 2.8	< 2.0
Southern Sedge Meadow (SSM)	> 6.3	5.6 - 6.3	3.8 - 5.5	1.0 - 3.7	< 1.0
Wet-Mesic Prairie (WMP)	> 5.5	4.6 - 5.5	3.1 - 4.5	1.9 - 3.0	< 1.9

Table 11. Provisional Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Driftless Area Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)	> 4.9	4.5 - 4.9	3.8 - 4.4	3.1 - 3.7	< 3.1
Emergent Marsh (EM)	> 5.2	4.8 - 5.2	3.4 - 4.7	1.7 - 3.3	< 1.7
Floodplain Forest (FF)	> 4.4	3.5 - 4.4	2.7 - 3.4	2.2 - 2.6	< 2.2
Shrub Carr (SC)	> 5.5	4.4 - 5.5	2.6 - 4.3	1.8 - 2.5	< 1.8
Southern Sedge Meadow (SSM)	> 5.9	5.1 - 5.9	1.6 - 5.0	1.1 - 1.5	< 1.1

Table of Contents

List of Figures

List of Figures (continued)

List of Tables

List of Tables (continued)

List of Appendices

Introduction

Wisconsin is a water-rich state, with over 15,000 named lakes, 84,000 miles of rivers and streams, over 1,000 miles of Great Lakes Shorelines along Lake Superior and Lake Michigan, and over 5.3 million acres of estimated wetland habitat. Though sometimes overlooked or misunderstood by the public, policy makers, and natural resources managers alike, wetlands are integral to the ecology and well-being of other aquatic ecosystems regardless of their landscape position (Mushet et al. 2018; Leibowitz et al. 2018; Lane et al. 2018; Schofield et al. 2018; Fritz et al. 2018; Marton et al. 2015). In addition, they provide a wide range of ecosystem services and functions to society and other important natural resources of Wisconsin (WDNR 1993). In fact, a recent economic analysis has estimated that Wisconsin's wetlands provide between $3.3 billion and $152 billion in economic value yearly to the local, regional, and national economy—even using conservative estimates (Earth Economics 2012). However, wetland resources have arguably suffered the greatest losses out of all water resources in Wisconsin, with nearly half of the original estimated area of Wisconsin's wetlands lost since European settlement by conversion to agricultural areas, urban developments, and industrial areas, and much of the remaining wetland area left in a degraded state (Dahl 2011; Hagen 2008; Dahl 1990). Indeed, these issues are of state, national, and international concern, with recent publications describing wetlands as "conservation's poor cousins" (Kingsford et al. 2016).

Given the widespread losses of wetland area and associated services previously provided by these ecosystems, the State of Wisconsin proactively adopted wetlands preservation, protection, restoration, and management policies (e.g. Wisconsin Administrative Code NR 1.95) and was the first state to adopt water quality standards specific to wetlands under Wisconsin Administrative Code NR 103 in 1991 (USGS 1996). This included adoption of two statewide wetland strategies, the most recent being "Reversing the Loss: A strategy to protect, restore and explore Wisconsin Wetlands" (Hagen 2008; WDNR 2000). Though tracking wetland losses and changes in wetland ecosystem types has arguably been successful (i.e. Wisconsin Wetlands Inventory; Jarosz and Haug 2015; Trochlell and Bernthal 2014), quantifying the current condition and function of wetland ecosystems and monitoring their change over time has been comparatively more difficult. To address this problem, the Wisconsin Department of Natural Resources (WDNR) has developed and refined numerous wetland assessment methods ranging across the 3 levels of wetland monitoring and assessment encouraged by US EPA: coarse-scale landscape assessment, on-site rapid assessment and intensive site assessment (*sensu* US EPA 2006; Miller et al. 2017; Marti and Bernthal 2016; Hatch and Bernthal 2008; Bernthal et al. 2007; Hauxwell et al. 2006; Bernthal and Willis 2004; Bernthal 2003; Lillie et al. 2002, Lillie et al. 2000). Despite these efforts, challenges to adequately monitor and assess the many different wetland types (also termed natural communities) across the state spanning multiple ecological and anthropogenic gradients still remain (WDNR 2018; Epstein 2017; WDNR 2015; Omernik et al. 2000; Figure 1; Figure 3). A uniform, cost-effective, and repeatable method to successfully monitor and assess wetland condition across all wetland community types was needed.

To address this need, the Wisconsin Department of Natural Resources (WDNR) led the development of the Wisconsin Floristic Quality Assessment Method (WFQA) as an intensive, site-level (Level 3), vegetation based approach for monitoring and assessment of wetland condition following work done by other Midwestern states and a group of Wisconsin lake experts (US EPA 2006; Bernthal 2003; Nichols 2001; Nichols 1999). The WFQA was based on the concepts of Wilhelm (1977) and Swink and Wilhelm (1994), who pioneered Floristic Quality Assessment (FQA) as a standardized, repeatable method to identify high conservation value areas in the Chicago Region of Illinois. Floristic Quality Assessment is predicated on *a priori* assignment of "Coefficient of Conservatism" values for the entire vascular flora of a region by expert botanists, with Conservatism values ranging from 0 (invasive species, disturbance tolerant species, and species having no to little fidelity to any specific natural community) to 10 (species restricted to least-disturbed or pre-European settlement natural community remnants, and highly intolerant of disturbance; Bernthal 2003). Using FQA, numerous metrics can be calculated such as the site Mean Coefficient of Conservatism ($\overline{C}$) or the Floristic Quality Index (*FQI*), including weighted variants of both ($w\overline{C}$ and $wFQI$) which factor in percent aerial cover of plant species if these estimates are made in the field (Kutcher and Forrester 2018; DeBerry et al. 2015; Bourdaghs 2012; Bernthal et al. 2003).

Despite recent concerns or skepticism regarding Floristic Quality Assessment or the "Coefficient of Conservatism" concept (e.g. DeBerry et al. 2015), numerous studies have reaffirmed the consistency and validity of Floristic Quality Assessment as a method to assess the response of wetland ecosystems to anthropogenic disturbance (Bried et al. 2018; Jog et al. 2017; Matthews et al. 2015; DeBerry et al. 2015; Bried et al. 2013; US EPA 2002). Indeed, numerous states across the Upper Midwest such as Illinois (Taft et al. 1997; Matthews 2003), Michigan (Herrman et al. 2001a; Herrman et al. 1997), Minnesota (Milburn et al. 2007), Ohio (Lopez and Fennessy 2002; Fennessy et al. 1998), and Indiana (Rothrock et al. 2005) have also developed Floristic Quality Assessment methods, and even a Great Lakes coastal wetland FQA has been developed (Bourdaghs et al. 2006).

However, one weakness of this approach is that very few entities (e.g. Bourdaghs 2012) have developed ways to interpret FQA metric scores among wetlands of the same type by setting Benchmarks to distinguish statistically defensible condition categories. For instance, if an Emergent Marsh is surveyed and receives a $\overline{C}$ score of 5.5 an FQI of 25.6, and has 35 total species does that mean it is in "Good" or "Poor" condition? If a Northern Sedge Meadow receives the same scores, is it in the same condition as the Emergent Marsh? Is it

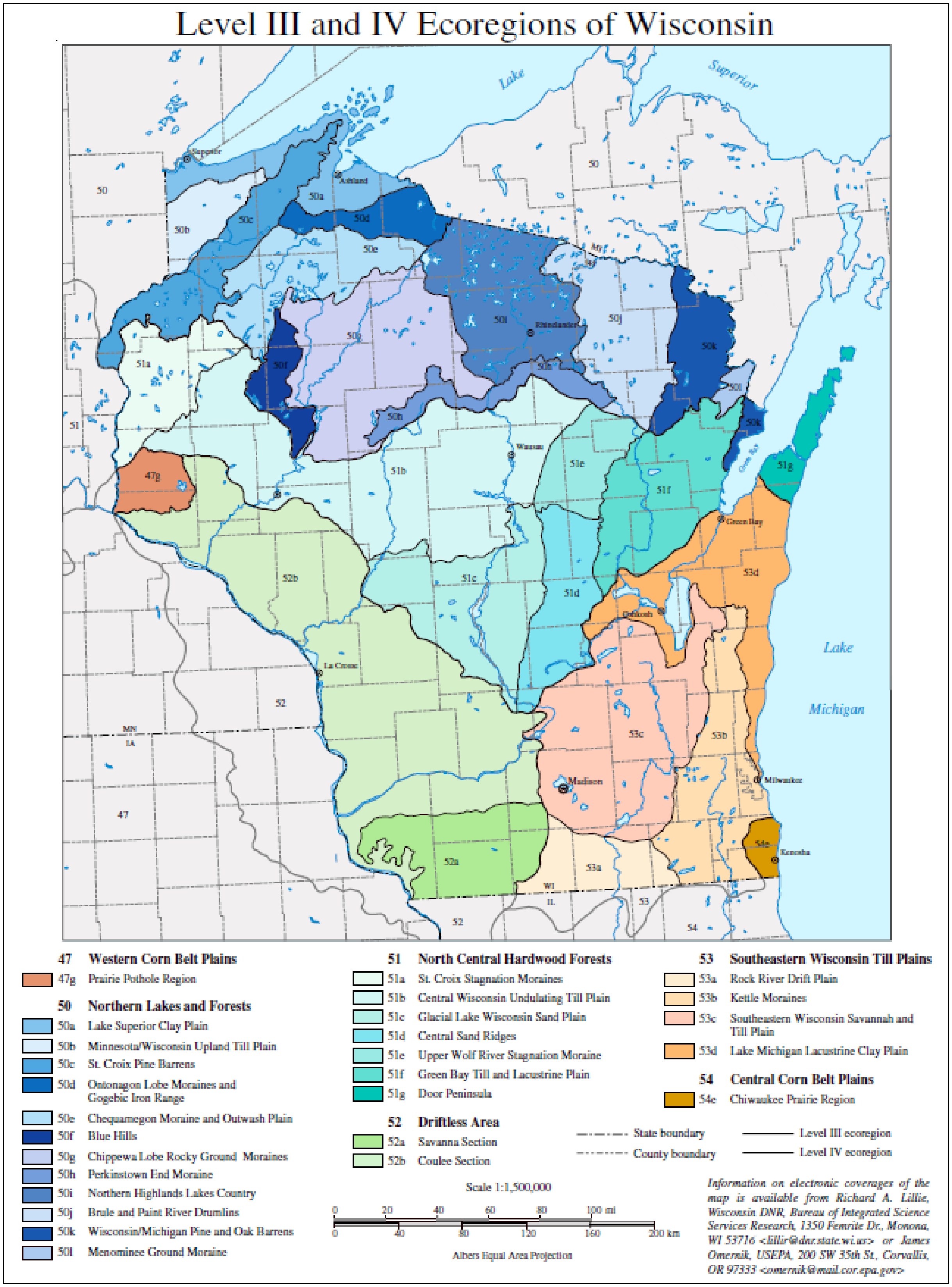


Figure 1. Level III and Level IV Ecoregions of Wisconsin (Reprinted from Omernik et al. 2000).

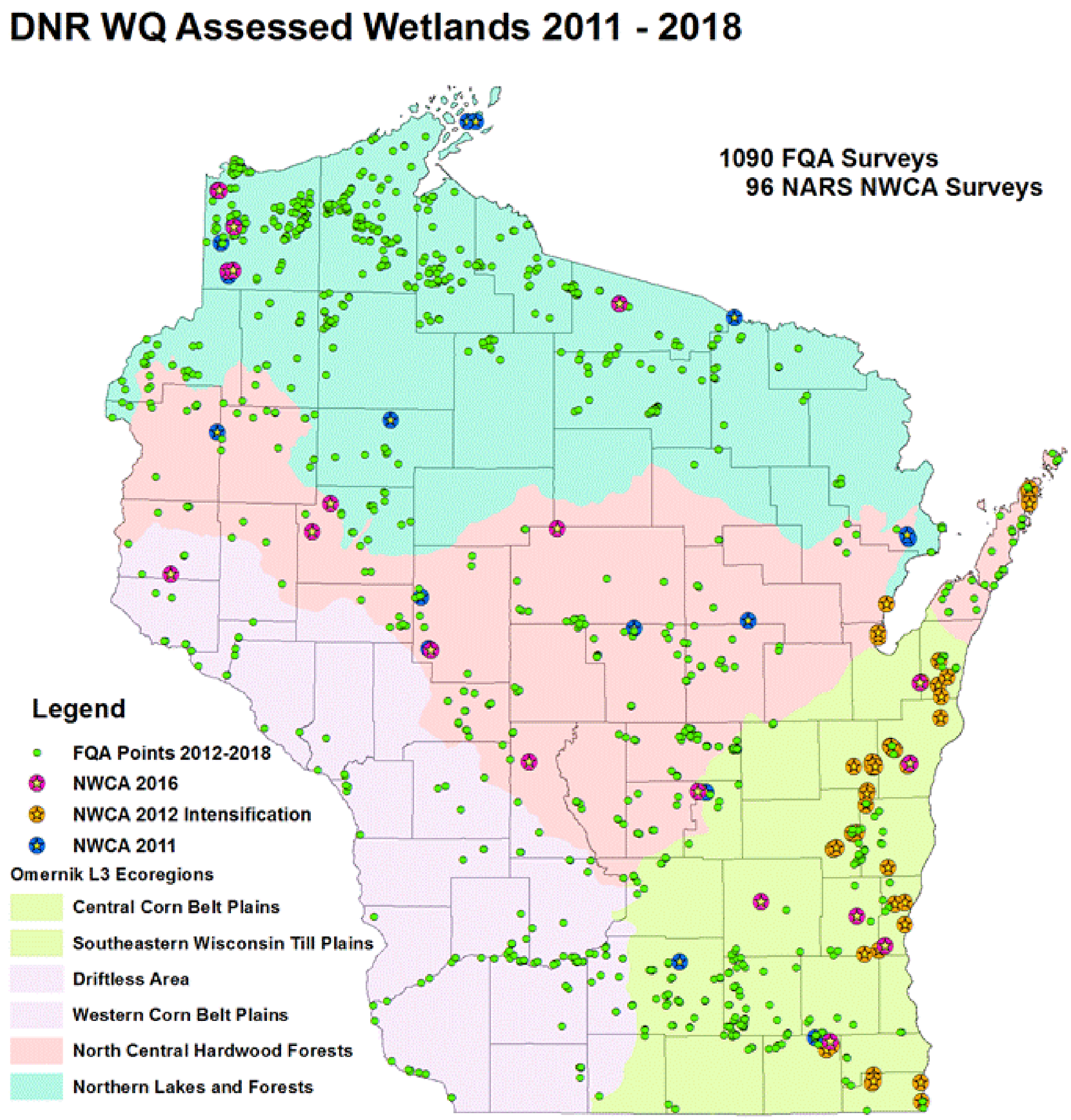


Figure 2. A map of wetland assessment areas assessed by the WDNR Wetland Monitoring and Assessment Team and partners since 2011 for the Floristic Quality Assessment Benchmarks Project ("FQA Surveys/Points"). Additional sites provided indicate locations of wetlands surveyed by WDNR and US EPA as part of the US EPA National Wetland Condition Assessment (US EPA 2016).

Figure 3. Ecological Landscapes of Wisconsin (Reprinted from WDNR 2015).

legitimate to set the same minimum metric score for "Good" condition for an Emergent Marsh in Ozaukee County as we would set for one in Vilas County? FQA metrics require a framework or benchmarks for comparison to utilize them effectively to meet state and federal regulatory mandates to monitor, assess, and report on the *condition* of wetlands or to effectively enforce wetland-specific water quality standards that protect wetland health as well as functional values. Absent a framework, the directive of the Clean Water Act to "restore and maintain the chemical, physical and biological integrity of the Nation's Waters" (33 U.S.C. §1251), notably for wetlands, remains a particularly elusive goal even for states that have developed advanced wetland monitoring and assessment methods such as FQA. This is due to the continued inability to *quantitatively* define and track the *condition* of wetlands from the wetland complex level to nation-wide scales. Benchmarks will assist with long-term goals of WDNR wetland monitoring and assessment program (e.g. establishment of wetland condition baselines at various scales, assessment of specific disturbances to wetland condition, assessment of wetland management practices, etc.), and, if desired and defensible, the creation of numeric Tiered Aquatic Life Use criteria to formulate numeric water quality standards as either stand alone or additional/supportive criteria.

To adopt the WFQA method as a comprehensive, quantitative, and repeatable method for Level 3 monitoring and assessment of wetland condition, WDNR engaged with partners in 2011 to develop Floristic Quality Assessment Benchmarks for all common wetland community types across Wisconsin. Since 2012, WDNR and partners have surveyed nearly 1,100 wetland assessment areas statewide for the Wisconsin Floristic Quality Assessment Benchmarks Project. (Figure 2). Hlina et al. (2015) previously reported the first phase of the project describing FQA Benchmarks for the US EPA Omernik Level III Northern Lakes and Forests Ecoregion (NLF) of Wisconsin, where preliminary Benchmarks for nine wetland community types were suggested (Table 1). This also included methods development, testing, and refinement of field methods and assessments (e.g. Hlina et al. 2012; Hlina et al. 2011; Bernthal et al. 2007). The objective for our current study was to create FQA Benchmarks for common wetland community types within the remaining ecoregions of Wisconsin outside the NLF using the strategy of Hlina et al. (2015) by comprehensively surveying wetlands across a gradient of anthropogenic stress.

Table 1. Summary of wetland community types sampled as part of the Wisconsin Department of Natural Resources Floristic Quality Assessment Benchmarks Study. Northern Lakes and Forests (NLF) data is from Hlina et al. (2015). All other Omernik Ecoregions (Omernik et al. 2000) are reported in this study. Target status refers to whether benchmarks were pursued for a given wetland community type. (n = number of assessment areas sampled, NCHF = North Central Hardwood Forests, SETP = Southeast Wisconsin Till Plains, DRFT = Driftless Area.)

	Omernik Level III Ecoregion							
	NLF[a]		NCHF		SETP		DRFT	
Community Type (and abbreviation)	Target Status	n	Target Status	n	Target Status	n	Target Status	n
Alder Thicket (AT)	Yes	54	Yes	21	No	···	Yes	11
Black Spruce Swamp (BSS)	Yes[b]	60	Yes	22	No	···	No	···
Boreal Rich Fen (BRF)	No	···	No	6	No	···	No	···
Calcareous Fen (CF)	No	···	No	3	Yes	27	No	···
Central Poor Fen (CPF)	No	···	Yes	23	No	···	No	···
Emergent Marsh (EM)	Yes[c]	34	Yes	15	Yes	36	Yes	34
Floodplain Forest (FF)	No	···	No	1	Yes	20	Yes	32
Muskeg (MK)	Yes	53	Yes	6	No	···	No	···
Northern Hardwood Swamp (NHS)	Yes	37	Yes	13	Yes	13	No	1
Northern Sedge Meadow (NSM)	Yes	57	Yes	21	No	···	No	···
Northern Tamarack Swamp (NTS)	Yes[b]	···	Yes	15	No	···	No	···
Northern Wet-Mesic Forest (NWMF)	Yes[d]	40	Yes	16	Yes	11	No	···
Open Bog (OB)	Yes	58	Yes	4	No	···	No	···
Poor Fen (PF)	No	···	No	9	No	···	No	···
Shrub Carr (SC)	Yes	37	Yes	19	Yes	20	Yes	19
Southern Hardwood Swamp (SHS)	No	···	No	6	Yes	13	No	···
Southern Sedge Meadow (SSM)	No	···	Yes	20	Yes	30	Yes	29
Wet-Mesic Prairie (WMP)	No	···	No	···	Yes	23	No	···
White Pine-Red Maple Swamp (WPRM)	No	···	No	1	No	···	No	···
Total	9	430	12	221	9	193	5	126

[a] From Hlina et al. (2015)

[b] BSS and NTS were combined into a single community type referred to as "Black Spruce Swamp" (BSS) in Hlina et al. (2015)

[c] Referred to as "Shallow Water Marsh" (SWM) in Hlina et al. (2015)

[d] Referred to as "White Cedar Swamp" (CS) in Hlina et al. (2015)

Methods

Study area and natural history

Our study area consisted of three large US EPA Omernik Level III Ecoregions (referred to as "Ecoregion" hereafter) that comprise approximately the southern two-thirds of Wisconsin, including the North Central Hardwood Forests (NCHF), the Driftless Area (DRFT), and the Southeastern Wisconsin Till Plains (SETP; Figure 1). The study area also includes two relatively small Level III Ecoregions: the Western Corn Belt Plains (WCBP) in Western Wisconsin and the Central Corn Belt Plains (CCBP) in far Southeastern Wisconsin (Figure 1). These small fragments of broader Ecoregions that span multiple states across the Upper Midwest were too small to justify sampling as independent ecoregions. Accordingly, these small ecoregional fragments were considered as part of the adjacent ecoregion which most closely matched its ecological characteristics based on Omernik et al. (2000)—the WCBP as an addition to the NCHF and the CCBP as an addition to the SETP. The boundaries of these conglomerated Ecoregions are very similar to the boundaries of Ecological Landscapes of Wisconsin, which are the primary landscape units for ecological planning, management, and assessment used by other WDNR programs (Figure 3; WDNR 2015). To see a summary of the rich and diverse geologic, ecological, and anthropogenic history of these areas please see Omernik et al. 2000 and WDNR 2015.

Sampling objective and selection of wetland community types for surveys

For each Ecoregion within the study area, our goal was to sample an adequate number of "least disturbed" and "most disturbed" inland (i.e., non-coastal) wetland assessment areas (defined *a priori* as n = ~20 per Ecoregion) of each commonly occurring wetland community type to assess the response of plant communities to a gradient of anthropogenic disturbance (i.e. Biological Condition Gradient, or BCG; *sensu* Davies and Jackson 2006; Figure 4) (Hlina et al. 2015). Wetland community types were defined using the WDNR Natural Heritage Conservation Bureau and a Key to Wetland Communities of Wisconsin whenever possible (O'Connor 2018; WDNR 2018; Epstein 2017; WDNR 2015). Commonly occurring wetland community types were selected based on their prevalence across a given Ecoregion using the records and field experience of Natural Heritage Conservation ecologists and wetland ecologists within the WDNR Watershed and Water Quality Bureaus (Table 1; also see O'Connor and Doyle 2017). For example, Emergent Marshes occur statewide and were planned to be sampled as part of every Omernik Level III Ecoregion. Other communities, such as Open Bog, were sampled only as part of the NCHF and NLF Ecoregions given that they are common in these Ecoregions but are infrequent elsewhere in the state (Hlina et al. 2015). Finally, some communities like Wild Rice Marshes and Southern Tamarack Swamps, though occurring in

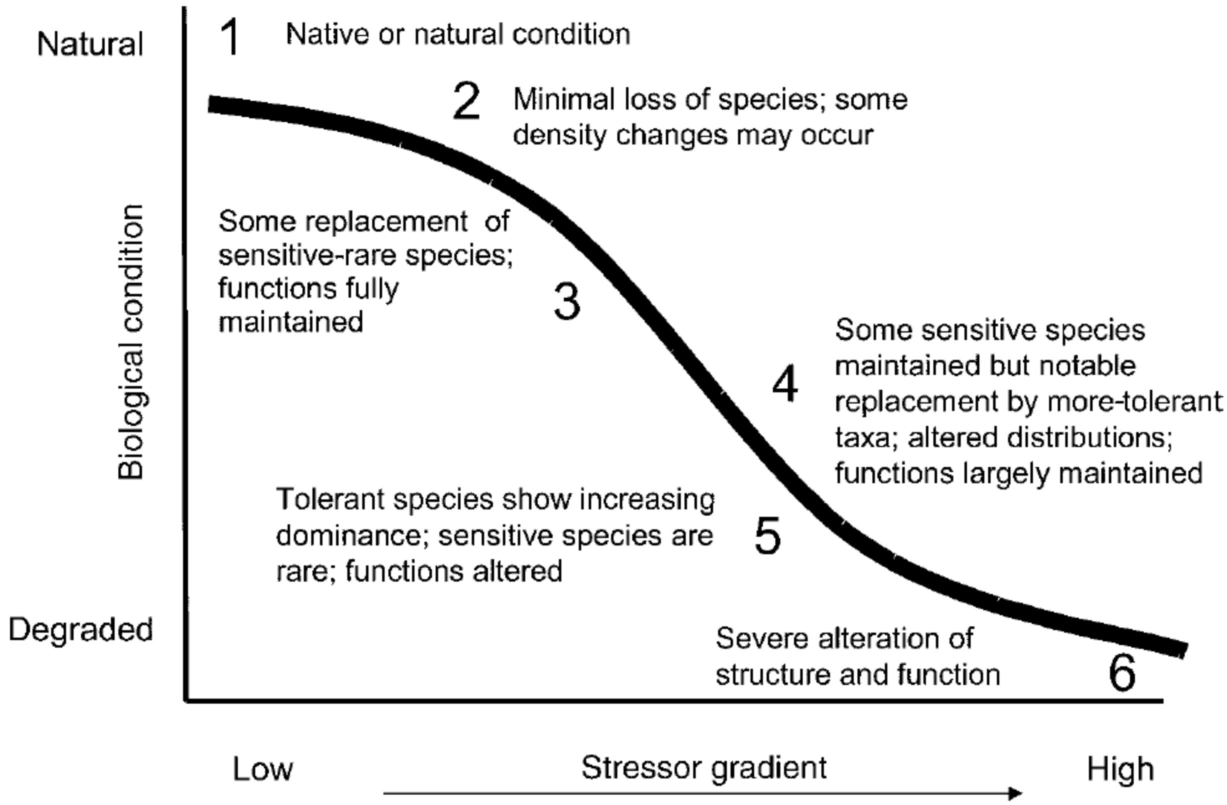


Figure 4. A conceptual model of the Biological Condition Gradient (Reprinted from Davies and Jackson 2006).

some areas of the state, were determined to be too limited in distribution to sample and were not included as part of this study.

Preliminary (office/desktop) identification of field assessment areas

A majority of field assessment areas were identified using two general methodologies. Assessment areas that were likely "least disturbed" or "reference" quality for a given wetland community type were identified using data from State Natural Areas (SNAs) and Natural Heritage Inventory (NHI) Element Occurrences (EOs) along with survey maps and digital aerial photos (see O'Connor and Doyle [2017] for more details). In contrast, a majority of the assessment areas that were likely "most disturbed" were identified using the Wisconsin Wetland Inventory (WWI) layer overlain on previous survey maps, the most current available digital aerial photos, and other WDNR layers in ArcGIS and interpreted by an experienced wetland field botanist with extensive GIS experience. Hlina et al. (2015) observed that buffer analyses in GIS using road densities as a proxy for disturbance was unreliable, and using land cover instead improved, but did not always accurately capture the severity of disturbance observed in the field. We were able in many instances to identify photographic signatures of common invasive species as well as potential anthropogenic disturbances (e.g. ditches, agricultural practices, non-point source runoff paths, etc.) within, adjacent to, near, or upgradient of a given wetland assessment area or complex of potential assessment areas. In some instances, the analyst was also able to identify nearby likely "least disturbed" wetlands, which were considered for field assessment if there was a potential shortage of documented "least disturbed" assessment areas of a given wetland community type within the Ecoregion. Finally, some assessment areas were opportunistically identified during the course of fieldwork. Regardless of *a priori* identification as potential "least disturbed" or "most disturbed" sites, wetland assessment areas were not classified as such unless corroborated by a field assessment of disturbance (see section regarding *Assessment and Rating of Disturbance [Potential Ecosystem Stressors] to Define Ecological Stressor Gradients*).

Given that an estimated 75% of wetlands in Wisconsin are on privately-owned lands (Hagen 2008), we made every attempt when potential "least disturbed" and "most disturbed" assessment areas were identified on these properties to obtain landowner permissions to conduct these surveys to attempt to not bias survey results towards only publicly owned wetlands. However, landowner unwillingness to allow a survey crew onto their properties left some spatial gaps across the state despite best efforts to include these areas within the surveys.

Verification of field assessment areas, Floristic Quality Assessment surveys, and calculation of Floristic Quality Assessment metrics

At each assessment area, field crews consisting of experienced wetland botanists confirmed whether the target wetland community type identified during the desktop assessment was present using the general descriptions of that wetland community from the NHC Wetland Communities of Wisconsin (O'Connor 2018; WDNR 2018; Epstein 2017; WDNR 2015). In the instance that a given assessment area did not match the target community type, field crews assessed which community type the given assessment area likely would be based on visual observation.

Wetland Floristic Quality Assessment Surveys were completed using the WDNR Timed-Meander Sampling Protocol for Wetland Floristic Quality Assessment (Trochlell 2016). Notes regarding observed anthropogenic disturbances (potential stressors) and their perceived severity were also noted while completing the survey. All plant species and their respective percent aerial cover (based on an ocular estimate of the percent of the assessment area covered by the canopy of that species) were then entered for a given assessment area into the Wisconsin Floristic Quality Assessment Calculator (WDNR 2017). FQA metrics were then calculated using the Coefficient of Conservatism values for Wisconsin (Bernthal 2003). To ensure consistency among sampling crews in estimating cover percentages for plant species, calibration days were held in each Ecoregion in a number of diverse wetland types where multiple crews conducted floristic surveys using these methods on the same assessment areas on the same day. Crews generally had few discrepancies in plant species listed and there were very few overall differences in percent cover estimates for any of the given calibration assessment areas.

When various plant species were not able to be practicably or accurately identified to species level in the field, specimens were collected and later pressed for identification. Species identified to genus level that were able to be classified to species were retained. Specimens that were unable to be able to identified to genus level or below were vouchered and sent to the UW-Madison Herbarium for identification by taxonomic experts. In addition, field crews also collected specimens that were known or anticipated to be county records of the Wisconsin Flora unless they were known threatened, endangered, or species of special concern, in which case they were photographed and documented with other additional notes in the field.

Assessment and rating of disturbance (potential ecosystem stressors) to define ecological stressor gradients

After completion of the Floristic Quality Assessment survey, the field crew reviewed any notes related to disturbances (potential stressors) noted during the survey. In addition, the field crews then, when possible, walked the remainder of the assessment area and its perimeter to identify and note any additional stressors not encountered during the Floristic Quality Assessment survey. Using in-field notes, as well as desktop notes (including historic aerial imagery from the Wisconsin State Cartographers Office, when available), crews completed the Disturbance Factors Field Checklist Form (Appendix 1) noting the type, general location/proximity, and perceived severity or impact of every disturbance encountered or observed. Field crews then considered each disturbance singularly, in-combination, and overall to assign an "Overall Disturbance" rating or score for the assessment area. Severity of disturbance was not necessarily pre-determined by the number of disturbances observed—rather, a thorough assessment of all disturbances and their degree of potential perceived severity was required to make a decision. For example, an assessment area that was ditched around a majority of its perimeter, but had no other apparent disturbances within, near, or upgradient, of the assessment area, still could receive a rating of "major" or "severe" disturbance if the ditching was perceived to have a dominant overriding effect on the hydrology of the assessment area. These decisions were often corroborated with general field observations. For example, a ditch that was perceived to be causing a wooded wetland community type in the assessment area to be significantly drier than normal might be corroborated by signs of an excessive degree of soil organic matter decomposition (e.g. if the soil onsite was mapped as dominantly peat textures at the surface, but observed texture onsite was dry, powdery muck) or observations of atypical (i.e. non-buttress) aerial exposure of tree roots.

The crew used their best professional judgement in the field to assign a "Plant Community Condition" score based solely on the vegetation survey (independently from the disturbances noted in assessing "Overall Disturbance") to assess whether the overall plant community composition, observed plant strata, and other plant community factors were representative of wetlands of the same community type in "least disturbed" condition for the Ecoregion. (e.g. similarity to pre-Euro-American settlement conditions or overall degree of ecosystem fidelity). If crews determined an assessment area was not representative of a "least disturbed" community, they then assessed the perceived degree of plant community alteration to estimate changes in ecosystem structure and function and rated the Plant Community Condition of the assessment area accordingly using Best Professional Judgement.

<u>Data management</u>

Data regarding general site information and ecosystem classification were recorded in a Microsoft Access database, along with Floristic Quality Assessment survey results, Overall Disturbance, and Plant Community Condition Scores for each assessment area.

Appendix 1. Wisconsin Department of Natural Resources Disturbance Factors Field Checklist Form

Wisconsin Floristic Quality Assessment for Wetlands
Disturbance Factors Field Checklist Form WFQA2017

Project: ______________________________

Site Location Information					
Site/Assessment Area Name:		**Plant Community Type:**			**County:**
Date:	**Time:**	**Observers:**			

Hydrological or Habitat Alteration (Stressor):	**Stressor**	**AA (Assess. Area)**	**30m Buffer**	**Historic**	**Impact Level (L, M, H)**
Is there a hydrological or habitat alteration present at the site?	Ditch				
	Tile				
Consider each Stressor. Check the box if current stressors are observed in the AA (Assessment Area) or within a 30m Buffer (around the AA).	Dike				
	Water Control				
	Dredging				
	Filling/grading				
Check the Historic box if a stressor is evident but occurred in the past.	Excavation				
	Clear/Selective cut*				
Rank the level of impact as L (low), M (medium) or H (high).	Herb removal				
	Entire Vegetation stratum removal				
	Mowing/Grazing				
	Plowing/Ag				
	Sedimentation				
	StormH20 input				
	Eutrophication				
	Motor vehicle use				
Buffer (30m): For buffer stressors, note how much of the buffer area was observed and any other explanatory notes.	Road/RR/trails				
	Invasive Animals**				
Other Stressors or Comments: Note and describe any additional stressors. Make additional comments related to disturbance (this could include how commonly the stressor occurs in the watershed/region of interest.)	Buffer Notes:				
* Tree Age class on next page * * Invasive plants on next page	Other Stressors or Comments:				

Tree Age Class: *Wooded wetlands: Estimate the degree of logging disturbance. Age is approximated by the average size (dbh) of the taller trees. Size is not always a reliable indicator of age.* ***Select only one.***	▫ Not applicable ▫ (1) Seedlings: < 2.5 cm (<1") - Very Recent, Very High Disturbance ▫ (2) Saplings: 2.5-10cm (1-4") Recent, High Disturbance ▫ (3) Middle-Age:10-25 cm (4–10") – Not Recent, Moderate Disturbance ▫ (4) Mature: >25 cm (>10") – Low Disturbance

% Coverage Invasive Plants[1]:		
Consider the entire site. List the invasive plants present at the site. What percent of the site is covered by each invasive plant? ***Select only one coverage class for each plant listed. List additional invasive plants in General Comments if needed.***	Invasive Plant 1:	▫ (1) Present: 1% or less aerial cover. ▫ (2) Sparse: 2-5% aerial cover. ▫ (3) Medium: 6-25% aerial cover. ▫ (4) Extensive: 26-50% aerial cover. ▫ (5) Very Extensive: >50% aerial cover.
	Invasive Plant 2:	▫ (1) Present: 1% or less aerial cover. ▫ (2) Sparse: 2-5% aerial cover. ▫ (3) Medium: 6-25% aerial cover. ▫ (4) Extensive: 26-50% aerial cover. ▫ (5) Very Extensive: >50% aerial cover.
	Invasive Plant 3:	▫ (1) Present: 1% or less aerial cover. ▫ (2) Sparse: 2-5% aerial cover. ▫ (3) Medium: 6-25% aerial cover. ▫ (4) Extensive: 26-50% aerial cover. ▫ (5) Very Extensive: >50% aerial cover.

[1]See the WDNR website for detailed information on invasive species: go to: dnr.wi.gov/, search "invasive plants"

Overall Disturbance: *Based on all the disturbance factors, what is the overall disturbance level at the site?* ***Select only one.***	▫ (1) Non-disturbed (Very Few alterations, none greater than low intensity) ▫ (2) Minimal (Small number of alterations of low intensity, none greater than moderate intensity) ▫ (3) Moderate (Alterations of mostly low and moderate intensity, no high intensity alterations) ▫ (4) Major (Many alterations, including at least one of high intensity) ▫ (5) Severe (Many alterations, including multiple high intensity ones)

Plant Community Condition Assessment: *Based on the vegetation survey, what is your best professional judgment of plant community condition in this Assessment Area?* ***Select only one.***	▫ (1) Natural structure & function of plant community maintained. ▫ (2) Minimal changes in structure & function. ▫ (3) Evident changes in structure & minimal changes in function. ▫ (4) Moderate changes in structure & minimal changes in function. ▫ (5) Major changes in structure & moderate changes in function. ▫ (6) Severe changes in structure & function.

General Comments:

Floristic Quality Assessment Benchmark statistical process overview

For each wetland community type surveyed within an Ecoregion, several statistical tests were used to assess appropriateness for creating Floristic Quality Benchmarks (after Hlina et al. 2015), referred to hereafter as the "standard Benchmarks process" or "standard Benchmarks methodology", including the following:

1) Wetland community types were evaluated for "distinctness" among each other within the same Ecoregion using Non-Metric Multi-Dimensional Scaling (NMDS) analysis and related post-hoc tests.
2) Scatterplots and linear regressions were used to observe potential relationships among Floristic Quality Assessment Metrics, Overall Disturbance, and Plant Community Condition for each wetland community within a given Ecoregion. Community types which had a significant inverse relationship with disturbance were considered for further Benchmark development.
3) "Least disturbed" and "most disturbed" condition class categories were assigned, when applicable, to individual wetland assessment areas based on both Overall Disturbance and Plant Community Condition scores.
4) The 75^{th} and 25^{th} percentiles of FQA metric scores for both "least disturbed" and "most disturbed" wetlands for a given wetland community type within an ecoregion were used to define numeric Benchmark criteria (and corresponding tiered aquatic life use "tiers" with narrative condition classes) specific to each individual FQA metric.
5) Four different sets of *preliminary* Floristic Quality Benchmarks were produced for communities meeting the above criteria within each Ecoregion. Two sets of $\overline{C}$ scores were generated with the disturbance gradient being defined by either the Overall Disturbance Scores or Plant Community Condition Scores, and 2 sets of $w\overline{C}$ scores were also generated using Overall Disturbance or Plant Community Condition These were compared and the strongest set of preliminary benchmarks was chosen as *provisional* Benchmarks for each community/ecoregion combination.

Further detail about each of these individual steps is described in depth hereafter (including any derivations from this general protocol when they were warranted).

Statistical analyses

Numerous multivariate analyses were completed to investigate whether wetland community types assigned to assessment areas based on NHC classification indeed represent "distinct" plant communities from a compositional standpoint rather than an abstract anthropogenic classification based on observations. Plant community data (species lists and % cover estimates) and wetland community type data were aggregated by Ecoregion. For each Ecoregion, all wetland community types that had fewer than 4 representative assessment areas were excluded from that Ecoregional dataset for the purposes of the Non-Metric Multi-Dimensional Scaling (NMDS) analysis. The data were then reviewed to exclude all individual plant species that occurred on fewer than five percent of all sites across all wetland community types (Hlina et al. 2015). Data were then uploaded into R v.3.3.3 (R Core Team 2017) and analyzed using the "metaMDS" function within the "Vegan" package (Oksanen et al. 2017) to complete NMDS analysis for all applicable wetland community types within a given Ecoregion. For the analysis, a 2-dimensional solution was sought (k = 2) using Bray-Curtis Dissimilarity with a minimum of 100 attempts set to reach a final best solution (ordination) based on previous best solutions encountered during the analysis. All NMDS attempts were able to return a tolerable 2-dimensional solution, but returned model stress values near or above 0.2, indicating that the model results were not within a tolerable range for interpretation (i.e. positioning of sites within the ordination were approaching near-arbitrary results or results equivalent to randomized placement within the ordination; *sensu* Quinn and Keough 2003). To correct this inadequacy, plant abundance data were then Hellinger transformed using the "decostand" function within "Vegan" and the "metaMDS" function was completed again for each Ecoregion using the previous model specifications. These modifications returned tolerable 2-dimensional model results with slightly improved stress values (e.g. 0.179 to 0.195), resulting in interpretable NMDS ordinations (Table 2).

To further aid in interpretation of potential community "distinctness" within each Ecoregional NMDS, multiple analyses were conducted to test whether the community composition of the given wetland community types were more homogenous than the composition of all community types using two different tests within the "Vegan" package—"ANOSIM"(Analysis of Similarity; Clarke 1993; Clarke and Warwick 1994) and "ADONIS" (Oksanen 2015). The ANOSIM procedure tests if the average of the rank dissimilarities between all pairs of assessment areas among wetland communities was greater than the average of rank dissimilarities between all pairs of assessment areas within individual wetland communities, similar to comparing between-group and within-group variation with rank dissimilarities using an Analysis of Variance (ANOVA) test (sensu Quinn and Keough 2003). In addition, the "ADONIS" function within the "Vegan" package was also used to evaluate community distinctness (Oksanen 2015). ADONIS is a multivariate analysis of variances using distance matrices and generally regarded as more robust than ANOSIM (Oksanen 2015). For further clarification of these analyses, their differences, and overall null hypotheses, Anderson and Walsh (2013) should be consulted (note that ADONIS is the equivalent of a permutational multivariate analysis of variance, or PERMANOVA test). Both ANOSIM and ADONIS functions were run using Bray-Curtis Dissimilarity and 999 model permutations. Because both ANOSIM and ADONIS results can only indicate overall differences among wetland communities, but cannot specify pairwise differences among communities, a "pairwise.adonis" function was used to assess pairwise differences among individual wetland plant communities within a given ecoregion (Martinez Arbizu 2019).

Once the "distinctness" of a given wetland community type within an Ecoregion was confirmed using NMDS and related tests, wetland communities were then assessed using scatterplots and linear regressions using the "ggplot2" package (Wickham 2016) and associated functions in R to observe whether Floristic Quality Assessment scores (response variables) had an overall inverse relationship with Overall Disturbance and/or Plant Community Condition (independent variables). All wetland communities with a minimum of 10 representative assessment areas were considered. Site mean Coefficient of Conservatism ($\overline{C}$) and cover-weighted mean Coefficient of Conservatism ($w\overline{C}$) scores calculated using all observed species (where all non-natives have $C = 0$; Bernthal 2003) were the only Floristic Quality Assessment Metrics considered, as numerous other studies have documented issues with Floristic Quality Index (*FQI*) and cover-weighted Floristic Quality Index (*wFQI*) metrics and strongly supported metrics not including species richness (e.g. Kutcher and Forrester 2018; Hlina et al. 2015; Bourdaghs 2012). Regression results were considered statistically significant at $\alpha = 0.05$.

For each wetland community where Floristic Quality Assessment scores had an overall inverse relationship with Overall Disturbance and/or Plant Community Condition, each individual assessment area was placed into a disturbance classification category based on the results of the Disturbance Factors Field Checklist Form (*sensu* Hlina et al. 2015; Appendix 1). For Overall Disturbance, "least disturbed" wetlands were considered those assessment areas which had an Overall Disturbance ranking of "1" or "2", and "most disturbed" wetlands were assessment areas of "4" or "5". For Plant Community Condition, "least disturbed" wetlands were considered those assessment areas which had a Plant Community Condition ranking of "1" or "2", and "most disturbed" wetlands were assessment areas of "4", "5", or "6". Assessment areas which were ranked a "3" for either Overall Disturbance and Plant Community Condition were not placed into a "most disturbed" or "least disturbed" category, but could be considered at an "intermediate" level of disturbance.

Using the disturbance classification categories, *preliminary* condition tier Benchmarks for Overall Disturbance and Plant Community Condition were created for each individual wetland community type within an Ecoregion that met criteria to be considered within the regression analysis and had a significant inverse relationship between Floristic Quality metric scores and Overall Disturbance/Plant Community Condition. Condition Tiers 1 and 2 (referred to narratively as "Excellent" and "Good" categories, respectively) were defined as "least disturbed" wetlands, with Tier 1 considered to be all wetlands with $\overline{C}$ and/or $w\overline{C}$ scores above the 75th percentile of the least disturbed disturbance classification category, and Tier 2 considered to be all wetlands with $\overline{C}$ and/or $w\overline{C}$ scores between the 75th and 25th percentiles of the least disturbed disturbance classification category. Conversely, Condition Tiers 4 and 5 (referred to narratively as "Poor" and "Very Poor" categories, respectively) were defined

Table 2. Model inputs and results for Ecoregional Non-Metric Multi-Dimensional Scaling analyses and post-hoc analyses for all Ecoregions reported in this study. Post-hoc tests were not performed on non-transformed models due to unacceptable initial stress values (≈0.2). Ordinations of final model results are reported in Figures 5, 8, and 11.

	Non-Metric Multi-Dimensional Scaling Model Information by Omernik Level III Ecoregion					
	NCHF		SETP		DRFT	
	Data Type		Data Type		Data Type	
	Non-Transformed	Hellinger[b]	Non-Transformed	Hellinger[b]	Non-Transformed	Hellinger[b]
Base Model Inputs						
Number of Assessment Areas	216	216	193	193	125	125
Number of Community Types	15	15	9	9	9	9
Number of Observed Plant Species	747	747	833	833	553	553
Number of Plant Species Included[a]	229	229	302	302	234	234
Minumum Number Attempts	100	100	100	100	100	100
Number of Dimensions (k)	2	2	2	2	2	2
Dissimilarity Metric	Bray-Curtis	Bray-Curtis	Bray-Curtis	Bray-Curtis	Bray-Curtis	Bray-Curtis
Model Results						
Model Stress	0.2095	**0.1954**	0.2022	**0.1922**	**0.1919**	**0.1792**
ANOSIM Results						
Number of Model Permutations	999	999	999	999	999	999
ANOSIM R	N/A	0.6837	N/A	0.645	N/A	0.6792
ANOSIM Significance Value	N/A	**0.001**	N/A	**0.001**	N/A	**0.001**
ADONIS Results						
Number of Model Permutations	999	999	999	999	999	999
ADONIS P-Value	N/A	$\boldsymbol{p < 0.001}$	N/A	$\boldsymbol{p < 0.001}$	N/A	$\boldsymbol{p < 0.001}$
F-Statistic	N/A	9.69	N/A	13.63	N/A	14.85

[a] Plant species included in the analyses had to occur on 5% of the total number of assessment areas

[b] All final models and ordinations reported in this study are based on Hellinger-transformed data

as “most disturbed” wetlands, with Tier 5 considered to be all wetlands with $\overline{C}$ and/or $w\overline{C}$ scores below the 25th percentile of the most disturbed disturbance classification category, and Tier 4 considered to be all wetlands with $\overline{C}$ and/or $w\overline{C}$ scores between the 75th and 25th percentiles of the most disturbed disturbance classification category. All wetlands which had $\overline{C}$ and/or $w\overline{C}$ scores between the 75th percentile of the most disturbed disturbance classification category and the 25th percentile of the least disturbed disturbance classification category were considered Tier 3 wetlands (assigned a narrative rating of “Fair”). Boxplots and tables of these values were created for display and interpretation of Benchmark values.

Results

For the sake of brevity and clarity, we present only limited results for each Ecoregion in the main body of this report, namely:

1) Basic summary statistics regarding sites, their classification, and disturbance gradients
2) NMDS and post-hoc analyses
3) *Provisional* Benchmarks & associated statistics for $w\overline{C}$ vs. Overall Disturbance

The remainder of the results for *preliminary* Benchmarks that were considered are included within Appendix 2 for those interested in further comparison of results (i.e. $\overline{C}$ vs. Overall Disturbance, $\overline{C}$ vs. Plant Community Condition, and $w\overline{C}$ vs. Plant Community Condition). We strongly encourage use of $w\overline{C}$ Benchmarks based on Overall Disturbance as *provisional* Benchmarks due to both statistical and scientific justifications detailed in the *Discussion* and *Conclusion* sections of this text. We have included only those results in the main body of this report to emphasize their preferential use.

North Central Hardwood Forests (NCHF) Ecoregion

Between 2013 and 2015, 221 wetland assessment areas were surveyed in the NCHF with 747 different plant species recorded across 18 wetland community types (Table 1). Specifics regarding community types, their acronyms, and number of assessment areas sampled per community type can be viewed in Table 1.

NMDS and associated post-hoc tests

Fifteen wetland community types (represented by 216 assessment areas) had 4 or more assessment areas surveyed and were included in the NMDS analysis (Figure 5; Table 2). A 2-dimensional ordination using 229 plant species was reached with interpretable results (stress = 0.1954). In general, the NMDS 1 axis likely represented a gradient of pH, with more alkaline to neutral communities being represented by lower NMDS 1 values, and more acidic wetland communities associated with higher NMDS1 values. The NMDS2 axis likely represented a gradient of tree cover, where communities with low NMDS2 values were associated with low percentage of tree cover and high NMDS2 values associated with high percentage of tree cover. In general, communities that would be expected to be ecologically similar (e.g. Southern Sedge Meadow and Northern Sedge Meadow, Shrub Carr and Alder Thicket) shared some overlap in their distributions, whereas communities that are generally very different floristically (e.g. Emergent Marsh and Northern Wet-Mesic Forest) did not. Both ANOSIM and ADONIS results indicated significant differences in community composition among wetland communities overall (ANOSIM R = 0.6837, Significance = 0.001; ADONIS $p < 0.001$, F=9.69). In addition, the Pairwise ADONIS analysis indicated significant differences ($p < 0.05$) among all individual wetland community types with the only exception being no difference in composition among Poor Fen and Open Bog ($p = 0.09$). However, Poor Fen and Open Bog had low overall sample numbers (n = 9 and n = 4 assessment areas, respectively), which *a priori* excluded these community types as candidates for Benchmarks.

Regression analyses and associated Benchmarks: $w\overline{C}$ and Overall Disturbance

Ten (10) different wetland community types met minimum data standards for Benchmark consideration, accounting for 185 assessment areas. However, multiple community types were arguably underrepresented on the "most disturbed" end of the disturbance gradient based on Overall Disturbance scores. Black Spruce Swamp and Northern Hardwood Swamp had only two "most disturbed" category assessment areas each, Central Poor Fen had only one "most disturbed" category assessment area, and Northern Wet-Mesic Forest had no "most disturbed" category assessment areas (Table 3). These community types were retained for the analysis despite not having the desired representation of sites, but their regression results were interpreted with additional scrutiny (i.e. r^2 needed to be greater than 0.30; confidence intervals on regression lines needed to be reasonably tight with data distribution generally matching the trend of the overall regression).

Benchmark values for wetland community types which met all requisite criteria are presented in Table 5. The standard analytical sequence was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ with the exception of Northern Wet-Mesic Forest due to a lack of observed "most disturbed" assessment areas in the field. To account for this discrepancy, only 3 Benchmarks are suggested for Northern Wet-Mesic Forest, creating 3 narrative categories of "Excellent-Good", "Fair", and "Poor-Very Poor". In this case, the 75th percentile of "least disturbed" sites served as the lowest acceptable score to receive an "Excellent-Good" narrative rating, the 25th percentile of "least disturbed" assessment areas as the lowest acceptable score to receive a "Fair" narrative rating, and all assessment areas scoring below the 25th percentile would receive a "Poor-Very Poor" narrative rating (Table 5; Figure 7). Northern Tamarack Swamp and Northern Wet-Mesic Forest had the overall highest required Benchmarks to receive an "Excellent" narrative rating ($w\overline{C} > 7.1$), followed by Northern Sedge Meadow ($w\overline{C} > 7.0$) and Emergent Marsh ($w\overline{C} > 6.6$; Table 5). The lowest overall $w\overline{C}$ score required to receive an "Excellent" narrative rating was $w\overline{C} > 5.7$ for Shrub Carr. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Emergent Marsh (5.8 $w\overline{C}$ units difference). The narrowest gap between these narrative ratings was observed for Northern Tamarack Swamp (2.6 $\overline{C}$ units difference; Table 5).

In the regressions of $w\overline{C}$ scores versus Overall Disturbance Scores, only 7 community types had an observed significant inverse linear relationship with Alder Thicket, Black Spruce Swamp, and Central Poor Fen not meeting this criterion (Figure 6; Table 4). The highest average $w\overline{C}$ scores of "least disturbed" assessment areas were Northern Wet-Mesic Forest ($\mu w\overline{C} \approx 7$), followed by Northern Tamarack Swamp and Northern Sedge Meadow ($\mu w\overline{C} \approx 6.7$ to 6.8; Figure 7). In contrast, the lowest average $w\overline{C}$ scores of "most disturbed" assessment areas were observed in Shrub Carr and Northern Sedge Meadow ($\mu w\overline{C} \approx 1.9$; Figure 9). Regression slope coefficients ranged from -0.50 to -1.45, with anywhere from 30 to 85% of the variation in the regressions explained by Overall Disturbance depending on community type (based on r^2 values; Table 4). Community types which declined most rapidly in $w\overline{C}$ scores over the disturbance gradient, based on regression slope coefficients, included Emergent Marsh, Northern Sedge Meadow, Southern Sedge Meadow, and Shrub Carr which all decreased over 1 unit of average weighted conservatism value per 1 unit increase in Overall Disturbance Score (Figure 6; Table 4). In fact, Emergent Marsh decreased nearly 1.5 units of average weighted conservatism value per 1 unit increase in Overall Disturbance Score. The smallest overall slope coefficient was observed for Northern Wet-Mesic Forest (-0.50). Comparing the slope coefficients between Emergent Marsh and Northern Wet-Mesic Forest, which had the highest and lowest coefficients, respectively, $w\overline{C}$ scores declined three times as rapidly per 1 unit increase in Overall Disturbance Score in Emergent Marsh as Northern Wet-Mesic Forest (also evidenced by the regression lines in Figure 6).

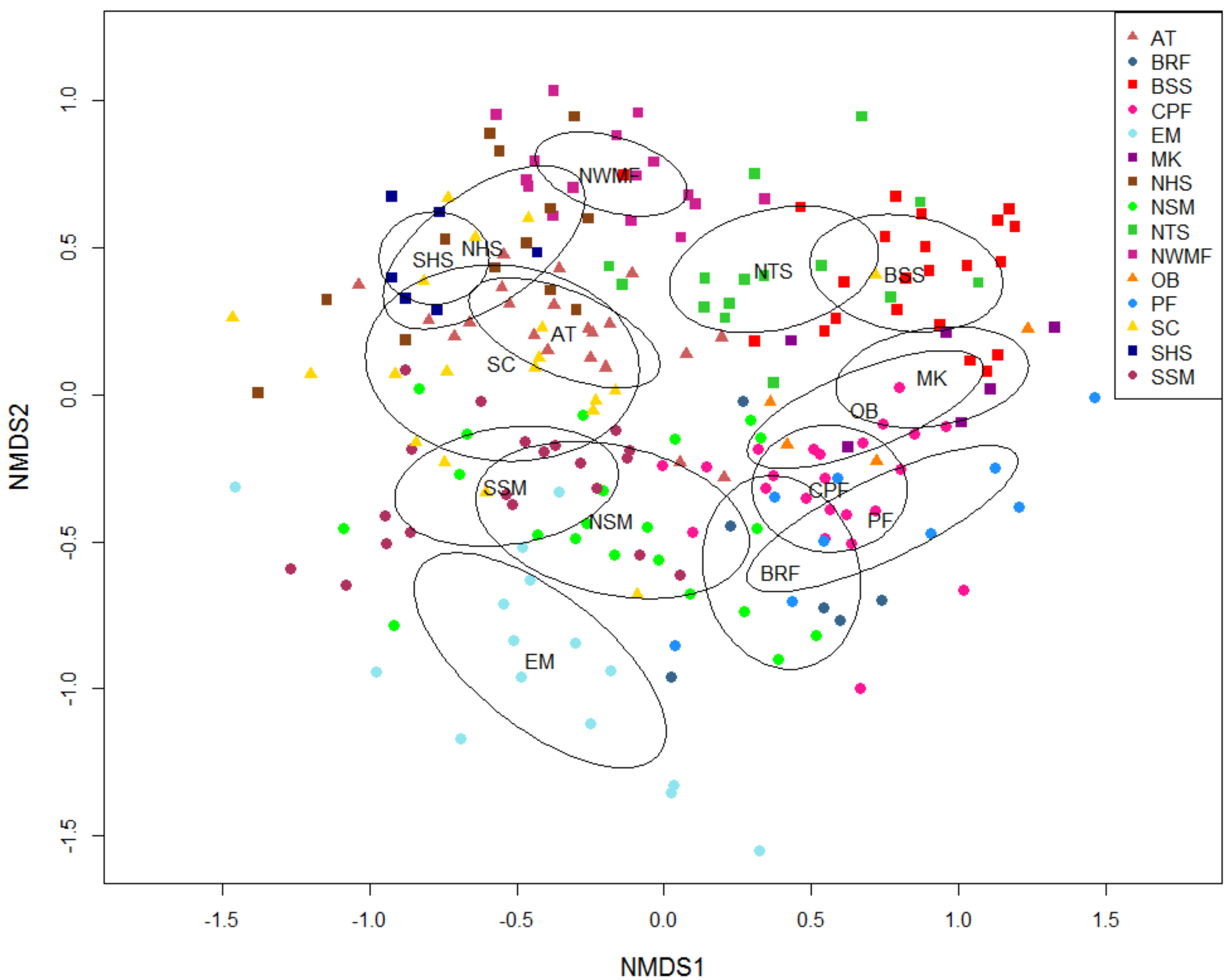


Figure 5. An ordination of 15 wetland plant communities (representing 229 plant species across 216 wetland assessment areas) using Non-Metric Multi-Dimensional Scaling (NMDS) for the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Ellipses indicate 1 standard deviation confidence interval around the centroid for each wetland community type (at location of community type label within the ellipse). Acronyms for wetland community types are described in Table 1. Model statistical results are described in Table 2.

Table 3. Number of assessment areas surveyed within the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion in "Most Disturbed" and "Least Disturbed" condition categories based on Overall Disturbance or Plant Community Condition scores from the Disturbance Factor Checklist. (n = total number of assessment areas surveyed).

		Disturbance Factor Checklist Disturbance Classification Type			
		Overall Disturbance Category		Plant Community Condition Category	
Community Type (and abbreviation)	n	Least Disturbed	Most Disturbed	Least Disturbed	Most Disturbed
Alder Thicket (AT)	21	10	9	10	6
Black Spruce Swamp (BSS)	22	18	2	14	4
Central Poor Fen (CPF)	23	19	1	20	2
Emergent Marsh (EM)	15	8	4	6	5
Northern Hardwood Swamp (NHS)	13	9	2	7	5
Northern Sedge Meadow (NSM)	21	14	5	12	6
Northern Tamarack Swamp (NTS)	15	7	6	5	8
Northern Wet-Mesic Forest (NWMF)	16	12	0	12	3
Shrub Carr (SC)	19	6	5	6	9
Southern Sedge Meadow (SSM)	20	9	6	9	7
Total	185	112	40	101	55

Table 4. Linear regression model results for Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Overall Disturbance scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y = -0.215x + 4.7	0.1	0.156
Black Spruce Swamp (BSS)	y = -0.173x + 7.8	0.08	0.208
Central Poor Fen (CPF)	y = 0.129x + 6.95	0.01	0.609
Emergent Marsh (EM)	y = -1.445x + 7.78	0.57	**0.001**
Northern Hardwood Swamp (NHS)	y = -0.954x + 6.68	0.46	**0.011**
Northern Sedge Meadow (NSM)	y = -1.367x + 8.35	0.85	**0.000**
Northern Tamarack Swamp (NTS)	y = -0.561x + 7.61	0.56	**0.001**
Northern Wet Mesic Forest (NWMF)	y = -0.501x + 7.64	0.3	**0.029**
Shrub Carr (SC)	y = -1.032x + 7.1	0.7	**0.000**
Southern Sedge Meadow (SSM)	y = -1.295x + 7.49	0.65	**0.000**

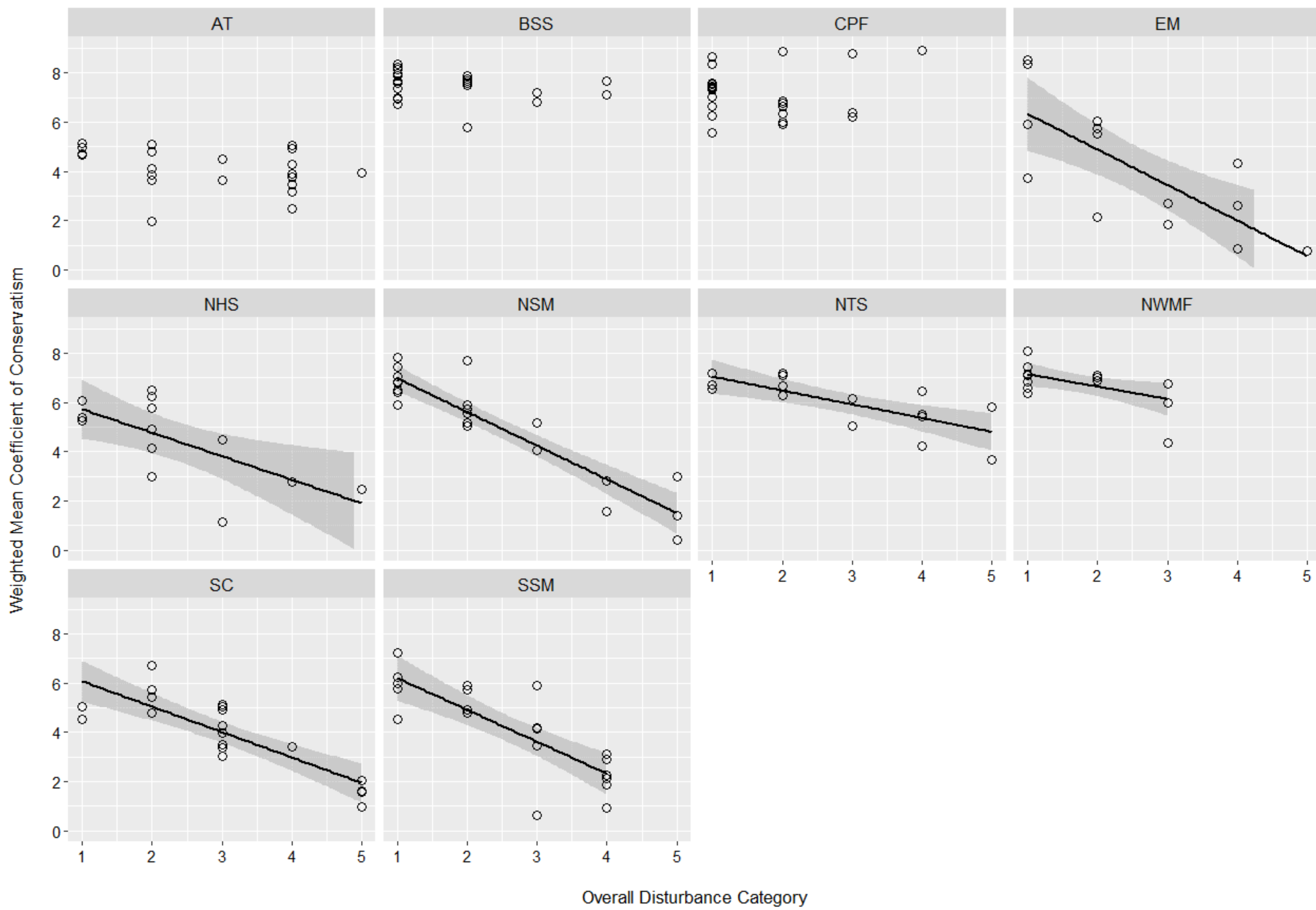


Figure 6. Scatterplots of assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Overall Disturbance Scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results ($\alpha = 0.05$). Community type abbreviations and regression statistical information are displayed in Table 4.

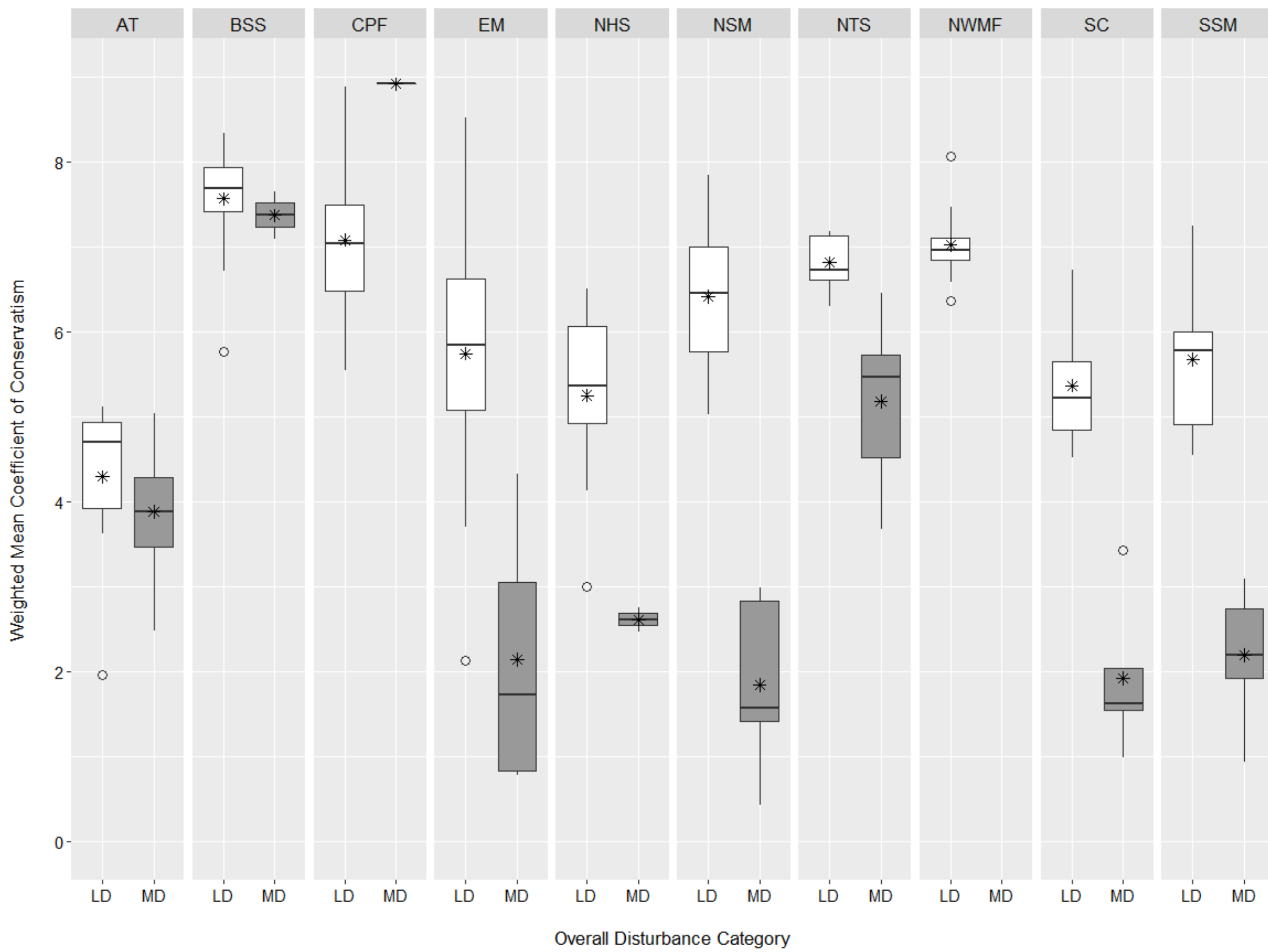


Figure 7. Boxplots of cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Overall Disturbance Scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Overall Disturbance Category by wetland community type are described in Table 3.

Table 5. Provisional Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)*	---	---	---	---	---
Black Spruce Swamp (BSS)*	---	---	---	---	---
Central Poor Fen (CPF)*	---	---	---	---	---
Emergent Marsh (EM)	> 6.6	5.2- 6.6	3.1 - 5.1	0.8 - 3.0	< 0.8
Northern Hardwood Swamp (NHS)	> 6.1	5.0 - 6.1	2.7 - 4.9	2.5 - 2.6	< 2.5
Northern Sedge Meadow (NSM)	> 7.0	5.9 - 7.0	2.8 - 5.8	1.4 - 2.7	< 1.4
Northern Tamarack Swamp (NTS)	> 7.1	6.7 - 7.1	5.7 - 6.6	4.5 - 5.6	< 4.5
Northern Wet Mesic Forest (NWMF)**	> 7.1		6.8 - 7.1	< 6.8	
Shrub Carr (SC)	> 5.7	4.9 - 5.7	2 - 4.8	1.6 - 1.9	< 1.6
Southern Sedge Meadow (SSM)	> 6.0	5.0 - 6.0	2.7 - 4.9	1.9 - 2.6	< 1.9

*Type did not have significant inverse relationship with Overall Disturbance; no benchmarks currently suggested

**Tiers calculated using Least Disturbed 75th and 25th %

Southeast Wisconsin Till Plains (SETP) Ecoregion

Between 2013 and 2017, 193 wetland assessment areas were surveyed in the SETP with 833 different plant species recorded across 9 observed wetland community types (Table 1). Specifics regarding community types, their specific acronyms, and number of assessment areas sampled per community type can be viewed in Table 1.

NMDS and associated post-hoc tests

All 9 surveyed wetland community types had 4 or more assessment areas surveyed and were included in the NMDS analysis (Figure 8; Table 2). A 2-dimensional ordination using 302 plant species was reached with interpretable results (stress = 0.1922). In general, the NMDS1 axis likely represented a moisture gradient, where communities with low NMDS1 scores were associated with lower overall frequency or depth of inundation, and communities with high NMDS1 scores were associated with more frequent or deeper inundation (Figure 8). The NMDS2 axis likely represented a gradient of tree cover, where communities with low NMDS2 values were associated with low percentage of tree cover and high NMDS2 values associated with high percentage of tree cover. In general, communities that would be expected to ecologically similar (e.g. Northern Hardwood Swamp and Northern Wet-Mesic Forest) shared some overlap in their distributions, whereas communities that are generally very different floristically (e.g. Wet Mesic Prairie and Floodplain Forest) did not. Both ANOSIM and ADONIS results indicated significant differences in community composition among wetland communities overall (ANOSIM R = 0.645, Significance = 0.001; ADONIS $p < 0.001$, F=13.63). In addition, the Pairwise ADONIS analysis indicated significant differences among all individual wetland community types ($p < 0.05$).

Regression analyses and associated Benchmarks: $w\overline{C}$ and Overall Disturbance

All 9 wetland community types surveyed met minimum data standards for Benchmark consideration based on 193 assessment areas. However, multiple community types were arguably underrepresented on the “most disturbed” end of the disturbance gradient based on Overall Disturbance scores. Floodplain Forest, Northern Hardwood Swamp and Northern Wet-Mesic Forest had 5 or fewer most disturbed category assessment areas each (Table 6). These community types were retained for the analysis despite not having the desired representation of most disturbed category assessment areas, but their regression results were interpreted with additional scrutiny (i.e. r^2 needed to be greater than 0.30; confidence intervals on regression lines needed to be reasonably tight with data distribution generally matching the trend of the overall regression).

Benchmarks were attained for all 9 wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table 8). In observing the $w\overline{C}$ Benchmark values Calcareous Fen had the overall highest required Benchmarks to receive an "Excellent" narrative rating ($w\overline{C} > 7.0$), followed by Northern Wet-Mesic Forest ($w\overline{C} > 6.5$) and Southern Sedge Meadow ($w\overline{C} > 6.3$; Table 8). The lowest overall $w\overline{C}$ score required to receive an "Excellent" narrative rating was $w\overline{C} > 4.0$ for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Southern Sedge Meadow (5.3 $w\overline{C}$ units difference). The narrowest gap between these narrative ratings was observed for Northern Wet-Mesic Forest (1.2 $\overline{C}$ units difference; Table 8).

In the regressions of $w\overline{C}$ scores versus Overall Disturbance Scores, all 9 candidate community types had an observed significant inverse linear relationship (Figure 9; Table 7). The highest average $w\overline{C}$ scores of "least disturbed" assessment areas were Calcareous Fen and Northern Wet-Mesic Forest ($\mu w\overline{C} \approx 6.3$), followed by Southern Sedge Meadow ($\mu w\overline{C} \approx 5.9$; Figure 10). In contrast, the lowest average $w\overline{C}$ scores of "most disturbed" assessment areas were observed in Emergent Marsh ($\mu w\overline{C} \approx 1.6$) and Floodplain Forest ($\mu w\overline{C} \approx 2.1$; Figure 10). Regression slope coefficients ranged from -0.35 to -1.27, with anywhere from 45 to 82% of the variation in the regressions explained by Overall Disturbance depending on community type (based on r^2 values; Table 7). Community types which declined most rapidly in $w\overline{C}$ scores over the disturbance gradient, based on regression slope coefficients, included Calcareous Fen, Emergent Marsh, and Southern Sedge Meadow which all decreased over 1 unit of average weighted conservatism value per 1 unit increase in Overall Disturbance Score (Figure 9; Table 7). In fact, Calcareous Fen decreased nearly 1.3 units of average weighted conservatism value per 1 unit increase in Overall Disturbance Score. The smallest overall slope coefficient was observed for Northern Wet-Mesic Forest (-0.35). Comparing the slope coefficients between Emergent Marsh and Northern Wet-Mesic Forest, which had the highest and lowest coefficients, respectively, $w\overline{C}$ scores declined over three-and-a-half times as rapidly per 1 unit increase in Overall Disturbance Score in Emergent Marsh as compared to Northern Wet-Mesic Forest as also evidenced by the regression lines in Figure 9.

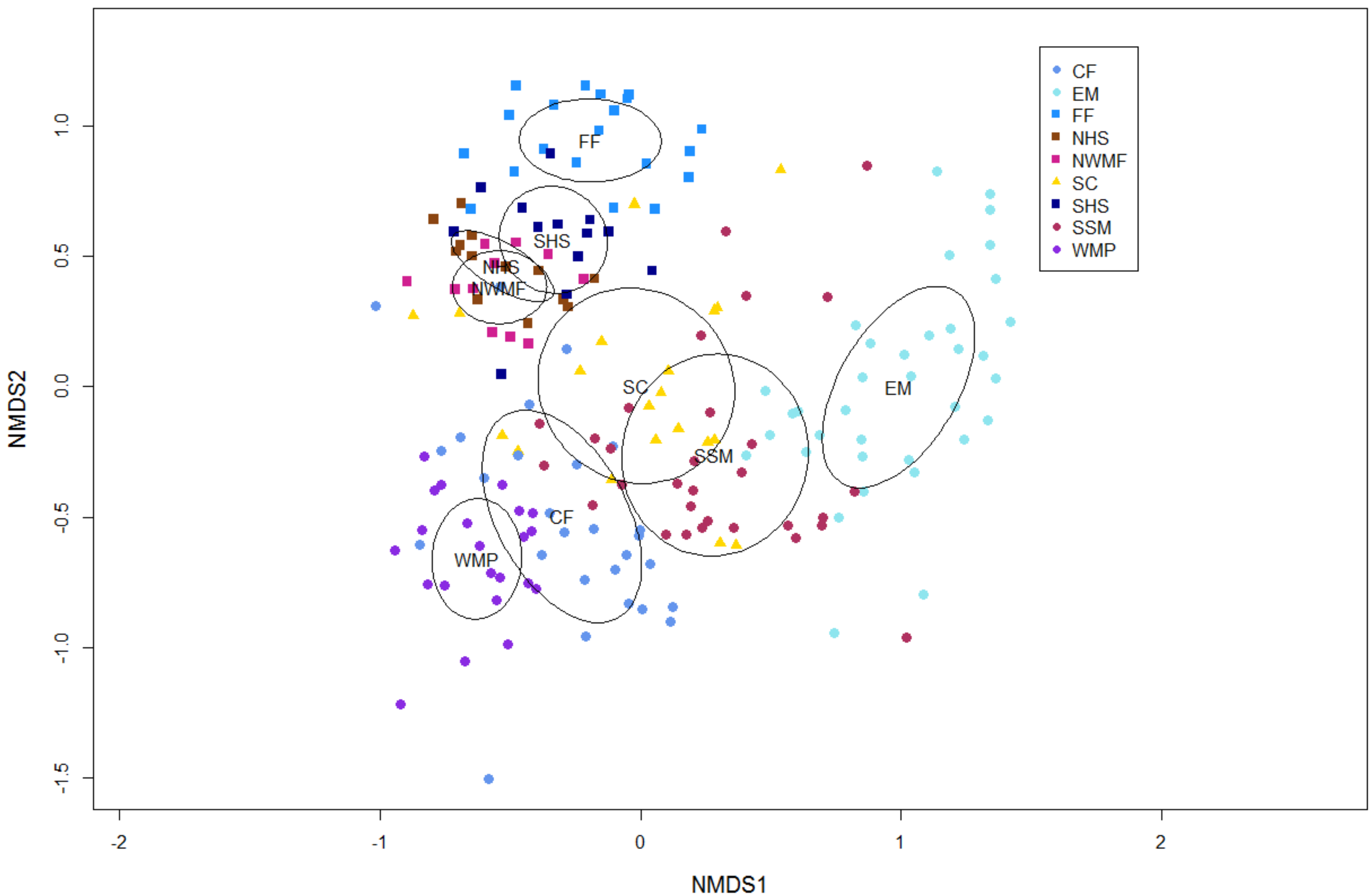


Figure 8. An ordination of 9 wetland plant communities (representing 302 plant species across 193 wetland assessment areas) using Non-Metric Multi-Dimensional Scaling (NMDS) for the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Ellipses indicate 1 standard deviation confidence interval around the centroid for each wetland community type (at location of community type label within the ellipse). Acronyms for wetland community types are described in Table 1. Model statistical results are described in Table 2.

Table 6. Number of assessment areas surveyed within the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion in "Most Disturbed" and "Least Disturbed" condition categories based on Overall Disturbance or Plant Community Condition scores from the Disturbance Factor Checklist. (n = total number of assessment areas surveyed).

		Disturbance Factor Checklist Disturbance Classification Type			
		Overall Disturbance Category		Plant Community Condition Category	
Community Type (and abbreviation)	n	Least Disturbed	Most Disturbed	Least Disturbed	Most Disturbed
Calcareous Fen (CF)	27	6	14	8	14
Emergent Marsh (EM)	36	10	13	12	15
Floodplain Forest (FF)	20	4	5	5	10
Northern Hardwood Swamp (NHS)	13	4	4	5	7
Northern Wet-Mesic Forest (NWMF)	11	5	5	5	6
Shrub Carr (SC)	20	9	9	9	7
Southern Hardwood Swamp (SHS)	13	6	6	6	7
Southern Sedge Meadow (SSM)	30	17	10	16	10
Wet-Mesic Prairie (WMP)	23	11	10	11	10
Total	193	72	76	77	86

Table 7. Linear regression model results for Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Overall Disturbance scores based on the Disturbance Factors Checklist. Bolded values indicate significance at α = 0.05.

Plant community type	Regression equation	r^2	*p*
Calcareous Fen (CF)	y= -1.27x + 8.66	0.67	**0.000**
Emergent Marsh (EM)	y= -1.14x + 6.99	0.53	**0.000**
Floodplain Forest (FF)	y= -0.76x + 5.21	0.55	**0.000**
Northern Hardwood Swamp (NHS)	y= -0.7x + 7.09	0.68	**0.000**
Northern Wet Mesic Forest (NWMF)	y= -0.35x + 7.01	0.45	**0.025**
Shrub Carr (SC)	y= -0.77x + 5.95	0.82	**0.000**
Southern Hardwood Swamp (SHS)	y= -0.56x + 5.02	0.52	**0.005**
Southern Sedge Meadow (SSM)	y= -1.11x + 7.65	0.65	**0.000**
Wet-Mesic Prairie (WMP)	y= -0.79x + 6.13	0.6	**0.000**

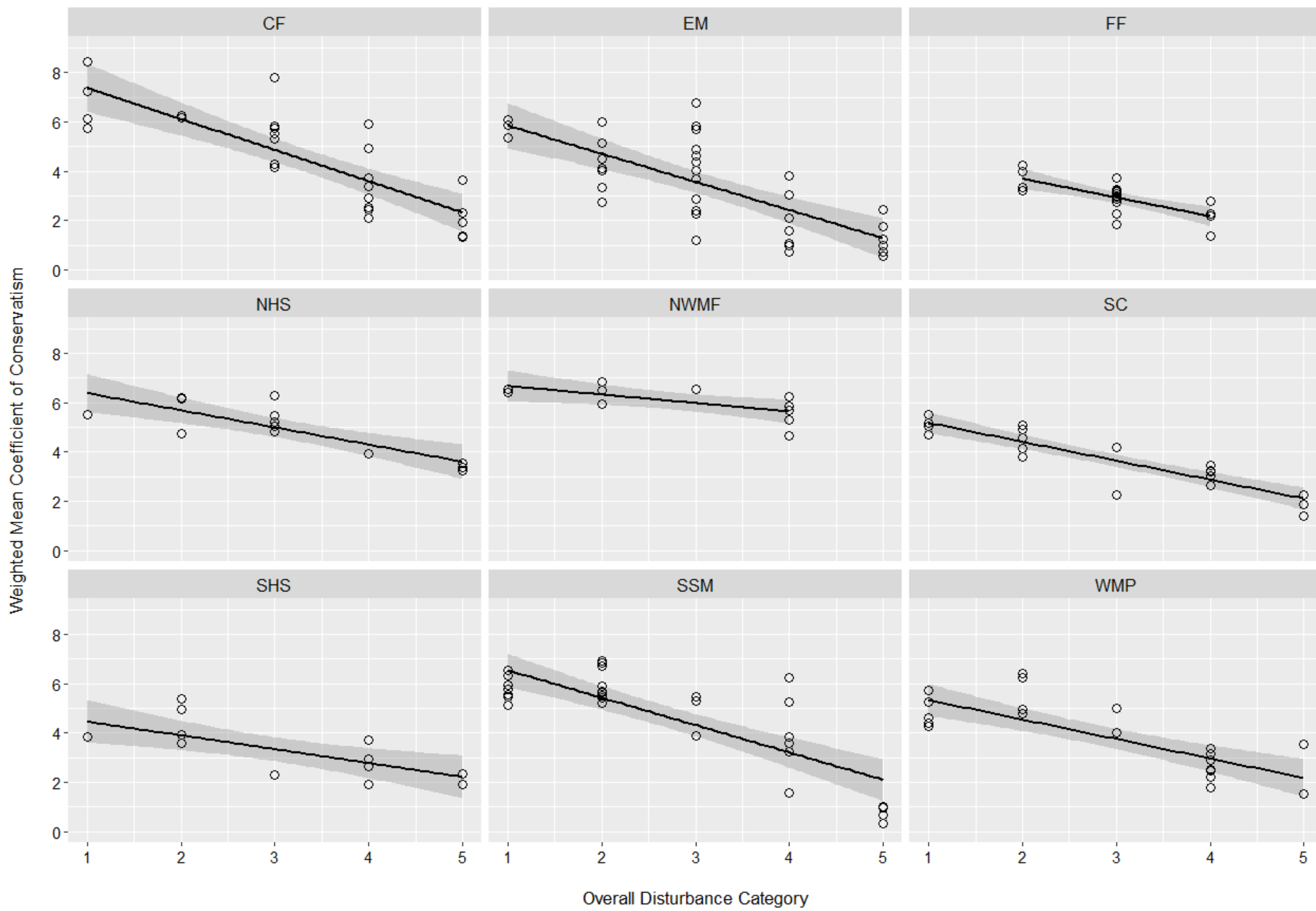


Figure 9. Scatterplots of assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Overall Disturbance Scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results ($\alpha = 0.05$). Community type abbreviations and regression statistical information are displayed in Table 7.

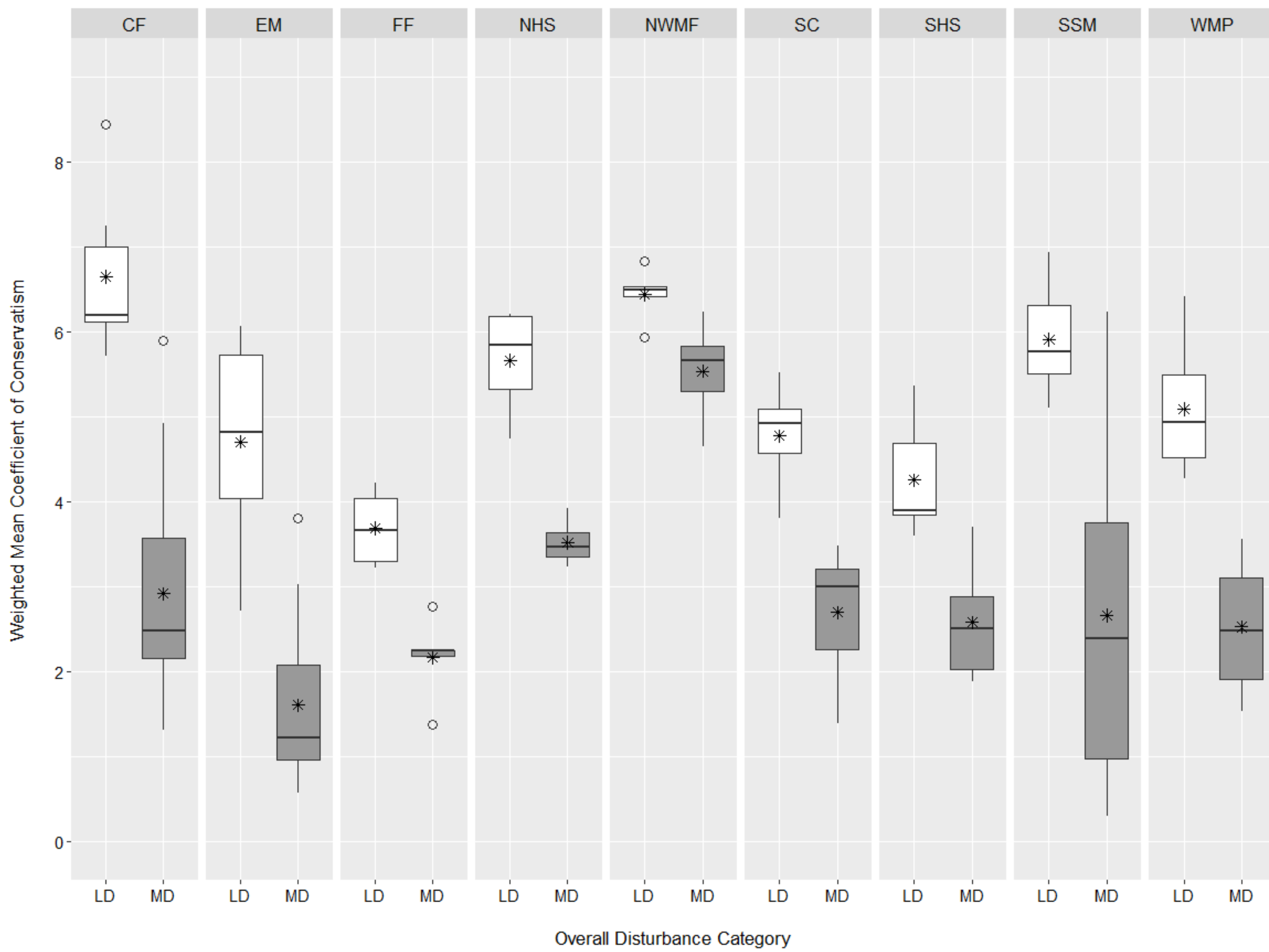


Figure 10. Boxplots of cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Overall Disturbance Scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Overall Disturbance Category by wetland community type are described in Table 6.

Table 8. Provisional Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Calcareous Fen (CF)	> 7.0	6.2 - 7.0	3.6 - 6.1	2.2 - 3.5	< 2.2
Emergent Marsh (EM)	> 5.7	4.1 - 5.7	2.1 - 4.0	1.0 - 2.0	< 1.0
Floodplain Forest (FF)	> 4.0	3.4 - 4.0	2.3 - 3.3	2.2	< 2.2
Northern Hardwood Swamp (NHS)	> 6.2	5.4 - 6.2	3.6 - 5.3	3.4 - 3.5	< 3.4
Northern Wet Mesic Forest (NWMF)	> 6.5	6.5	5.8 - 6.4	5.3 - 5.7	< 5.3
Shrub Carr (SC)	> 5.1	4.7 - 5.1	3.2 - 4.6	2.3 - 3.1	< 2.3
Southern Hardwood Swamp (SHS)	> 4.7	4.0 - 4.7	2.9 - 3.9	2.0 - 2.8	< 2.0
Southern Sedge Meadow (SSM)	> 6.3	5.6 - 6.3	3.8 - 5.5	1.0 - 3.7	< 1.0
Wet-Mesic Prairie (WMP)	> 5.5	4.6 - 5.5	3.1 - 4.5	1.9 - 3.0	< 1.9

Driftless Area Ecoregion

Between 2015 and 2018, 126 wetland assessment areas were surveyed in the DRFT with 553 different plant species recorded across 6 observed wetland community types (Table 1). Specifics regarding community types, their specific acronyms, and number of assessment areas sampled per community type can be viewed in Table 1.

NMDS and associated post-hoc tests

Five (5) of the 6 surveyed wetland community types (represented by 125 assessment areas) had 4 or more assessment areas surveyed and were included in the NMDS analysis (Figure 11; Table 2). A 2-dimensional ordination using 234 plant species was reached with interpretable results (stress = 0.1792). The NMDS1 axis likely represented a gradient of woody (tree and/or shrub) cover, where communities with low NMDS1 values were associated with a high percentage of woody cover and high NMDS1 values associated with a low percentage of woody cover (Figure 11). The NMDS 2 axis was not interpretable as any type of environmental or community compositional gradient. Communities that would be expected to ecologically similar (e.g. Shrub Carr and Alder Thicket) shared some overlap in their distributions, whereas communities that are very different floristically (e.g. Emergent Marsh and Floodplain Forest) did not. Both ANOSIM and ADONIS results indicated significant differences in community composition among wetland communities overall (ANOSIM R = 0.679, Significance = 0.001; ADONIS $p < 0.001$, F=14.85). In addition, the Pairwise ADONIS analysis indicated significant differences among all individual wetland community types ($p < 0.001$).

Regression analyses and associated Benchmarks: $w\overline{C}$ and Overall Disturbance

Of wetland community types surveyed, 5 of 6 met minimum data standards for Benchmark consideration, accounting for 125 assessment areas. However, Alder Thicket was underrepresented on the "most disturbed" end of the disturbance gradient based on Overall Disturbance with only 3 most disturbed category assessment areas (Table 9). Alder Thicket was retained for the analysis despite not having the desired representation of most disturbed category sites, but regression results were interpreted with additional scrutiny (i.e. r^2 needed to be greater than 0.30; confidence intervals on regression lines needed to be reasonably tight with data distribution generally matching the trend of the overall regression).

Benchmark values for $w\overline{C}$ are presented in Table 11 for all 5 surveyed communities. The standard analytical sequence as described in the "Methods" section was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table 25). Southern Sedge Meadow had the overall highest required Benchmarks to receive an "Excellent" narrative rating ($w\overline{C} > 5.9$), followed by Shrub Carr ($w\overline{C} > 5.5$) and Emergent Marsh ($w\overline{C} > 5.2$; Table 11). The lowest overall $w\overline{C}$ score required to receive an "Excellent" narrative rating was $w\overline{C}$ > 4.4 for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Southern Sedge Meadow (4.8 $w\overline{C}$ units difference). The narrowest gap between these narrative ratings was observed for Alder Thicket (1.8 $\overline{C}$ units difference; Table 11).

In the regressions of $w\overline{C}$ scores versus Overall Disturbance Scores, all 5 candidate community types had a significant inverse linear relationship (Figure 12; Table 10). The highest average $w\overline{C}$ score of "least disturbed" assessment areas was Southern Sedge Meadow ($\mu w\overline{C} \approx 5.5$), followed by Emergent Marsh ($\mu w\overline{C} \approx 5.0$; Figure 13). In contrast, the lowest average $w\overline{C}$ scores of "most disturbed" assessment areas were observed in Southern Sedge Meadow ($\mu w\overline{C} \approx 1.5$) and Shrub Carr ($\mu w\overline{C} \approx 2.2$; Figure 13). Regression slope coefficients ranged from -0.46 to -1.18, with anywhere from 53 to 84% of the variation in the regressions explained by Overall Disturbance depending on community type (based on r^2 values; Table 10). Community types which declined most rapidly in $w\overline{C}$ scores over the disturbance gradient, based on regression slope coefficients, included Southern Sedge Meadow and Emergent Marsh which all decreased over 0.9 units of average weighted conservatism value per 1 unit increase in Overall Disturbance Score (Figure 12; Table 10). In fact, Southern Sedge Meadow decreased nearly 1.2 units of average weighted conservatism value per 1 unit increase in Overall Disturbance Score. The smallest overall slope coefficient was observed for Alder Thicket (-0.46). Comparing the slope coefficients between Southern Sedge Meadow and Alder Thicket, which had the highest and lowest coefficients, respectively, $w\overline{C}$ scores declined over two-and-a-half times as rapidly per 1 unit increase in Overall Disturbance Score in Southern Sedge Meadow as compared to Alder Thicket as also evidenced by the regression lines in Figure 12.

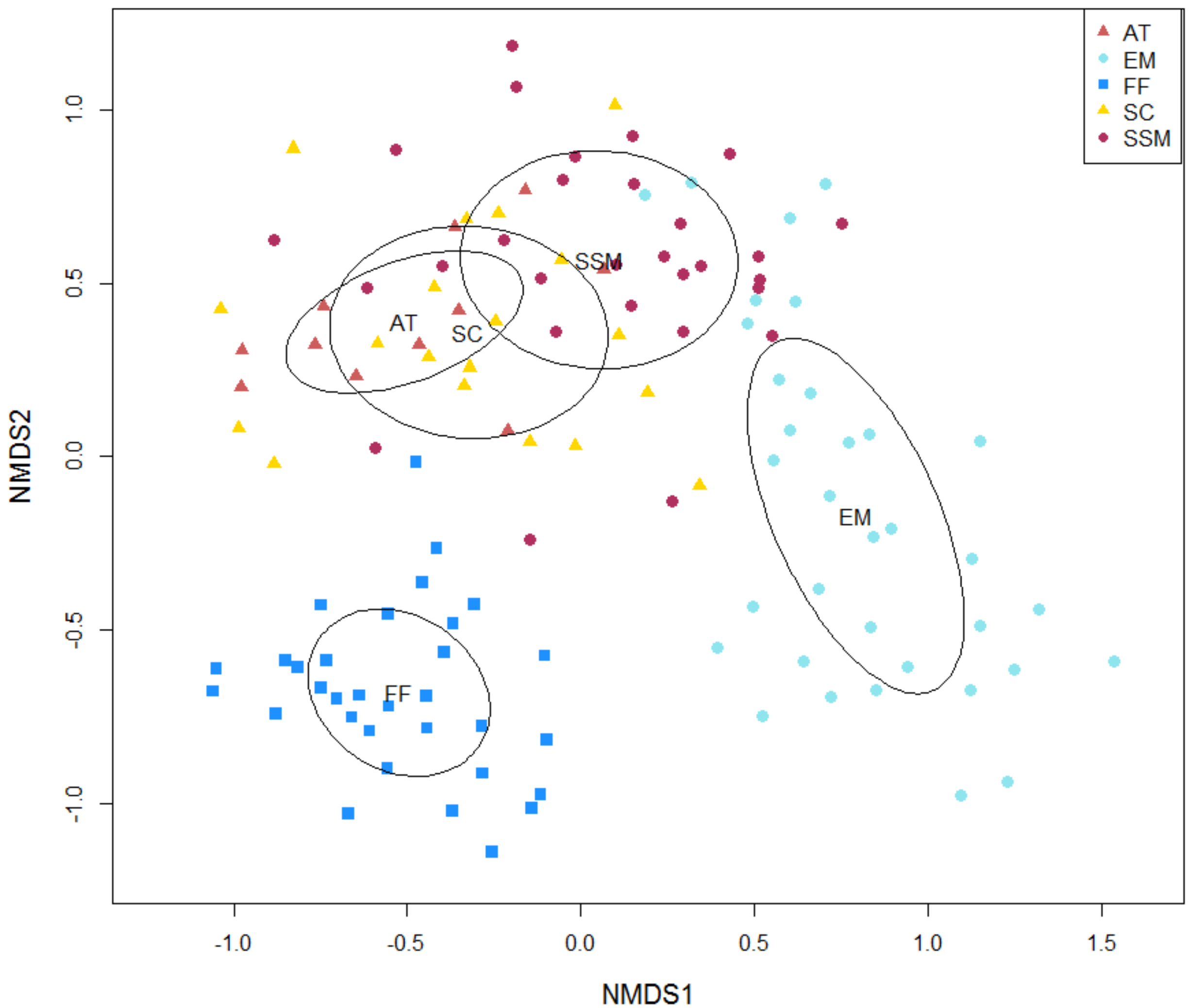


Figure 11. An ordination of 5 wetland plant communities (representing 234 plant species across 125 wetland assessment areas) using Non-Metric Multi-Dimensional Scaling (NMDS) for the Wisconsin Omernik Level III Driftless Area Ecoregion. Ellipses indicate 1 standard deviation confidence interval around the centroid for each wetland community type (at location of community type label within the ellipse). Acronyms for wetland community types are described in Table 1. Model statistical results are described in Table 2.

Table 9. Number of assessment areas surveyed within the Wisconsin Omernik Level III Driftless Area Ecoregion in "Most Disturbed" and "Least Disturbed" condition categories based on Overall Disturbance or Plant Community Condition scores from the Disturbance Factor Checklist. (n = total number of assessment areas surveyed).

		Disturbance Factor Checklist Disturbance Classification Type			
		Overall Disturbance Category		Plant Community Condition Category	
Community Type (and abbreviation)	n	Least Disturbed	Most Disturbed	Least Disturbed	Most Disturbed
Alder Thicket (AT)	11	6	3	6	3
Emergent Marsh (EM)	34	19	11	17	11
Floodplain Forest (FF)	32	11	14	11	16
Shrub Carr (SC)	19	8	10	8	10
Southern Sedge Meadow (SSM)	29	15	13	14	13
Total	125	59	51	56	53

Table 10. Linear regression model results for Wisconsin Omernik Level III Driftless Area Ecoregion assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Overall Disturbance scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y= -0.46x + 5.4	0.77	**0.000**
Emergent Marsh (EM)	y= -0.93x + 6.57	0.64	**0.000**
Floodplain Forest (FF)	y= -0.55x + 4.93	0.53	**0.000**
Shrub Carr (SC)	y= -0.86x + 5.98	0.74	**0.000**
Southern Sedge Meadow (SSM)	y= -1.18x + 7.12	0.84	**0.000**

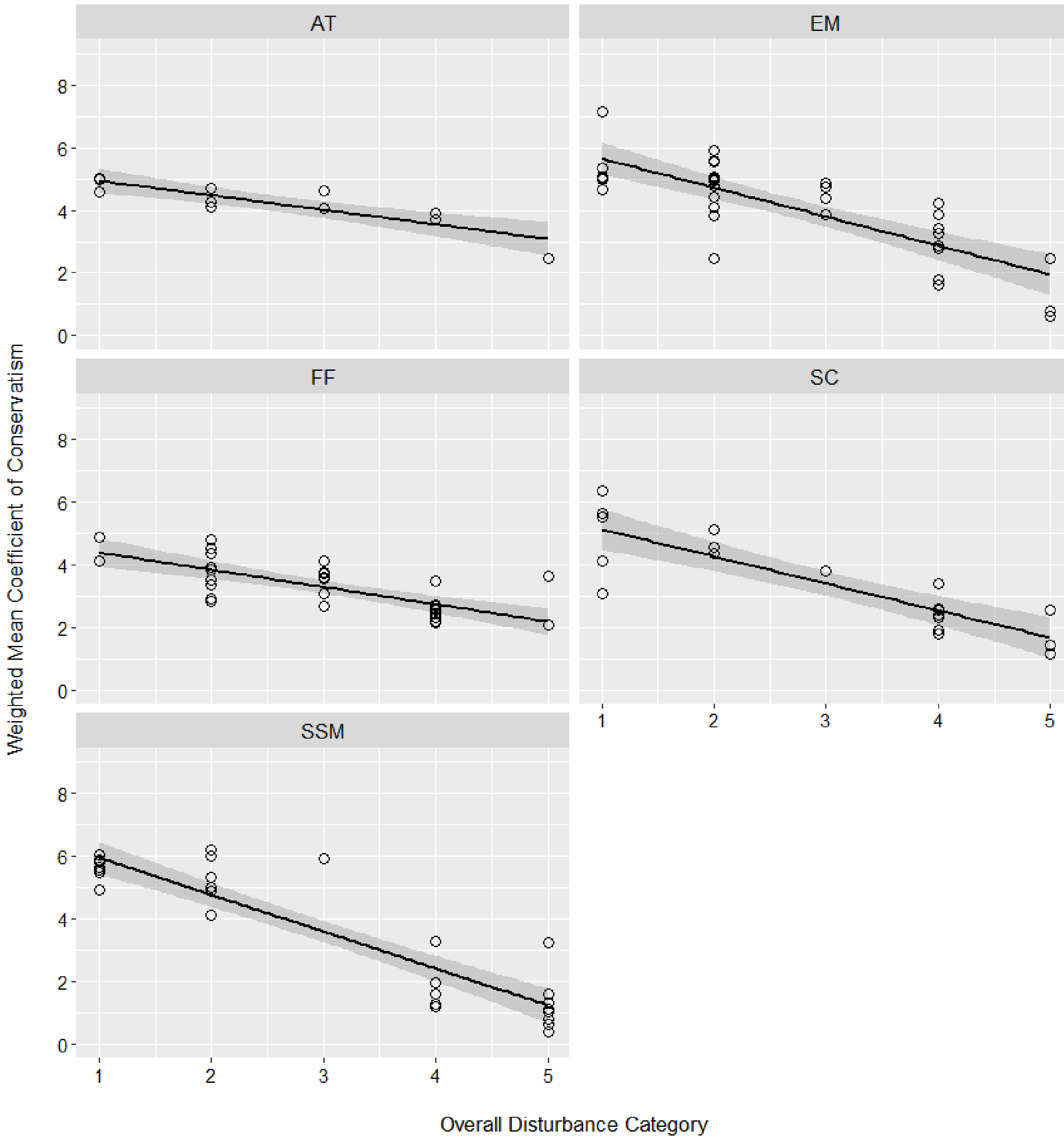


Figure 12. Scatterplots of assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Overall Disturbance Scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table 10.

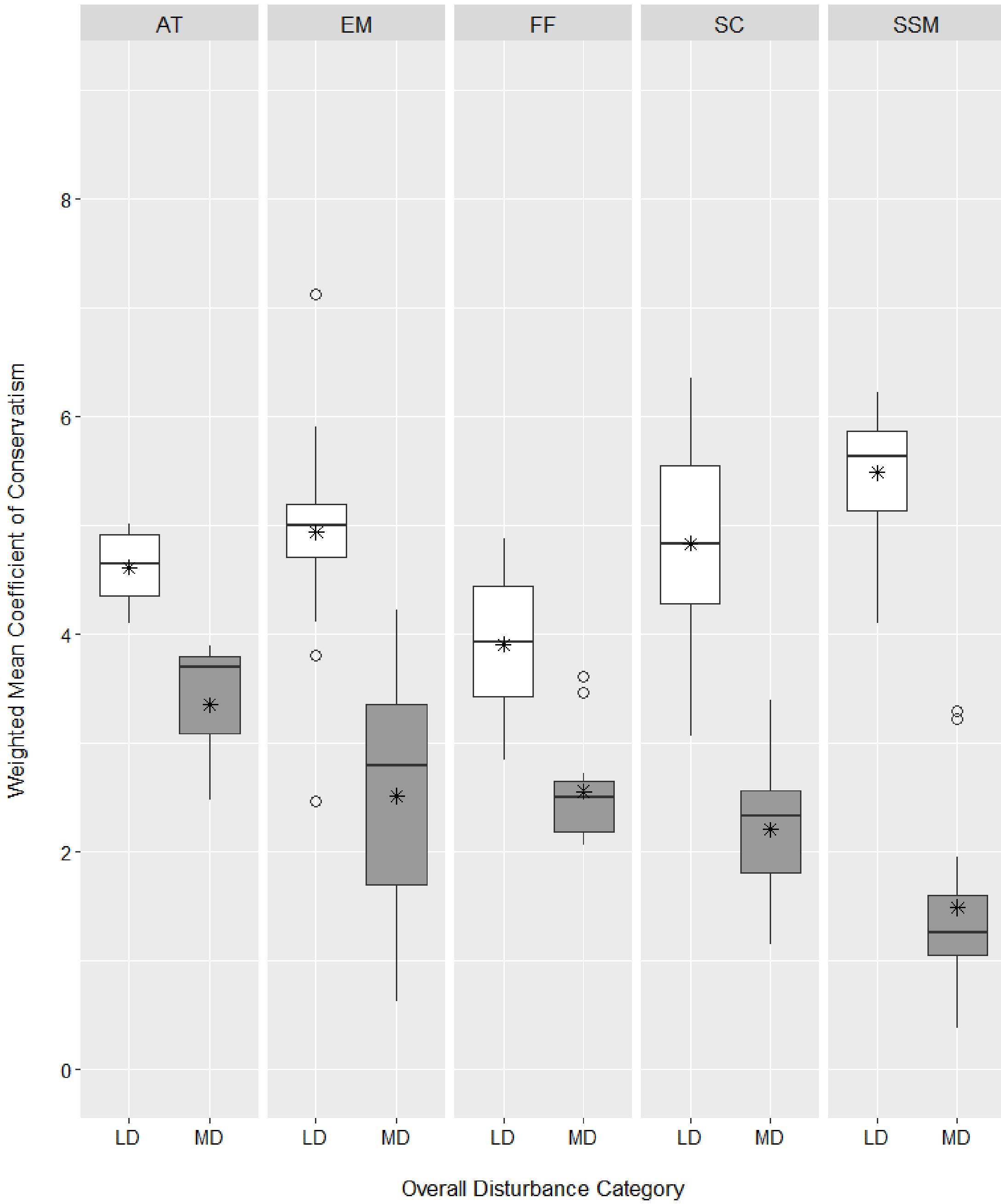


Figure 13. Boxplots of cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Overall Disturbance scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Overall Disturbance Category by wetland community type are described in Table 9.

Table 11. Provisional Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Driftless Area Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)	> 4.9	4.5 - 4.9	3.8 - 4.4	3.1 - 3.7	< 3.1
Emergent Marsh (EM)	> 5.2	4.8 - 5.2	3.4 - 4.7	1.7 - 3.3	< 1.7
Floodplain Forest (FF)	> 4.4	3.5 - 4.4	2.7 - 3.4	2.2 - 2.6	< 2.2
Shrub Carr (SC)	> 5.5	4.4 - 5.5	2.6 - 4.3	1.8 - 2.5	< 1.8
Southern Sedge Meadow (SSM)	> 5.9	5.1 - 5.9	1.6 - 5.0	1.1 - 1.5	< 1.1

Discussion

Generation of FQA Benchmarks

The Wisconsin Floristic Quality Assessment Benchmarks study represented the first attempt to generate provisional FQA Benchmarks for a majority of common inland wetland community types across the entirety of Wisconsin at Ecoregion-specific scales. Four different sets of "preliminary" Floristic Quality Benchmarks were produced for all communities meeting the required statistical criteria within each Ecoregion. Two sets of $\overline{C}$ scores were generated with the disturbance gradient being defined by either the Overall Disturbance Scores or Plant Community Condition Scores, and 2 sets of $w\overline{C}$ scores were also generated using Overall Disturbance or Plant Community Condition. These were compared and the strongest set of preliminary benchmarks were chosen as provisional Benchmarks for each community/ecoregion combination. In all cases we chose $w\overline{C}$ as the response metric and chose Overall Disturbance over Plant Community Condition to define the disturbance gradient.

Cover-weighted Mean C ($w\overline{C}$) outperforms un-weighted Mean C ($\overline{C}$)

Cover-weighted Mean C ($w\overline{C}$)was chosen as a more defensible metric than un-weighted Mean C ($\overline{C}$) across the board for several reasons. Similar to previous studies attempting to create FQA Benchmarks for wetland community types based on a disturbance gradient (e.g. Bourdaghs 2012; Hlina et al. 2015), $w\overline{C}$ was consistently more responsive to disturbance than $\overline{C}$ as evidenced by both the regression statistical results and corresponding Benchmark values. Community diversity and the effects of overall cover of individual plant species are captured using $w\overline{C}$, thus resulting in a more ecologically and statistically defensible assessment metric and corresponding set of Benchmark criteria for comparison. Based on these factors, $w\overline{C}$ Benchmarks should be used as *provisional* Benchmarks whenever possible, but in the instance that only limited historical/past acquired data are available (i.e. a plant species list/inventory without cover percentage estimates), preliminary $\overline{C}$ Benchmarks may be applied with the understanding of their potential limitations. These are included, along with a discussion, in Appendix 2.

For example, when comparing the regression slope coefficients between the regressions for $\overline{C}$ and $w\overline{C}$ versus Overall Disturbance Scores for NCHF Northern Sedge Meadow, the slope of the regression for $w\overline{C}$ (-1.367) predicted an over two-and-a-half times greater decrease in C units per 1 unit increase in Overall Disturbance Score than that for $\overline{C}$ (-0.523; Table 4 and Appendix 2 Table I). In addition, the regression for $w\overline{C}$ was able to explain 43% more variation ($r^2 = 0.85$) than the regression based on $\overline{C}$ ($r^2 = 0.42$; Table 4 and Appendix 2 Table I). When comparing Benchmark scores based on Overall Disturbance within NCHF Northern Sedge Meadow, the minimum numeric criteria needed to receive an

"Excellent" condition class rating was 0.7 C units higher for $w\overline{C}$ ($w\overline{C}$ > 7.0) compared to $\overline{C}$ ($\overline{C}$ > 6.3; Table 5 and Appendix 2 Table II). When comparing Benchmark scores for "Very Poor" narrative condition class criteria based on Overall Disturbance Scores within NCHF Northern Sedge Meadow, the maximum scores still meeting "Very Poor" narrative condition classes were $w\overline{C}$ < 0.8 and $\overline{C}$ < 3.9, a difference of 3.1 C units (Table 5 and Appendix 2 Table II). These examples from NCHF Northern Sedge Meadow regression results and Benchmark criteria illustrate many of the benefits of using $w\overline{C}$ rather than $\overline{C}$ as an FQA metric.

Plant community response to disturbance gradients

We used Overall Disturbance as the first choice to define the disturbance gradient. There are a few subtle differences in the Benchmarks generated using our two different measures of disturbance (i.e., Overall Disturbance or Plant Community Condition; also see results in Appendix 2). In general, more potential Benchmarks were able to be generated using Plant Community Condition Scores as a measure of anthropogenic stress than Overall Disturbance Scores. However, Overall Disturbance more faithfully represents the project goal of generating FQA Benchmarks using the Biological Condition Gradient approach (Davies and Jackson 2006), which emphasizes assessing wetland vegetative condition in relation to a stressor or multiple stressors. Plant Community Condition was based on the Best Professional Judgement of a team of expert botanists about the status of ecosystem structure and function in an assessment area based on the composition of a given plant community versus the best-known examples of intact wetland plant communities of the same type. Thus, Benchmarks based on Overall Disturbance rather than Plant Community Condition are arguably more defensible in the sense that they are based on a semi-quantitative and iterative process to describe potential anthropogenic disturbance and less reliant on Best Professional Judgement. However, given that results differed only slightly between Overall Disturbance and Plant Community Condition, this suggests that expert wetland botanists (i.e. 5+ years of experience in identification of the Wisconsin Flora) may be able to judge the Overall Disturbance of a site with reasonable accuracy based on their best professional judgement of the Plant Community Condition—potentially eliminating the need for a Disturbance Factors Checklist in some applications.

Special cases

No one approach could generate statistically valid Benchmark results for every single wetland community type. This is to be expected considering the diversity of wetland community types, landscape settings, historic land use practices and current environmental stressors across the state. Thus, some wetland communities had no or limited Floristic Quality Benchmarks based on the standard approach. One of these was Central Poor Fen, for which there was a lack of "most disturbed" assessment areas. Some Central Poor Fen assessment areas that were selected as "most disturbed" due to historic moss harvesting may have had plant communities which had partially recovered by the time of the survey, which also may have complicated results. Some communities, such as Alder Thicket in the NCHF, appeared to have ample representation of "most disturbed" and "least disturbed" conditions (Table 3), but did not always yield statistically valid Benchmark results (Table 5). Numerous other wetland community types such as Northern Wet-Mesic Forest consistently needed minor modifications to the standard methods in order to have interpretable Benchmarks, and one, Black Spruce Swamp, had only one instance where defensible *preliminary* Benchmarks were obtained, again likely due to a lack of moderate and "most disturbed" sites. However, similar to Hlina's (et al. 2015) observation that coniferous swamps (Black Spruce Swamp, Northern Tamarack Swamp, Muskeg) and Open Bogs likely degrade and change compositionally to shrub or emergent wetland community types (e.g. Johnston 2003) once disturbance exceeds particular threshold, this may also be the case for Northern Wet-Mesic Forest, Central Poor Fen, and Black Spruce Swamps. One example might be flooding (due to nearby hydrologic modifications or changes in long-term climatic regimes) or eutrophication (e.g. non-point source pollution, water management of cranberry operations, etc.) of a Central Poor Fen that leads to eventual conversion to an Emergent Marsh. If these patterns in degradation do truly exist, it may not be possible to sample additional "most disturbed" assessment areas of a handful of wetland community types that exhibit wholesale community change when exceeding a particular disturbance threshold. In these cases, we only generated Benchmarks that were justified based on the ranges of observed disturbance, so some communities lack the full range of Tiered Aquatic Life Use condition tiers within narrative condition class categories. Future work in both basic and applied research to understand and elucidate some of these processes is warranted. Further, the potential for long-term wholesale changes in community type due to anthropogenic disturbances underscores the need for historic review in assessing the disturbance history of any assessed wetland community to the extent possible.

<u>Comparison of results to a previous study</u>

A previous attempt to create FQA Benchmarks within Wisconsin was made by Bernthal et al. (2007), where generation of FQA Benchmarks for very general wetland vegetative types (e.g. "lowland hardwoods", "meadow/shrub" and "marsh"—i.e. not recognized NHC community types) of the Wisconsin SETP Ecoregion was attempted. The 2007 study mainly used pre-existing, vetted data from recent inventory surveys, with some additional fieldwork performed as resources permitted to fill in spatial gaps. Disturbance assessment for Benchmark generation was done based on GIS data for pre-existing surveys and supplemented by observations on a field disturbance checklist for new surveys (Bernthal et al. 2007). A single set of generalized FQA Benchmarks for all vegetative types combined together was created, with wetlands receiving a $\overline{C}$ < 2.4 representing "low quality" wetland plant communities, and "high quality" wetland plant communities represented by $\overline{C}$ > 4.6. The weaknesses of the SETP study; a relatively small number of sites, lack of in-field disturbance assessments for all sites, and most importantly a lack of cover estimates meaning that only $\overline{C}$ scores could be calculated, which lead to changes in the design of this study.

Comparing the "low quality" $\overline{C}$ scores of Bernthal et. al (2007) with those found in this study for the "very poor" $\overline{C}$ class for SETP, Bernthal et al. (2007) criteria were notably lower across all community types (0.3 to 1.3 $\overline{C}$ units difference in scores depending on the community type and disturbance gradient; Appendix 2, Tables VIII and X). Similarly, comparing Bernthal et. al (2007) $\overline{C}$ criteria for "high quality" plant communities with $\overline{C}$ Benchmarks for "excellent" wetlands in this study, Bernthal et al. (2007) criteria were anywhere from 0.2 to 1.4 lower across all emergent and scrub-shrub wetland types (Calcareous Fen, Shrub Carr, Southern Sedge Meadow, and Wet-Mesic Prairie) that had $\overline{C}$ Benchmarks in this study, but slightly higher (0.2 to 0.5 $\overline{C}$ units) than most forested types (Floodplain Forest, Southern Hardwood Swamp; Appendix 2, Tables VIII and X). In general, this suggests that the community type specific Benchmarks in this study were able to better span the disturbance gradient than the proposed general Benchmarks in Bernthal et al. (2007) for SETP, particularly at the "least disturbed" end of the disturbance gradient.

<u>Comparison of results amongst Ecoregions</u>

A major emphasis of the FQA Benchmarks Project was to create Benchmarks for wetland community types relevant to the particular Ecoregions in which they are found, as differences in the geologic, ecological, and anthropogenic history of an Ecoregion may affect the condition of its wetlands. For example, one commonly occurring wetland community type present across all Wisconsin Ecoregions is Emergent Marsh. However, $w\overline{C}$ scores considered to meet an "Excellent" narrative condition rating (based on Overall Disturbance) differ starkly among the four Ecoregions. For example, $w\overline{C}$ > 7.1 is the minimum criteria described in Hlina et al. (2015) for NLF Emergent Marsh meeting an "Excellent" narrative condition rating, whereas $w\overline{C}$ > 5.2 is the minimum criteria meeting an "Excellent" narrative condition rating described in this study for DRFT Emergent Marsh (Table 11; NOTE: Hlina et al. [2015] created condition "tiers" rather than assigning any sort of narrative criteria for individual wetland community types. Tier 1 in Hlina et al. [2015] is considered the equivalent of an "Excellent" narrative condition rating in this study. Also, "Shallow Water Marsh" as described in Hlina et al. 2015 is equivalent to the community description for Emergent Marsh in this study.) In addition, a general north to south gradient is observed in minimum criteria meeting an "Excellent" narrative condition rating, with NLF Emergent Marsh having the highest minimum criteria, followed by NCHF Emergent Marsh ($w\overline{C}$ > 6.6), SETP Emergent Marsh ($w\overline{C}$ > 5.7), and DRFT Emergent Marsh ($w\overline{C}$ > 5.2; Tables 5, 8, and 11). Conversely, a general south to north gradient is observed in the maximum $w\overline{C}$ scores still meeting "Very Poor" narrative condition classes, with DRFT Emergent Marsh having the highest scores in this condition class ($w\overline{C}$ < 1.7), followed by SETP Emergent Marsh ($w\overline{C}$ <

1.0), NCHF Emergent Marsh ($w\overline{C}$ < 0.8) and NLF Emergent Marsh ($w\overline{C}$ < 0.7; Tables 11, 8, and 5). Thus, the largest range of scores between "Excellent" and "Very Poor" condition class criteria also followed a general north to south gradient, with NLF Emergent Marsh having the largest difference (6.4 $w\overline{C}$ units difference), and the smallest difference for DRFT Emergent Marsh (3.5 $w\overline{C}$ units difference; Table 11). These examples lend support to the strategy of surveying and analyzing ecoregions separately, but further analyses could explore if there are communities for which some ecoregions could share a common set of Benchmarks. Other states in the Upper Midwest such as Minnesota (Bourdaghs 2012) have created statewide FQA Benchmarks due to a number of reasonable justifications (i.e. lack of resources to generate Ecoregion-specific FQA Benchmarks, value in having "universal" statewide criteria for wetland monitoring and assessment for specific wetland community types), but data and the resultant FQA Benchmarks in this study (when combined with Hlina et al. [2015]) have elucidated the ecological and statistical need for Ecoregion-specific Benchmarks, at least for some communities, when using FQA for wetland monitoring and assessment.

The provisional FQA Benchmarks based on Overall Disturbance also align closely with FQA Benchmarks of an Upper Midwestern neighbor to Wisconsin—Minnesota. The Minnesota Pollution Control Agency (MPCA) has been successful in its development and application of a Rapid FQA assessment method and Statewide FQA Benchmarks using nearly identical field and office methods to this study, with the main methodological difference being an abridged species list of approximately 300 plant species and cover estimates generated using cover classes rather than direct estimation to the nearest 1% by field crews (Bourdaghs 2012). In addition, the Rapid FQA method and Benchmarks use the US Army Corps of Engineers Eggers and Reed (2011) wetland plant community classification, which differ but are comparable to the WDNR NHC Wetland Communities of Wisconsin classification (O'Connor 2018; WDNR 2018; Epstein 2017). Thus, because of these minor procedural and classification differences, slight variation in scores between both states would be expected, with MN Benchmarks slightly lower. For example, Calcareous Fen $w\overline{C}$ Benchmarks in MN require $w\overline{C}$ >6.4 (and introduced species cover < 1%) for a Calcareous Fen wetland assessment area to rank as a "Tier 1" category wetland, similar to the SETP $w\overline{C}$ Benchmark scores in this study needed to achieve "Excellent" or "Good" narrative class criteria of $w\overline{C}$ >7.0 and 7.0 > $w\overline{C}$ >6.2, respectively (Table 8). Many other comparisons of similarity could be made between the Benchmarks for both states but would be beyond the overall scope and aims of this study. For further information, a side-by side comparison of the tables of Benchmarks provided in this study with those of Bourdaghs (2012) is suggested with aforementioned caveats considered.

Application of FQA Benchmarks

Benchmarks provided within this study and Hlina et al. (2015) may be applied to a variety of applications both within WDNR and by the greater wetland monitoring and assessment community. First and foremost, FQA Benchmarks were a necessary first step towards establishing a current baseline of wetland condition for Wisconsin. Though the scale of implementation for establishing wetland condition baselines is still being discussed (e.g. watershed vs. ecoregional vs. statewide), the Benchmarks will provide a relative quantitative scale for comparison for WFQA results that is both specific to wetland type and ecoregion. However, additional application of the Benchmarks within the WDNR Water Resources Program are also warranted and advised as wetland monitoring and assessment projects evaluating wetland extent and condition would complement and better inform ongoing water resources protection and restoration efforts. For example, the WDNR 2015-2020 Water Resources Monitoring Strategy emphasizes the ongoing implementation of Targeted Watershed Assessments and Directed Lakes Studies for a variety of purposes (e.g. monitoring for stressor identification, nutrient impacts, watershed planning, protection/antidegradation, and evaluation/success of non-point source implementation plans; WDNR 2015b). In addition, WDNR manages and distributes over $6 million dollars annually to local partner organizations (e.g. local governments, lake and river associations, and qualified conservation non-profits) through the Surface Water Grants Program for planning, management, education, and protection of surface waters (A. Mikulyuk, personal communication). Though customized project planning would likely be needed to fit wetland monitoring and assessment efforts within the scope of the larger projects or planning, information regarding wetland condition is likely a key “missing link” that warrants additional resources for exploration.

Other applications of the FQA Benchmarks within WDNR may include aiding in wetland related permitting decisions (e.g. assessment of potential environmental impacts, setting conditions/criteria, and follow-up monitoring), setting objective performance criteria for or evaluation of wetland mitigation projects, or monitoring and assessment of potential unintended effects of water resources permitting decisions for other surface waters on adjacent or nearby wetlands (e.g. dam and floodplain permitting, aquatic invasive species or aquatic plant management permitting). Wetland practitioners may also use these Benchmarks when planning projects or developments for clients to attempt to avoid and minimize potential wetland effects, to set goals for wetland restoration and mitigation efforts, or to monitor and assess the progress of wetland plant community “trajectories” through these efforts (e.g. Matthews 2015; Matthews et al. 2009). Both private wetland practitioners and public agency staff will also find the Benchmarks useful for monitoring and documenting stewardship (e.g., through invasive species control or prescribed burning) of high-quality wetlands, such as on State Natural Areas.

Fieldwork and data from this study, combined with that of Hlina et al. (2015), have generated a number of other useful applications, including generation of a wetland reference network for Wisconsin for long-term wetland monitoring and assessment (O'Connor and Doyle 2017). In addition, this is the first study we know of in Wisconsin to attempt to statistically "test" the "distinctness" of a select number of wetland communities of Wisconsin using the classification from WDNR Natural Heritage Conservation Program for the three broad Ecoregions addressed in this report (O'Connor 2018; WDNR 2018; Epstein 2017). Though these natural communities were in large part based on or refinements of observations of Curtis (1959) and Waller and Rooney (2008), multivariate tests in this study such as NMDS analyses and associated post-hoc tests suggest that the community composition of these natural communities are indeed "distinct" from one another, even for communities which anecdotally are considered similar in composition. Given the "distinctness" of these communities, this emphasizes and supports an underlying assertion by Epstein (2017) that there likely is no "one-size-fits-all" approach for management, even for communities of similar broad wetland vegetation classes (e.g. forested, scrub-shrub, and herbaceous), and that the individual flora and the communities which they are a part of must be considered holistically in order to facilitate successful management and conservation of these ecosystems. Further, this speaks to the value of having nearly 1,100 wetland assessment areas of plant community and disturbance data, which surely will have many future applications for wetland monitoring and assessment but may also have value for wetland restoration and mitigation efforts.

Current potential limitations and opportunities for capacity building

There may also be a number of limitations to immediate application and use of FQA methodology. The FQA surveys completed for this study were done by expert botanists with substantial experience identifying Wisconsin flora, generally all with 5 or more years of experience as botanists within a conservation biologist role or similar experience. FQA surveys conducted by those with lesser expertise are likely to miss some species and mis-identify some species, and all "single day" surveys will miss some species due to the seasonality of species presence and identifiability. Ocular estimation of cover percentages in the field is a skill that generally takes time and substantial practice to develop but is an essential component of the Timed Meander Survey protocol. Substantial efforts will be needed to train staff in order for these surveys to be accurately implemented but this need not be an overwhelming obstacle to implementation. One option could be to use state and regional aquatic monitoring funds to hire wetland assessment experts (e.g. Regional Wetland Ecologists or Wetland Botanists) that could specialize in FQA assessment in addition to other wetland ecology-specific needs. This may be a more practical and cost-effective option than widespread attempts at internal training and additional workload allocation to existing regional water resources biologists while also building further capacity for wetland monitoring, assessment, and statewide applied research efforts.

From the standpoint of environmental consulting companies, many of which have staff specialized already in wetland delineation and assessment, the timed meander protocol is a relatively new approach in comparison to long used plot-based methods that have been an industry standard for decades, generally due to concerns of repeatability and continuity. Indeed, WDNR began introducing the Timed Meander methods in 2017 as part of its Critical Methods seminars provided as training to the consulting community (Willman 2017). However, given that the timed meander method, when applied correctly, can create more complete species lists (Bourdaghs 2012; Hlina et al. 2011), the issue of continuity is minimized so long as assessment areas for given wetland community types are clearly defined, documented, and maintained. Furthermore, this method is a standard method for other states in the Upper Midwest (Bourdaghs 2012), and overall is more efficient in time and effort than plot-, transect- or revele-based survey methods (Bourdaghs 2012; Hlina et al. 2011, P. Trochllel and R. Henderson, unpublished data). In fact, when the procedure is completed by two qualified botanists, the timed meander survey method has been estimated to be four times faster than the aforementioned standard methods (Hlina et al. 2011)

Future applied research opportunities to overcome limitations

Another approach to ease current limitations and encourage implementation by a wider range of professionals would be a Wisconsin-based adaptation of the “Rapid FQA” protocol developed in Minnesota by Bourdaghs (2012), which is based on a limited number of more easily identified plant taxa. This Rapid FQA method would require only a moderate level of field botany experience for field crews and consultants, and training efforts can be directed to a smaller subset of plant taxa. While this approach would help to alleviate some of the taxonomic expertise needed to conduct a full Timed Meander Survey, the same amount of physical field effort and post-field data processing would likely be needed (Bourdaghs 2012). WDNR may be able to develop a similar approach for Wisconsin, calibrating the results generated by candidate “rapid” taxa lists to those generated from our current survey database. For example, WDNR may be able to adapt Bourdaghs’ (2012) Rapid FQA Species List for Minnesota to Wisconsin. An alternative method to develop a Rapid FQA Species List, though more statistically rigorous in terms of development, may also yield similar or even more refined results specific to individual wetland community types. Multiple researchers have been exploring the use of TITAN (**T**hreshold **I**ndicator **T**axa **AN**alysis; Baker and King 2010) to determine ecological community thresholds by detecting differences in distributions in taxa of a given community type along environmental gradients over space or time. Further, the analysis also uses a variety of built-in statistical methods to detect whether there are synchronous responses of multiple species within a given community to a given stressor or environmental gradient, which can provide evidence of ecological “tipping points” or thresholds (Baker and King 2010). Because distinct taxa, their abundances, and overall response to a given stressor or environmental gradient are identified as part of these analyses in relation to the predicted ecological threshold, identifying species near the predicted threshold (both prior to and after reaching an estimated ecological "tipping point") may be able to yield refined species lists for monitoring to assess whether a given community is approaching or beyond a prescribed threshold. Indeed, TITAN has already been applied to data collected from Laurentian Great Lakes coastal wetland ecosystems and suggests overall congruence of community thresholds across multiple disjunct taxa (birds, fish, plants, macroinvertebrates, and diatoms) in relation to anthropogenic stress (Kovalenko et al. 2014). The success of Kovalenko et al. (2014) in applying TITAN in wetland ecosystems serves as a strong preliminary "proof of concept" that similar efforts for inland wetlands of Wisconsin may yield promising results—though, to our knowledge using TITAN to develop targeted species lists for rapid assessment would be a first application of TITAN for that purpose in wetlands or other ecosystems .

Though some target wetland communities had no or limited Benchmarks, a number of potential approaches may be used to eventually derive initial or refined Benchmarks for these communities. Some communities may simply require further fieldwork to attempt to "fill the gaps" with surveys of additional assessment areas (if possible) for underrepresented disturbance classes to further assess plant community responses to disturbance, whereas others might require creative alternative statistical/analytical procedures to arrive at suitable community Benchmarks. Some community types like NCHF Alder Thicket, which appeared to have ample representation along the disturbance gradient (Table 3), may be affected by a "buffering effect"--that is, because the community is defined by having a minimum of > 50% cover of tall shrubs (>5 ft tall), with over half (> 25%) of the tall shrub cover comprised of *Alnus* spp. (O'Connor 2018), the conservatism value of *Alnus* ($C = 4$) may arbitrarily increase the $w\overline{C}$ scores of even the most disturbed assessment areas. Hence, one method to overcome this potential effect would be to attempt to derive Benchmarks for this community by using the same statistical process used to derive the other Benchmarks, but use adjusted $w\overline{C}$ scores instead of whole assessment area $w\overline{C}$ scores (e.g. eliminating all *Alnus* spp. from calculation of $w\overline{C}$ scores, while still considering all other plant taxa). Adaptations of this method may also be applicable to re-assess Benchmarks for communities that have a narrow range between narrative condition classes, such as Black Spruce Swamp, Northern Tamarack Swamp or Northern Wet-Mesic Forest, where a single or few dominant shrub or tree species are the defining criteria to meet the definition of that community type (e.g. *Picea mariana* [$C = 8$] for Black Spruce Swamp, *Larix larcinia* [$C = 8$] for Northern Tamarack Swamp; *Thuja occidentalis* [$C = 9$] for Northern Wet-Mesic Forest, etc.). Another method for consideration might be pooling data for the same wetland community type across similar Ecoregions to create aggregated Ecoregional Benchmarks, where statistically and ecologically justified. For example, one could pool data from all Alder Thickets for the NCHF and NLF Ecoregions to create a "Northern Wisconsin (Combined) Ecoregion", and then use the same Benchmarks process to attempt to derive FQA Benchmarks. NMDS analyses could be used to confirm plant community similarity of Alder Thicket communities across Ecoregions in this instance, and standard statistical tests (e.g. ANOVAs) could be used to confirm no significant differences in the distributions of "least disturbed" and "most disturbed" FQA metrics, respectively, across Ecoregions. For example, Minnesota has FQA Benchmarks based on statewide, non-Ecoregion specific surveys of wetland community types, which cover somewhat dissimilar Ecoregions (Bourdaghs 2012). While these approaches may yield logical and defensible solutions, there are likely other alternative statistical methods and comparisons outside our current knowledge which may have applicability and no options should be left unconsidered. Exploration of these methods using existing and expanded datasets through future applied research efforts is warranted from a cost-effectiveness standpoint and may yield important information for future consideration.

Provisional FQA Benchmarks are only an initial step towards evaluating wetland ecosystem condition for Wisconsin—though it will allow for WDNR to begin implementing wetland monitoring and assessment based on a Level 3 assessment method after nearly three decades of progress, among other potential applications. Plant communities are only one component of wetland ecosystems, and condition as defined by the plant community alone may fail to recognize that even a wetland with a degraded plant community may still provide some high levels of ecosystem functions and services dependent upon the context in which they are considered (e.g. landscape, watershed, wetland complex; *e contrario sensu* 281.36(4n)(a)3, Wis. Stat.). For example, Doherty et al. (2014) noted tradeoffs in ecosystem services or "bundles" of ecosystem services within constructed treatment wetlands in Wisconsin, where wetlands with the highest measured levels of gross primary production had the lowest levels of flow attenuation, stormwater retention, diversity support (i.e. plant species richness), erosion resistance, and water quality improvement. Indeed, others in the Upper Midwest have cautioned against using vegetative condition to infer the status of ecosystem functions in wetlands and have noted that other biotic assemblages and environmental variables may also be effective indicators or wetland condition (Bourdaghs 2015). Thus, other biotic and abiotic components may deserve further consideration to assess ecosystem condition and/or function in relationship to anthropogenic stress. Biotic indicators for consideration that can be found across a majority of wetland community types might include diatoms (e.g. Stevenson 2014; US EPA 2011; Hauxwell et al. 2004; Lillie et al. 2002; US EPA 2002), bryophytes (Schumacher et al. 2016; Stapanian et al. 2016a; Stapanian et al. 2016b), and soil microbial communities/enzyme activity (Hill et al. 2017; Hill et al. 2014; Berkowitz and White 2013; Hill et al. 2006; Newman et al. 2003). Similarly, abiotic components for further consideration might include soil physicochemistry (Marti and Bernthal 2016; Stapanian et al. 2016c), surface/pore water chemistry (Johnston and Brown 2013; US EPA 2011; Lougheed et al. 2001), and hydrology (US EPA 2016). These potential indicators could be developed and tested both as stand-alone assessment components and/or in relation to other levels of wetland monitoring and assessment (e.g. Wetlands By Design [Level 1; Miller et al. 2017]; Wisconsin Wetland Rapid Assessment Method V. 2.0 [Level 2; WDNR 2014], and WFQA Benchmarks [this study]).

Conclusion

This study addressed a long-standing need for wetland monitoring and assessment in Wisconsin by creating provisional WFQA Benchmarks for a majority of common wetland community types at an Ecoregion-specific level. In general, $w\overline{C}$ Benchmarks were more readily generated for most communities and out-performed $\overline{C}$ Benchmarks in every ecoregion. Cover-weighted Mean C ($w\overline{C}$) Benchmarks based on Overall Disturbance are recommended for use as provisional Benchmarks, but preliminary Benchmarks based on $\overline{C}$ may be applied when only limited historical data are available (i.e. a plant species list/inventory without cover percentage estimate) or when no $w\overline{C}$ Benchmark is available.

The Benchmarks in this study and Hlina et al. (2015) should be considered *provisional* at this point—that is, further refinements and investigation based on strategies detailed in "Discussion" section and beyond may be undertaken as time and resources permit, but the provisional Benchmarks as proposed in this report may be immediately applied with the understanding that they may be improved over time. In fact, sites surveyed during this project are part of ongoing WDNR applied research further investigating relationships among the disturbance factors listed in this study and their relationship to soil and water physicochemical variables, which ultimately are likely the ultimate drivers of wetland condition (Marti and Nemecek 2019; Marti 2018). Despite the Benchmarks being of provisional nature at this time, they constitute a solid starting point for application of the WFQA as a statistically-valid, cost-effective, repeatable approach that will allow for relative comparisons across sites and time at most scales of interest for monitoring and assessment purposes. Understanding and documenting wetland condition, as well as the stressors likely driving condition, will allow for enhanced management and restoration opportunities of wetlands while also allowing for protection of wetlands already in excellent condition.

References

Anderson, M.J., and D.C.I. Walsh. 2013. PERMANOVA, ANOSIM and the Mantel test in the face of heterogeneous dispersions: what null hypothesis are you testing? *Ecological Monographs* 83:557-574.

Berkowitz, J.F., and J.R. White. 2013. Linking wetland functional rapid assessment models with quantitative hydrological and biogeochemical measurements across a restoration chronosequence. *Soil Sci. Soc. Am. J.* 77:1442–1451. doi:10.2136/sssaj2013.01.0044

Bernthal, T.W. 2003. Development of a floristic quality assessment methodology for Wisconsin. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD975115-01-0. http://dnr.wi.gov/topic/wetlands/documents/fqamethodwithacknowledgements.pdf

Bernthal, T.W. and K.G. Willis. 2004. Using Lansat 7 imagery to map invasive reed canary grass (Phalaris arundinacea): a landscape level wetland monitoring methodology. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD975115-01-0. DNR PUB-SS-992 2004. http://dnr.wi.gov/topic/wetlands/documents/rcg_mapping_report.pdf

Bernthal, T.W., J. Kline, and A. Reis. 2007. Floristic quality assessment benchmarks for wetlands in Southeastern Wisconsin. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD965118-01-0.

Bourdaghs, M. 2012. Development of a rapid floristic quality assessment. Document number: wq-bwm2-02a St. Paul, MN, USA Minnesota Pollution Control Agency.

Bourdaghs, M. 2015. Status and Trends of Wetlands in Minnesota: Vegetation Quality Baseline. Wq-bwm-1-09. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Bourdaghs, M., Johnston, C.A., and R.R. Regal. 2006. Properties and performance of the floristic quality index in Great Lakes coastal wetlands. *Wetlands* 26:718–735.

Bried, J. T., S. K. Jog, and J. W. Matthews. 2013. Floristic quality assessment signals human disturbance over natural variability in a wetland system. *Ecological Indicators* 34:260-267.

Bried, J.T., B.E. Allen, E.T. Azeria, V.E. Crisfeld, and M.J. Wilson. 2018. Experts and models can agree on species sensitivity values for conservation assessments. *Biological Conservation* 225:222-228.

Clarke, K. R. 1993. Non-parametric multivariate analysis of changes in community structure. *Australian Journal of Ecology* 18:117–143.

Clarke, K.R., and R.M. Warwick. 1994. *Change in Marine Communities: an approach to statistical analysis and interpretation*. PRIMER-E: Plymouth.

Curtis, J.T. 1959. Vegetation of Wisconsin. University of Wisconsin Press, Madison, WI.

Dahl, T.E. 1990. Wetland Losses in the United States, 1780s to 1980s. Report to Congress. No. PB-91-169284/XAB. National Wetlands Inventory, St. Petersburg, Florida, USA.

Dahl, T.E. 2011. Status and Trends of Wetlands in the Conterminous United States, 2004 to 2009. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Davies, S.P. and S.K. Jackson. 2006. The biological condition gradient: a descriptive model for interpreting change in aquatic ecosystems. *Ecological Applications* 16:1251-1266.

DeBerry, D.A., S.J. Chamberlain, and J.W. Matthews. 2015. State of the Science Report: Trends in floristic quality assessment for wetland evaluation. *Wetland Science and Practice* 32:12-22.

Doherty, J.M., J.F. Miller, S.G. Prellwitz, A.M. Thompson, S.P. Loheide, and J.B. Zedler. 2014. Hydrologic regimes revealed bundles and tradeoffs among six wetland services. *Ecosystems* 17:1026-39.

Earth Economics. 2012. Rapid assessment of the economic value of Wisconsin's wetlands. Prepared for the Wisconsin Wetlands Association. 16pp.

Eggers, S.D., and D.M. Reed. 2011. Wetland Plants and Plant Communities of Minnesota and Wisconsin (3rd Ed). US. Army Corps of Engineers, St. Paul District. St. Paul, MN.

Epstein, E.E. 2017. Natural communities, aquatic features, and selected habitats of Wisconsin. Chapter 7 in *The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management*. Wisconsin Department of Natural Resources, PUB-SS-1131H 2017, Madison.

Fennessy, M. S., R. Geho, B. Elifritz, and R. D. Lopez. 1998. Testing the floristic quality assessment index as an indicator of riparian wetland disturbance. Ohio Environmental Protection Agency, Division of Surface Water, Columbus, Ohio.

Fritz, K.M., K.A. Schofield, L.C. Alexander, M.G. McManus, H.E. Golden, C.R.Lane, W.G. Kepner, S.D. LeDuc, J.E. DeMeester, and A.I. Pollard. 2018. Physical and chemical connectivity of streams and riparian wetlands to downstream waters: a synthesis. *Journal of the American Water Resources Association (JAWRA)* 1–23. https://doi.org/10.1111/1752-1688.12632

Goff, F.G., G. Dawson and J. Rochow. 1982. Site examination for threatened and endangered plant species. *Environmental Management* 6(4):307-316.

Hagen, C.L. 2008. Reversing the Loss: A Strategy to Protect, Restore and Explore Wisconsin Wetlands. Wisconsin Department of Natural Resources. Madison, WI. DNR PUB-WT-893 2008.

Hatch, B.K. and T.W. Bernthal. 2008. Mapping Wisconsin wetlands dominated by reed canary grass, Phalaris arundinacea L.: a landscape level assessment. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #96544501-0. DNR PUB-WT-900 2008. http://dnr.wi.gov/topic/wetlands/documents/RCGFinalReport10_08.pdf

Hauxwell, J., G. LaLiberte, A. Mikulyuk, P. Garrison, and G. Vorhes. 2006. Use of plants and diatoms for nutrient assessment in north temperate depressional wetlands. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD975658-01-0. DNR PUB-SS-1023 2006.

Herman, K. D., L. A. Masters. M. R. Penskar, A. A. Reznicek, G. S. Wilhelm, and W. W. Brodowicz. 1997. Floristic Quality Assessment: development and application in the State of Michigan (USA). *Natural Areas Journal* 17:265-279.

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, W.W. Brodovich and K.P. Gardiner (2001). Floristic quality assessment with wetland categories and examples of computer applications for the State of Michigan. Lansing, MI, Michigan Department of Natural Resources.

Hill, B.H., C.M. Elonen, A.T. Herlihy, T.M. Jicha, and G. Serenbetz. 2017. Microbial ecoenzyme stoichiometry, nutrient limitation, and organic matter decomposition in wetlands of the conterminous United States. *Wetlands Ecology and Management*. https://doi.org/10.1007/s11273-017-9584-5

Hill, B.H., C.M. Elonen, T.M. Jicha, A.M. Cotter, A.S. Trebitz, and N.P. Danz. 2006. Sediment microbial enzyme activity as an indicator of nutrient limitation in Great Lakes coastal wetlands. *Freshwater Biology* 51:1670-1683.

Hill, B.H., C.M. Elonen, T.M. Jicha, R.K. Kolka, L.L.P. Lehto, S.D. Sebestyen, and L.R. Seifert-Monson. 2014. Ecoenzymatic stoichiometry and microbial processing of organic matter in northern bogs and fens reveals a common P-limitation between peatland types. *Biogeochemistry* 120:203-224.

Hlina, P., N.P. Danz, K. Beaster, D. Anderson, and S. Hagedorn. 2015. Northern Lakes and Forests Inland Wetland Surveys: Relationship between Floristic Quality Assessment and Anthropogenic Stressors. Technical Report 2015-2, Lake Superior Research Institute, University of Wisconsin-Superior, Superior, WI.

Hlina, P.S. N.P. Danz and K. Prihoda. 2012. Standard Operating Procedure – Timed-meander sampling protocol for forested and non-forested wetland floristic quality assessment - Lake Superior Research Institute, SOP-FS/27.

Hlina, P.S., D.S. Anderson and K. Nummi. 2011. Comparing wetland sampling methods for floristic quality assessment in Superior, Wisconsin. Publication filed with Wisconsin Department of Natural Resources, Grant #QMJ00000814.

Jarosz, S.G., and D.G. Haug. 2015. Developing a Wisconsin wetland change analysis & building compliance monitoring efforts: understanding wetland changes in West-Central and North-Western Wisconsin. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #00E00756.

Jog, S.K., Bried, J.T., Feng, X., Dzialowski, A.R., Papeş, M., and Davis, C.A. 2017. Can land use indicate wetland floristic quality and taxonomic distinctness? *Ecological Indicators* 78: 331–339.

Johnston, C.A. 2003. Shrub species as indicators of wetland sedimentation. *Wetlands* 23:911-920.

Johnston, C.A. and T.N. Brown. 2013. Water chemistry distinguishes wetland plant communities of the Great Lakes coast. *Aquatic Botany* 104:111-120.

Kingsford, R.T., A. Basset, and L. Jackson. 2016. Wetlands: conservation's poor cousins. *Aquatic Conservation: Marine and Freshwater Ecosystems* 26:892-916.

Kovalenko, K.E., V.J. Brady, T.N. Brown, J.J.H. Ciborowski, N.P. Danz, J.P. Gathman, G.E. Host, R.W. Howe, L.B. Johnson, G.J. Niemi, and E.D. Reavie. 2014. Congruence of community thresholds in response to anthropogenic stress in Great Lakes coastal wetlands. *Freshwater Science* 33:958-971.

Lane, C.R., S.G. Leibowitz, B.C. Autrey, S.D. LeDuc, and L.C. Alexander. 2018. Hydrological, physical, and chemical functions and connectivity of non-floodplain wetlands to downstream waters: a review. *Journal of the American Water Resources Association (JAWRA)* 1–26. https://doi.org/10.1111/1752-1688.12633

Leibowitz, S.G., P. J. Wigington Jr., K. A. Schofield, L.C. Alexander, M.K. Vanderhoof, and H.E. Golden. 2018. Connectivity of streams and wetlands to downstream Waters: an integrated systems framework. *Journal of the American Water Resources Association (JAWRA)* 1–25. https://doi.org/10.1111/1752-1688.12631

Lillie, R.A. 2000. Development of a biological index and classification system for Wisconsin wetland using macroinvertebrates and plants. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD985491-01-0. http://dnr.wi.gov/topic/Wetlands/documents/WetlandBioIndexInvertebratesPlantsText.pdf

Lillie, R.A., P. Garrison, S.I. Dodson, R.A. Bautz, and G. LaLiberte. 2002. Refinement and expansion of wetland biological indices for Wisconsin. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD975115-01-0. DNR PUB-SS-968 2002. http://dnr.wi.gov/topic/Wetlands/documents/RefinementExpansionBioIndices.pdf

Lopez, R. D. and M. S. Fennessy. 2002. Testing the floristic quality assessment index as an indicator of wetland condition. *Ecological Applications* 12:487-497.

Lougheed, V.L., B. Crosbie, and P. Chow-Fraser. 2001. Primary determinants of macrophyte community structure in 62 marshes across the Great Lakes basin: latitude, land use, and water quality effects. *Canadian Journal of Fisheries and Aquatic Sciences* 58, 1603–1612.

Marti, 2018. Understanding wetland condition at a “deeper” level: partner project allows NRCS and WDNR to achieve common conservation goals. Cooperative Soil Science 2018 Highlights. USDA- NRCS Wisconsin. pp. 46-48.

Marti, A.M. and T.W. Bernthal. 2016. The 2011-2012 Wisconsin Intensification Study: Assessment of Wetland Condition in Wisconsin’s Southern Lake Michigan Basin. Final Report to US EPA Region V, Grants #CD00E78201, CD00E00961 and #CD00E01167. Wisconsin Department of Natural Resources. EGAD # 3200-2016-03.

Marti, A.M. and J. Nemecek. 2019. Let's Stop "Mucking Around": Understanding Wetland Soil Physicochemistry in Relation to Water Quality, Ecosystem Integrity, and Risk Assessment for Wisconsin's Wetlands and Other Waters. National Water Quality Monitoring Council 11th National Monitoring Conference. Denver, CO. March.

Martinez Arbizu, P. 2019. pairwiseAdonis: Pairwise multilevel comparison using adonis. R package version 0.3. Accessed January 01, 2019. https://github.com/pmartinezarbizu/pairwiseAdonis

Marton, J.M., I.F. Creed, D.B. Lewis, C.R. Lane, N.B. Basu, M.J. Cohen, and C.B. Craft. 2015. Geographically isolated wetlands are important biogeochemical reactors on the landscape. *Bioscience* doi:10.1093/biosci/biv009

Matthews, J. W. 2003. Assessment of the Floristic Quality Index for use in Illinois, USA, wetlands. *Natural Areas Journal* 23: 53-60.

Matthews, J. W. 2015. Group-based modeling of ecological trajectories in restored wetlands. *Ecological Applications* 25:481-491.

Matthews, J. W., G. Spyreas and C.L. Long. 2015. A null model test of Floristic Quality Assessment: Are plant species' Coefficients of Conservatism valid? *Ecological Indicators* 52:1-7.

Matthews, J. W., G. Spyreas, and A. G. Endress. 2009. Trajectories of vegetation-based indicators used to assess wetland restoration progress. *Ecological Applications* 19:2093-2107.

Milburn, S.A., M. Bourdaghs, and J.J. Husveth. 2007. Floristic Quality Assessment for Minnesota Wetlands. Minnesota Pollution Control Agency, St. Paul, Minnesota.

Miller, N., J. Kline, T. Bernthal, J. Wagner, C. Smith, M. Axler, M. Matrise, M. Kille, M. Silveira, P. Moran, S. Gallagher Jarosz, and J. Brown. 2017. Wetlands by Design: A Watershed Approach for Wisconsin. Wisconsin Department of Natural Resources and The Nature Conservancy. Madison, WI.

Mushet, D.M., A.J.K. Calhoun, L.C. Alexander, M.J. Cohen, E.S. DeKeyser, L. Fowler, C.R. Lane, M.W. Lang, M.C. Rains, and S.C. Walls. 2015. Geographically isolated wetlands: rethinking a misnomer. *Wetlands* 35:423-431.

Newman, S., P.V. McCormick, and J.G. Backus. 2003. Phosphatase activity as an early warning indicator of wetland eutrophication: problems and aspects. *Journal of Applied Phycology* 15: 45–59.

Nichols, S. A. 1999. Floristic Quality Assessment of Wisconsin lake plant communities with example applications. *Journal of Lake and Reservoir Management* 15:133-141.

Nichols, S. A. 2001. Long-term change in Wisconsin lake plant communities. Journal of *Freshwater Ecology* 16:1-13.

O'Connor, R. 2018. Key to Wetland Communities of Wisconsin. Wisconsin Department of Natural Resources Natural Heritage Conservation Bureau. Accessed January 01, 2019. https://dnr.wi.gov/topic/EndangeredResources/documents/KeyToWetlandCommunities.pdf

O'Connor, R.P. and K. Doyle. 2017. Setting floristic quality assessment benchmarks for inland wetland plant community condition across Wisconsin: establishing a reference wetland network. Final Report to US EPA Region V, Grant #CD00E78202. Wisconsin Department of Natural Resources.

Oksanen, J. 2015. Multivariate analysis of ecological communities in R: vegan tutorial. Accessed January 01, 2019. http://cc.oulu.fi/~jarioksa/opetus/metodi/vegantutor.pdf

Oksanen, J., F. G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, R. B. O'Hara, G.L. Simpson, P. Solymos, M. H. H. Stevens, E. Szoecs, and H. Wagner. 2017. vegan: Community Ecology Package. R package version 2.4-5. https://CRAN.R-project.org/package=vegan

Omernik, J.M., S. Chapman, A. Bartelt, R.A. Lillie, R.T. Dumke. 2000. Ecoregions of Wisconsin. *Wisconsin Academy of Sciences, Arts, and Letters*. 88:77-103.

Quinn, G.P., and M.J. Keough. 2002. Experimental design and data analysis for biologists. Cambridge University Press, Cambridge, UK. 537 pp.

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rothrock, P. E. and M. A. Homoya. 2005. An evaluation of Indiana's Floristic Quality Analysis. *Proceedings of the Indiana Academy of Science* 114:9-18.

Schofield, K.A., L.C. Alexander, C.E. Ridley, M.K. Vanderhoof, K.M. Fritz, B.C. Autrey, J.E. DeMeester, W.G. Kepner, C.R. Lane, S.G. Leibowitz, and A.I. Pollard, 2018. Biota connect aquatic habitats throughout freshwater ecosystem mosaics. *Journal of the American Water Resources Association (JAWRA)* 1–28. https://doi.org/10.1111/1752-1688.12634

Schumacher, W., M.A. Stapanian, B.K. Andreas, and B. Gara. 2016. Number of genera as a potential screening tool for assessing quality of bryophyte communities in Ohio Wetlands. *Wetlands* 36:771-778.

Stapanian M.A., W. Schumacher, B. Gara, J.V. Adams, and N. Viau. 2016a. Mosses in Ohio wetlands respond to indices of disturbance and vascular plant integrity. *Ecological Indicators* 63:110–120.

Stapanian, M.A., W. Schumacher, B. Gara, and S. Monteith S. 2016b. Moss and vascular plant indices in Ohio wetlands have similar environmental predictors. *Ecological Indicators* 62:138–146.

Stapanian, M.A., W. Schumacher, B. Gara, and S. Monteith. 2016c. Negative effects of excess soil phosphorus on floristic quality in Ohio wetlands. *Science of the Total Environment* 551–552:556–562

Stevenson, R. J. 2014. Ecological assessments with algae: a review and synthesis. *Journal of Phycology*. DOI: 10.1111/jpy.12189

Swink, F. and G. Wilhelm. 1994. Plants of the Chicago Region. 4th ed. Indiana Academy of Science, Indianapolis, IN. 921 pgs.

Taft, J. B., G. S. Wilhelm, D. M. Ladd, and L. A. Masters. 1997. Floristic quality assessment for vegetation in Illinois: a method for assessing vegetation integrity. *Erigenia* 15:3-95.

Trochlell, P.A. 2016. Timed-Meander Sampling Protocol for Wetland Floristic Quality Assessment. Wisconsin Department of Natural Resources. Accessed January 01, 2019. https://dnr.wi.gov/topic/Wetlands/documents/TimedMeanderSamplingProtocol.pdf

Trochlell, P.A., and T.W. Bernthal. 2014. Southeast Wisconsin Wetland Change Study, 2005-2010. Wisconsin Department of Natural Resources. Madison, WI. Final Report to United States Environmental Protection Agency, Region V Wetland Grant #CD00E78201.

US EPA. 2002. *Methods for Evaluating Wetland Condition: Using Vegetation to Assess Environmental Conditions in Wetlands*. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-020.

US EPA. 2002. *Methods for Evaluating Wetland Condition: Using Algae To Assess Environmental Conditions in Wetlands*. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-021.

US EPA. 2006. Application of Elements of a State Water Monitoring and Assessment Program for Wetlands. Wetlands Division. Office of Wetlands, Oceans and Watersheds.

US EPA. 2011a. National Wetland Condition Assessment: Field Operations Manual. United States Environmental Protection Agency. Washington, DC 20460. EPA-843-R-10-001.

US EPA. 2016a. National Wetland Condition Assessment 2011: A Collaborative Survey of the Nation's Wetlands. United States Environmental Protection Agency. Washington, DC 20460. EPA-843-R-15-005

USGS. 1996. National Water Summary of Wetland Resources. United States Geological Supply Paper 2425. United States Department of the Interior. 431 pp.

Waller, D.M., and T.P. Rooney, editors. 2008. *The vanishing present: Wisconsin's changing lands, waters, and wildlife*. University of Chicago Press, Chicago. 507 pp.

WDNR. 1993. Wetland Functional Values. Wisconsin Department of Natural Resources. DNR PUBL-WZ-026 1993.

WDNR. 2000. Reversing the Loss – A Strategy for Protecting & Restoring Wetlands in Wisconsin. Wisconsin Department of Natural Resources. PUB-FH-232-2000. 26 pages.

WDNR. 2014. WDNR Wetland Rapid Assessment Methodology- User Guidance Document. Version 2.0. Wisconsin Department of Natural Resources. Accessed January 1, 2019. https://dnr.wi.gov/topic/wetlands/documents/WRAMUserGuide.pdf

WDNR. 2015. *The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management*. Wisconsin Department of Natural Resources, PUB-SS-1131 2015, Madison.

WDNR. 2015b. Wisconsin's Water Monitoring Strategy: 2015-2020. Wisconsin Department of Natural Resources. EGAD # 3200-2016-01.

WDNR. 2017. The Wisconsin Floristic Quality Assessment Calculator (October 2017). Wisconsin Department of Natural Resources. Accessed January 01, 2019. https://dnr.wi.gov/topic/Wetlands/documents/WDNR_FQA_CALCULATORv1.10.17.xlsx

WDNR. 2018. Natural Heritage Working List. Bureau of Natural Heritage Conservation, Wisconsin DNR. Madison, WI. https://dnr.wi.gov/topic/NHI/documents/NHIWorkingList.pdf

Wickham, H. 2016. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Wilhelm, G.S. 1977. Ecological assessment of open land areas in Kane County, Illinois. Kane County Urban Development, Geneva, IL, USA.

Willman, A. 2017. Timed Meander Sampling Protocol. Wisconsin Department of Natural Resources Critical Methods Seminar. UW- La Crosse Continuing Education. Madison, WI.

Appendix 2: Supplemental Results, Figures, and Tables

Table of Contents

List of Supplemental Figures

List of Supplemental Figures (continued)

List of Supplemental Tables

List of Supplemental Tables (continued)

List of Supplemental Tables (continued)

Supplemental Results

North Central Hardwood Forests (NCHF) Ecoregion

Ten (10) different wetland community types met minimum data standards for Benchmark consideration, accounting for 185 assessment areas. However, multiple community types were arguably underrepresented on the "most disturbed" end of the disturbance gradient based on Overall Disturbance scores. Black Spruce Swamp (Black Spruce Swamp) and Northern Hardwood Swamp had only two most disturbed category assessment areas each, Central Poor Fen had only one most disturbed category assessment area, and Northern Wet-Mesic Forest had no most disturbed category assessment areas (Table 3 in Main Text of Report). Similarly, some community types also had limited "most disturbed" representation based on Plant Community Condition scores, including Black Spruce Swamp (4 assessment areas) Northern Wet-Mesic Forest (3 assessment areas) and Central Poor Fen (2 assessment areas). These community types were retained for the analysis despite not having the desired representation of most disturbed category sites, but their regression results were interpreted with additional scrutiny (i.e. r^2 needed to be greater than 0.30; confidence intervals on regression lines needed to be reasonably tight with data distribution generally matching the trend of the overall regression).

Regression analyses and associated Benchmarks: $\overline{C}$ and Overall Disturbance

Benchmark values for $\overline{C}$ for 7 of the 10 communities surveyed are presented in Table II. Benchmarks were created for all wetland community types which had significant regressions and $r^2 \geq 0.30$ with the exception of Northern Wet-Mesic Forest which had no observed "most disturbed" assessment areas in the field using the Disturbance Factors Checklist. To account for this discrepancy, only 3 Benchmarks are suggested for Northern Wet-Mesic Forest, consisting of 3 narrative categories of "Excellent-Good", "Fair", and "Poor-Very Poor". In this case, the 75th percentile of "least disturbed" sites served as the lowest acceptable score to receive an "Excellent-Good" narrative rating, the 25th percentile of "least disturbed" assessment areas as the lowest acceptable score to receive a "Fair" narrative rating, and all assessment areas scoring below the 25th percentile would receive a "Poor-Very Poor" narrative rating (Table II).

Northern Sedge Meadow had the overall highest Benchmark required to receive an "Excellent" narrative rating ($\overline{C}$ > 6.3), followed by Northern Tamarack Swamp ($\overline{C}$ > 6.1), Emergent Marsh, Northern Wet Mesic Forest, and Shrub Carr (all requiring $\overline{C}$ > 6.0; Table II). The lowest overall $\overline{C}$ score required to receive an "Excellent" narrative rating was $\overline{C}$ > 5.5 for Southern Sedge Meadow. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Shrub Carr (3.3 $\overline{C}$ units difference).

The narrowest range of $\overline{C}$ values (excluding Northern Wet-Mesic Forest) was observed for Northern Tamarack Swamp (0.8 $\overline{C}$ units difference; Table II)

Of these 10 candidate community types, only 7 community types had an observed significant inverse linear relationship between $\overline{C}$ and Overall Disturbance Scores (Figure I; Table I). The three communities that did not have a significant inverse relationship included Alder Thicket, Central Poor Fen and Northern Hardwood Swamp; Figure I; Table I). Black Spruce Swamp, though having a significant inverse linear relationship ($p = 0.048$) with Overall Disturbance Scores, had an overall low correlation value and thereby was not considered fit for further $\overline{C}$ Benchmark development ($r^2 = 0.18$; Table I).

Of the community types which had significant regressions and $r^2 \geq 0.30$, the highest average $\overline{C}$ scores of "least disturbed" assessment areas were Northern Tamarack Swamps (Northern Tamarack Swamp; $\mu\overline{C} \approx 6$), followed by Northern Wet Mesic Forest, Emergent Marsh, and Northern Sedge Meadow ($\mu\overline{C} \approx 5.6$ to 5.8; Figure II). In contrast, the lowest average $\overline{C}$ scores of "most disturbed" assessment areas were observed in Shrub Carr ($\mu\overline{C} \approx 3.2$) and Southern Sedge Meadow ($\mu\overline{C} \approx 3.6$; Figure II). Regression slope coefficients ranged from -0.23 to -0.74, with anywhere from 32 to 60% of the variation in the regressions explained by Overall Disturbance depending on community type (based on r^2 values; Table I). Community types which declined most rapidly in $\overline{C}$ scores over the disturbance gradient, based on regression slope coefficients, included Northern Wet-Mesic Forest, Shrub Carr, Southern Sedge Meadow, Emergent Marsh, and Northern Sedge Meadow, which all decreased over 0.5 units of average conservatism value per 1 unit increase in Overall Disturbance Score (Figure I; Table I). The smallest overall slope coefficient was observed for Northern Tamarack Swamp (-0.23). Comparing the slope coefficients between Northern Wet-Mesic Forest and Northern Tamarack Swamp, which had the highest and lowest coefficients, respectively, $\overline{C}$ scores declined three times as rapidly per 1 unit increase in Overall Disturbance Score in Northern Wet-Mesic Forest as compared to Northern Tamarack Swamp (Figure I).

Regression analyses and associated Benchmarks: $\overline{C}$ and Plant Community Condition

Benchmark values for $\overline{C}$ for 9 of the 10 communities surveyed are presented in Table IV. Benchmarks were created for all wetland community types which had significant regressions and $r^2 \geq 0.30$. Black Spruce Swamp, as previously noted, had few observed "most disturbed" assessment areas based on Plant Community Condition in the field and an r^2 value narrowly missing minimum criteria. As observable on the boxplots of $\overline{C}$, the 25th percentile of "least disturbed" Black Spruce Swamp and the 75th percentile of "most disturbed" Black Spruce Swamp are roughly equal, with $\overline{C} = 7$ (Figure IV). To account for this discrepancy, minor adjustments were needed to derive Benchmarks for Black Spruce Swamp given that there would be marginal overlap (~0.1 $\overline{C}$ value) of "Good", "Fair" and "Poor" narrative classes if only the standard methods were used. $\overline{C} = 7$ was set as the score needed to achieve a "Fair" narrative rating, $\overline{C}$ = 7.1 (an increase in 0.1 C value from the standard) was set as the minimum value needed to achieve a "Good" narrative rating, and $\overline{C}$ = 6.9 (an decrease in 0.1 C value from the standard) was set as the maximum score still considered a "Poor" narrative rating (Table IV).

In observing the $\overline{C}$ Benchmark values for wetland community types which met all requisite criteria without methodological adjustments, Northern Sedge Meadow had the overall highest Benchmarks required to receive an "Excellent" narrative rating ($\overline{C}$ > 6.2), followed by Northern Tamarack Swamp, Northern Wet-Mesic Forest, and Shrub Carr (all requiring $\overline{C}$ > 6.0; Table IV). The lowest overall $\overline{C}$ score required to receive an "Excellent" narrative rating was $\overline{C}$ > 5.1 for Northern Hardwood Swamp. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Northern Sedge Meadow (2.4 $\overline{C}$ units difference).The narrowest gap between these narrative ratings within a given community type (excluding Black Spruce Swamp due to the modified process needed to obtain Benchmarks for that community) was observed for Northern Tamarack Swamp (0.8 $\overline{C}$ units difference; Table IV)

Of 10 candidate community types, 9 community types had an observed significant inverse linear relationship between $\overline{C}$ and Plant Community Condition Scores (Figure III; Table III). The only wetland community type that did not have a significant inverse relationship was Central Poor Fen (Figure III; Table III). Black Spruce Swamp (Black Spruce Swamp), though having a significant inverse linear relationship ($p = 0.01$) with Plant Community Condition Scores, had an $r^2 = 0.29$, slightly below the tolerable limit specified for community types with few representative sites in the "most disturbed" category ($r^2 = 0.30$; Tables 3 and IV). However, Black Spruce Swamp was further considered for Benchmarks under continued scrutiny (non-overlap of quartiles of "most" and "least" disturbed boxplots for Benchmark determination).

Of the community types which had significant regressions and $r^2 \geq 0.30$, the highest average $\overline{C}$ scores of "least disturbed" assessment areas based on Plant Community Condition were Northern Tamarack Swamps (Northern Tamarack Swamp; $\mu\overline{C} \approx 6$), followed by Northern Wet-Mesic Forest, Emergent Marsh, and Northern Sedge Meadow ($\mu\overline{C} \approx 5.6$ to 5.8; Figure IV). In contrast, the lowest average $\overline{C}$ scores of "most disturbed" assessment areas based on Plant Community Condition were observed in Northern Hardwood Swamp and Southern Sedge Meadow ($\mu\overline{C} \approx 3.4$ to 3.5; Figure IV). Regression slope coefficients ranged from -0.19 to -0.50, with anywhere from 33 to 54% of the variation in the regressions explained by Plant Community Condition scores depending on community type (based on r^2 values; Table III). Community types which declined most rapidly in $\overline{C}$ scores over the Plant Community Condition disturbance gradient, based on regression slope coefficients, included Northern Wet-Mesic Forest, Shrub Carr, and Southern Sedge Meadow, which all decreased over 0.4 units of average conservatism value per 1 unit increase in Plant Community Condition Score (Figure III; Table III). In fact, Northern Wet-Mesic Forest decreased over 0.5 units of average conservatism value per 1 unit increase in Plant Community Condition Score. The smallest overall slope coefficient was observed for Northern Tamarack Swamp (-0.19). Comparing the slope coefficients between Northern Wet-Mesic Forest and Northern Tamarack Swamp, which had the highest and lowest coefficients, respectively, $\overline{C}$ scores declined almost three times as rapidly per 1 unit increase in Plant Community Condition Score in Northern Wet-Mesic Forest as compared to Northern Tamarack Swamp as also evidenced by the regression lines in Figure III.

<u>Regression analyses and associated Benchmarks: $w\overline{C}$ and Plant Community Condition</u>

Benchmark values for $w\overline{C}$ for 9 of the 10 communities surveyed are presented in Table VI. Regarding $w\overline{C}$ Benchmark values, the standard analytical sequence as described in the "Methods" section was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ with the exception of Northern Wet-Mesic Forest, again likely due to a lack of observed "most disturbed" assessment areas based on Plant Community Condition in the field. Like the Black Spruce Swamp $\overline{C}$ Benchmarks described previous, the 25th percentile of "least disturbed" Northern Wet-Mesic Forest and the 75th percentile of "most disturbed" Northern Wet-Mesic Forest were roughly equal, with $\overline{C}$ = 6.8 (Figure VI). To account for this discrepancy, the same process of minor adjustments used to modify the Black Spruce Swamp $\overline{C}$Benchmarks was used to slightly modify the scores needed within "Good", "Fair" and "Poor" narrative classes for Northern Wet-Mesic Forest $w\overline{C}$ Benchmarks (Table VI).

Emergent Marsh had the overall highest required Benchmarks to receive an "Excellent" narrative rating ($w\overline{C}$ > 7.7), followed by Northern Tamarack Swamp, ($w\overline{C}$ > 7.1) and Northern Sedge Meadow ($w\overline{C}$ > 6.9; Table VI). The lowest overall $w\overline{C}$ score required to receive an "Excellent" narrative rating was $w\overline{C}$ > 5.0 for Alder Thicket. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Emergent Marsh (6.9 $w\overline{C}$ units difference). The narrowest gaps (excluding Northern Wet-Mesic Forest due to the modified process needed to obtain Benchmarks for that community) between these narrative ratings were observed for Alder Thicket (1.8 $w\overline{C}$ units difference) and Northern Tamarack Swamp (2.3 $w\overline{C}$ units difference; Table VI).

In the regressions of $w\overline{C}$ scores versus Plant Community Condition scores, 8 community types had an observed significant inverse linear relationship, with Black Spruce Swamp and Central Poor Fen not meeting this criterion (Figure V; Table V). The highest average $w\overline{C}$ scores of "least disturbed" assessment areas based on Plant Community Condition were Northern Wet-Mesic Forest ($\mu w\overline{C} \approx 6.5$), followed by Northern Tamarack Swamp, Northern Sedge Meadow, and Emergent Marsh ($\mu w\overline{C} \approx 6.2$ to 6.4; Figure VI). In contrast, the lowest average $w\overline{C}$ scores of "most disturbed" assessment areas were observed in Southern Sedge Meadow and Emergent Marsh ($\mu w\overline{C} \approx 1.9$ to 2; Figure VI). Regression slope coefficients ranged from -0.37 to -1.17, with anywhere from 32 to 84% of the variation in the regressions explained by Plant Community Condition scores depending on community type (based on r^2 values; Table V). Community types which declined most rapidly in $w\overline{C}$ scores over the Plant Community Condition disturbance gradient, based on regression slope coefficients, included Emergent Marsh, Northern Sedge Meadow, Southern Sedge Meadow, which all decreased over 1 unit of average weighted conservatism value per 1 unit increase in Plant Community Condition Score (Figure V; Table V). In fact, Emergent Marsh decreased nearly 1.2 units of average weighted conservatism value per 1 unit increase in Plant Community Condition. The smallest overall slope coefficient was observed for Northern Wet-Mesic Forest (-0.37). Comparing the slope coefficients between Emergent Marsh and Northern Wet-Mesic Forest, which had the highest and lowest coefficients, respectively, $w\overline{C}$ scores declined over three times as rapidly per 1 unit increase in Plant Community Condition Score in Emergent Marsh as compared to Northern Wet-Mesic Forest as also evidenced by the regression lines in Figure V.

Southeast Wisconsin Till Plains (SETP) Ecoregion

All 9 wetland community types surveyed met minimum data standards for Benchmark consideration, accounting for 193 assessment areas. However, multiple community types were arguably underrepresented on the "most disturbed" end of the disturbance gradient based on Overall Disturbance scores. Floodplain Forest, Northern Hardwood Swamp and Northern Wet-Mesic Forest had 5 or fewer most disturbed category assessment areas each (Table 6 in Main Text of Report). These community types were retained for the analysis despite not having the desired representation of most disturbed category assessment areas, but their regression results were interpreted with additional scrutiny (i.e. r^2 needed to be greater than 0.30; confidence intervals on regression lines needed to be reasonably tight with data distribution generally matching the trend of the overall regression).

Regression analyses and associated Benchmarks: $\overline{C}$ and Overall Disturbance

Benchmark values for $\overline{C}$ for 7 of the 9 communities surveyed are presented in Table VIII. The standard analytical sequence as described in the "Methods" section was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table VII). Calcareous Fen had the overall highest Benchmarks required to receive an "Excellent" narrative rating ($\overline{C} > 6.0$), followed by Southern Sedge Meadow ($\overline{C} > 5.7$) and Shrub Carr ($\overline{C} > 5.4$; Table VIII). The lowest overall $\overline{C}$ score required to receive an "Excellent" narrative rating was $\overline{C} > 4.1$ for Floodplain Forest. The largest gap between

"Excellent" and "Very Poor" narrative ratings within a given community type was observed for Calcareous Fen (3.2 $\overline{C}$ units difference). The narrowest gap between these narrative ratings within a given community type was observed for Southern Hardwood Swamp (1.1 $\overline{C}$ units difference; Table VIII).

Of the 9 candidate community types, only 7 community types had an observed significant inverse linear relationship between $\overline{C}$ and Overall Disturbance Scores (Figure VII; Table VII). The communities that did not have a significant inverse relationship included Northern Hardwood Swamp and Northern Wet-Mesic Forest (Figure VII; Table VII). Emergent Marsh, though having a significant inverse linear relationship ($p = 0.018$) with Overall Disturbance Scores, had an overall low correlation value and thereby was not considered fit for further $\overline{C}$ Benchmark development ($r^2 = 0.15$; Table VII).

Of the community types which had significant regressions and $r^2 \geq 0.30$, the highest average $\overline{C}$ scores of "least disturbed" assessment areas were observed for Calcareous Fen ($\mu\overline{C} \approx 5.6$), followed by Southern Sedge Meadow ($\mu\overline{C} \approx 5.3$; Figure VIII). In contrast, the lowest average $\overline{C}$ scores of "most disturbed" assessment areas were observed in Floodplain Forest ($\mu\overline{C} \approx 2.7$) and Wet-Mesic Prairie ($\mu\overline{C} \approx 3.2$; Figure VIII). Regression slope coefficients ranged from -0.25 to -0.84, with anywhere from 42 to 64% of the variation in the regressions explained by Overall Disturbance depending on community type (based on r^2 values; Table VII). All community types with the exception of Southern Hardwood Swamp decreased over 0.5 units of average conservatism value per 1 unit increase in Overall Disturbance Score (Figure VII; Table VII). In fact, Calcareous Fen decreased 0.84 units of average conservatism value per 1 unit increase in Overall Disturbance Score. The smallest overall slope coefficient was observed for Southern Hardwood Swamp (-0.23). Comparing the slope coefficients between Calcareous Fen and Southern Hardwood Swamp, which had the highest and lowest coefficients, respectively, $\overline{C}$ scores declined nearly three-and-a-half times as rapid per 1 unit increase in Overall Disturbance Score in Calcareous Fen as compared to Southern Hardwood Swamp as also evidenced by the regression lines in Figure VII.

Regression analyses and associated Benchmarks: $\overline{C}$ and Plant Community Condition

Benchmark values for $\overline{C}$ for 7 of 9 communities surveyed are presented in Table X. All 9 community types and had an observed significant inverse linear relationship between $\overline{C}$ and Plant Community Condition Scores (Figure IX; Table IX). Emergent Marsh, though having a significant inverse linear relationship ($p = 0.012$) with Overall Disturbance Scores, had an overall low correlation value and thereby was not considered fit for further $\overline{C}$ Benchmark development ($r^2 = 0.17$; Table IX).

The standard analytical sequence as described in the "Methods" section was able to create Benchmarks for 7 of the 8 wetland community types which had significant regressions and $r^2 \geq 0.30$. The lone wetland community type where Benchmarks were unable to be created was Northern Wet-Mesic Forest, which despite meeting all statistical criteria, had notable overlap between "most disturbed" and "least disturbed" communities as determined by the Plant Community Condition Score. This is observable on the boxplots of $\overline{C}$ for Northern Wet-Mesic Forest, as the 25th percentile of "least disturbed" Northern Wet-Mesic Forest and the 75th percentile of "most disturbed" Northern Wet-Mesic Forest overlap (Figure X). No overall statistically justifiable corrections could be made to account for this overlap observed for Northern Wet-Mesic Forest scores, and thus Northern Wet-Mesic Forest was not considered fit for further $\overline{C}$ Benchmark development.

Among wetland community types which met all requisite criteria, Calcareous Fen had the overall highest Benchmarks required to receive an "Excellent" narrative rating ($\overline{C}$ > 6.1), followed by Southern Sedge Meadow ($\overline{C}$ > 5.8) and Shrub Carr ($\overline{C}$ > 5.4; Table X). The lowest overall $\overline{C}$ score required to receive an "Excellent" narrative rating was $\overline{C}$ > 4.0 for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Calcareous Fen (3.3 $\overline{C}$ units difference). The narrowest gap between these narrative ratings within a given community type was observed for Southern Hardwood Swamp (1.0 $\overline{C}$ units difference; Table X)

Of the community types which had significant regressions and $r^2 \geq 0.30$, the highest average $\overline{C}$ scores of "least disturbed" assessment areas based on Plant Community Condition were Calcareous Fen ($\mu\overline{C} \approx 5.8$), followed Southern Sedge Meadow ($\mu\overline{C} \approx 5.3$; Figure X). In contrast, the lowest average $\overline{C}$ scores of "most disturbed" assessment areas based on Plant Community Condition were observed in Floodplain Forest and Wet-Mesic Prairie ($\mu\overline{C} \approx 3.1$ to 3.2; Figure X). Regression slope coefficients ranged from -0.19 to -0.72, with anywhere from 34 to 69% of the variation in the regressions explained by Plant Community Condition scores depending on community type (based on r^2 values; Table IX). Community types which declined most rapidly in $\overline{C}$ scores over the Plant Community Condition disturbance gradient, based on regression slope coefficients, included Calcareous Fen, Wet-Mesic Prairie, Southern Sedge Meadow, and Shrub Carr, which all decreased over 0.4 units of average conservatism value per 1 unit increase in Plant Community Condition Score (Figure IX; Table IX). In fact, Calcareous Fen decreased nearly 0.75 units of average conservatism value per 1 unit increase in Plant Community Condition Score. The smallest overall slope coefficient was observed for Southern Hardwood Swamp (-0.19). Comparing the slope coefficients between Calcareous Fen and Southern Hardwood Swamp, which had the highest and lowest coefficients, respectively, $\overline{C}$ scores declined over three and a half times as rapidly per 1 unit increase in Plant Community Condition Score in Northern Wet-Mesic Forest as compared to Southern Hardwood Swamp as also evidenced by the regression lines in Figure IX.

Regression analyses and associated Benchmarks: $w\overline{C}$ and Plant Community Condition

Benchmark values for $w\overline{C}$ for 7 of 9 communities surveyed are presented in Table XII. Regarding $w\overline{C}$ Benchmark values, the standard analytical sequence as described in the "Methods" section was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table XI). In observing the $w\overline{C}$ Benchmark values for wetland community types which met all standard requisite criteria, Calcareous Fen had the overall highest required Benchmarks to receive an "Excellent" narrative rating ($w\overline{C}$ > 7.4), followed by Southern Sedge Meadow ($w\overline{C}$ > 6.4) and Northern Hardwood Swamp ($w\overline{C}$ > 6.2; Table XII). The lowest overall $w\overline{C}$ score required to receive an "Excellent" narrative rating was $w\overline{C}$ > 4.0 for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Southern Sedge Meadow (5.4 $w\overline{C}$ units difference). The narrowest gaps between these narrative ratings were observed for Floodplain Forest (1.8 $w\overline{C}$ units difference; Table XII).

In the regressions of $w\overline{C}$ scores versus Plant Community Condition scores, 8 of 9 community types had an observed significant inverse linear relationship with Northern Wet-Mesic Forest narrowly not meeting these criteria ($p = 0.061$, $r^2 = 0.34$; Figure XI; Table XI). The highest average $w\overline{C}$ scores of "least disturbed" assessment areas based on Plant Community Condition were Calcareous Fen ($\mu w\overline{C} \approx 6.6$ to 6.7), followed by Southern Sedge Meadow ($\mu w\overline{C} \approx 5.9$) and Northern Hardwood Swamp ($\mu w\overline{C} \approx 5.6$ to 5.7 Figure XII). In contrast, the lowest average $w\overline{C}$ scores of "most disturbed" assessment areas were observed in Emergent Marsh ($\mu w\overline{C} \approx 1.7$ to 1.8; Figure XII). Regression slope coefficients ranged from -0.46 to -1.12, with anywhere from 58 to 81% of the variation in the regressions explained by Plant Community Condition scores depending on community type (based on r^2 values; Table XI). Community types which declined most rapidly in $w\overline{C}$ scores over the Plant Community Condition disturbance gradient, based on regression slope coefficients, included Calcareous Fen, Southern Sedge Meadow, and Emergent Marsh which all decreased over 0.9 units of average weighted conservatism value per 1 unit increase in Plant Community Condition Score (Figure XI; Table XI). In fact, Calcareous Fen decreased 1.12 units of average weighted conservatism value per 1 unit increase in Plant Community Condition. The smallest overall slope coefficient was observed for Southern Hardwood Swamp (-0.46). Comparing the slope coefficients between Calcareous Fen and Southern Hardwood Swamp, which had the highest and lowest coefficients, respectively, $w\overline{C}$ scores declined nearly two-and-a-half times as rapidly per 1 unit increase in Plant Community Condition Score in Calcareous Fen as compared to Southern Hardwood Swamp as also evidenced by the regression lines in Figure XI.

Driftless Area Ecoregion

Of wetland community types surveyed, 5 of 6 met minimum data standards for Benchmark consideration, accounting for 125 assessment areas. However, Alder Thicket was arguably underrepresented on the "most disturbed" end of the disturbance gradient based on both Overall Disturbance and Plant Community Condition scores with only 3 most disturbed category assessment areas (Table 9 in Main Text of Report). Alder Thicket was retained for the analysis despite not having the desired representation of most disturbed category sites, but regression results were interpreted with additional scrutiny (i.e. r^2 needed to be greater than 0.30; confidence intervals on regression lines needed to be reasonably tight with data distribution generally matching the trend of the overall regression).

Regression analyses and associated Benchmarks: $\overline{C}$ and Overall Disturbance

Benchmark values for $\overline{C}$ are presented in Table XIV for 4 of the 6 communities surveyed. The standard analytical sequence as described in the "Methods" section was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table XIII). Emergent Marsh had an $r^2 = 0.27$, slightly below the tolerable limit specified for community types, but was still considered (Table XIII). As observable on the boxplots of $\overline{C}$, the 25th percentile of "least disturbed" Emergent Marsh and the 75th percentile of "most disturbed" Emergent Marsh are roughly equal, with $\overline{C}$ = 4.4 (Figure XIV). To account for this discrepancy, minor adjustments were needed to derive Benchmarks for Emergent Marsh given that there would be marginal overlap (~0.1 $\overline{C}$ value) of "Good", "Fair" and "Poor" narrative classes if only the standard methods were used. $\overline{C}$ = 4.4 was set as the score needed to achieve a "Fair" narrative rating, $\overline{C}$ = 4.5 (an increase in 0.1 C value from the standard) was set as the minimum value needed to achieve a "Good" narrative rating, and $\overline{C}$ = 4.3 (an decrease in 0.1 C value from the standard) was set as the maximum score still considered a "Poor" narrative rating (Table XIV).

Southern Sedge Meadow had the overall highest Benchmarks required to receive an "Excellent" narrative rating ($\overline{C}$ > 5.3; Table XIV). The lowest overall $\overline{C}$ score required to receive an "Excellent" narrative rating was $\overline{C}$ > 4.5 for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Southern Sedge Meadow (2.4 $\overline{C}$ units difference). The narrowest gap between these narrative ratings within a given community type was observed for Floodplain Forest (0.9 $\overline{C}$ units difference; Table XIV)

Of these 5 candidate community types, only 4 community types had an observed significant inverse linear relationship between $\overline{C}$ and Overall Disturbance Scores (Figure XIII; Table XIII). Alder Thicket was the only community that did not have a significant inverse relationship (Figure XIII; Table XIII). Emergent Marsh, though having a significant inverse linear relationship ($p = 0.001$) with Overall Disturbance Scores, had an $r^2 = 0.27$, slightly below the tolerable limit specified for community types ($r^2 = 0.30$; Table 22). However, Emergent Marsh was further considered for Benchmarks under continued scrutiny.

Of the community types which had significant regressions and $r^2 \geq 0.30$, the highest average $\overline{C}$ scores of "least disturbed" assessment areas were observed for Southern Sedge Meadow ($\mu\overline{C} \approx 4.8$), followed by Shrub Carr ($\mu\overline{C} \approx 4.7$; Figure XIV). In contrast, the lowest average $\overline{C}$ scores of "most disturbed" assessment areas were observed in Shrub Carr ($\mu\overline{C} \approx 3.4$) and Floodplain Forest ($\mu\overline{C} \approx 3.7$; Figure XIV). Regression slope coefficients ranged from -0.24 to -0.46, with anywhere from 32 to 58% of the variation in the regressions explained by Overall Disturbance depending on community type (based on r^2 values; Table XIII). Shrub Carr was the only community type that decreased over 0.4 units of average conservatism value per 1 unit increase in Overall Disturbance Score and had the largest overall slope coefficient of -0.46 (Figure XIII; Table XIII). The smallest overall slope coefficient was observed for Floodplain Forest (-0.24). Comparing the slope coefficients between Shrub Carr and Floodplain Forest, $\overline{C}$ scores declined nearly two times as rapid per 1 unit increase in Overall Disturbance Score in Shrub Carr as compared to Floodplain Forest as also evidenced by the regression lines in Figure XIII.

Regression analyses and associated Benchmarks: $\overline{C}$ and Plant Community Condition

Benchmark values for $\overline{C}$ are presented in Table XVI for 4 of the 6 communities surveyed. Regarding $\overline{C}$ Benchmark values, the standard analytical sequence as described in the "Methods" section was able to create Benchmarks for 4 of the 5 wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table XV). The lone wetland community type where Benchmarks were unable to be created was Alder Thicket, which had low overall numbers of "most disturbed" communities as determined by the Plant Community Condition Score (Table 9 in Main Text of Report).

Among wetland community types which met all requisite criteria, Southern Sedge Meadow had the overall highest Benchmarks required to receive an "Excellent" narrative rating ($\overline{C} > 5.3$), followed by Emergent Marsh ($\overline{C} > 5.2$; Table XVI). The lowest overall $\overline{C}$ score required to receive an "Excellent" narrative rating was $\overline{C} > 4.5$ for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Southern Sedge Meadow (2.4 $\overline{C}$ units difference). The narrowest gap between these narrative ratings within a given community type was observed for Floodplain Forest (0.9 $\overline{C}$ units difference; Table XVI)

Of the 5 candidate community types, 4 community types had an observed significant inverse linear relationship between $\overline{C}$ and Plant Community Condition Scores (Figure XV;

Table XV). Alder Thicket was the only community that did not have a significant inverse relationship (Figure XV; Table XV). Of the community types which had significant regressions and $r^2 \geq 0.30$, the highest average $\overline{C}$ scores of "least disturbed" assessment areas based on Plant Community Condition Southern Sedge Meadow and Emergent Marsh ($\mu\overline{C} \approx$ 4.8 to 4.9; Figure XVI). In contrast, the lowest average $\overline{C}$ scores of "most disturbed" assessment areas based on Plant Community Condition were observed in Shrub Carr ($\mu\overline{C} \approx$ 3.2 to 3.3; Figure XVI). Regression slope coefficients ranged from -0.20 to -0.36, with anywhere from 37 to 61% of the variation in the regressions explained by Plant Community Condition scores depending on community type (based on r^2 values; Table XV). Shrub Carr declined most rapidly in $\overline{C}$ scores over the Plant Community Condition disturbance gradient, based on regression slope coefficients, at nearly 0.4 units of average conservatism value per 1 unit increase in Plant Community Condition Score (Figure XV; Table XV). The smallest overall slope coefficient was observed for Floodplain Forest (-0.20). Comparing the slope coefficients between Shrub Carr and Floodplain Forest, $\overline{C}$ scores declined nearly two times as rapidly per 1 unit increase in Plant Community Condition Score in Shrub Carr as compared to Floodplain Forest as also evidenced by the regression lines in Figure XV.

Regression analyses and associated Benchmarks: $w\overline{C}$ and Plant Community Condition

Benchmark values for $w\overline{C}$ for 4 of 6 communities surveyed are presented in Table XVIII. Regarding $w\overline{C}$ Benchmark values, the standard analytical sequence as described in the "Methods" section was able to create Benchmarks for all wetland community types which had significant regressions and $r^2 \geq 0.30$ (Table XVII). In observing the $w\overline{C}$ Benchmark values for wetland community types which met all standard requisite criteria, Southern Sedge Meadow had the overall highest required Benchmarks to receive an "Excellent" narrative rating ($w\overline{C} > 5.9$), followed by Shrub Carr ($w\overline{C} > 5.5$; Table XVIII). The lowest overall $w\overline{C}$ score required to receive an "Excellent" narrative rating was $w\overline{C} > 4.4$ for Floodplain Forest. The largest gap between "Excellent" and "Very Poor" narrative ratings within a given community type was observed for Southern Sedge Meadow (4.8 $w\overline{C}$ units difference). The narrowest gaps between these narrative ratings were observed for Alder Thicket (1.8 $w\overline{C}$ units difference) and Floodplain Forest (2.2 $w\overline{C}$ units difference; Table XVIII).

In the regressions of $w\overline{C}$ scores versus Plant Community Condition scores, all 5 candidate community types had an observed significant inverse linear relationship (Figure XVII; Table XVII). The highest average $w\overline{C}$ scores of "least disturbed" assessment areas based on Plant Community Condition were Southern Sedge Meadow ($\mu w\overline{C} \approx$ 5.5 to 5.6), followed by Emergent Marsh ($\mu w\overline{C} \approx$ 5.2; Figure XVIII). In contrast, the lowest average $w\overline{C}$ scores of "most disturbed" assessment areas were observed in Southern Sedge Meadow ($\mu w\overline{C} \approx$ 1.5 to 1.6; XVIII). Regression slope coefficients ranged from -0.41 to -0.97, with anywhere from 56 to 91% of the variation in the regressions explained by Plant Community Condition scores depending on community type (based on r^2 values; Table XVII). Community types which declined most rapidly in $w\overline{C}$ scores over the Plant Community Condition disturbance gradient, based on regression slope coefficients, included Southern Sedge Meadow and Emergent Marsh which both decreased over 0.7 units of average weighted conservatism value per 1 unit increase in Plant Community Condition Score (Figure XVII; Table XVII). In fact, Southern Sedge Meadow decreased nearly 1 unit of average weighted conservatism value per 1 unit increase in Plant Community Condition. The smallest overall slope coefficient was observed for Floodplain Forest (-0.41). Comparing the slope coefficients between Southern Sedge Meadow and Floodplain Forest, $w\overline{C}$ scores declined over two times as rapidly per 1 unit increase in Plant Community Condition Score in Southern Sedge Meadow as compared to Floodplain Forest as also evidenced by the regression lines in Figure XVII.

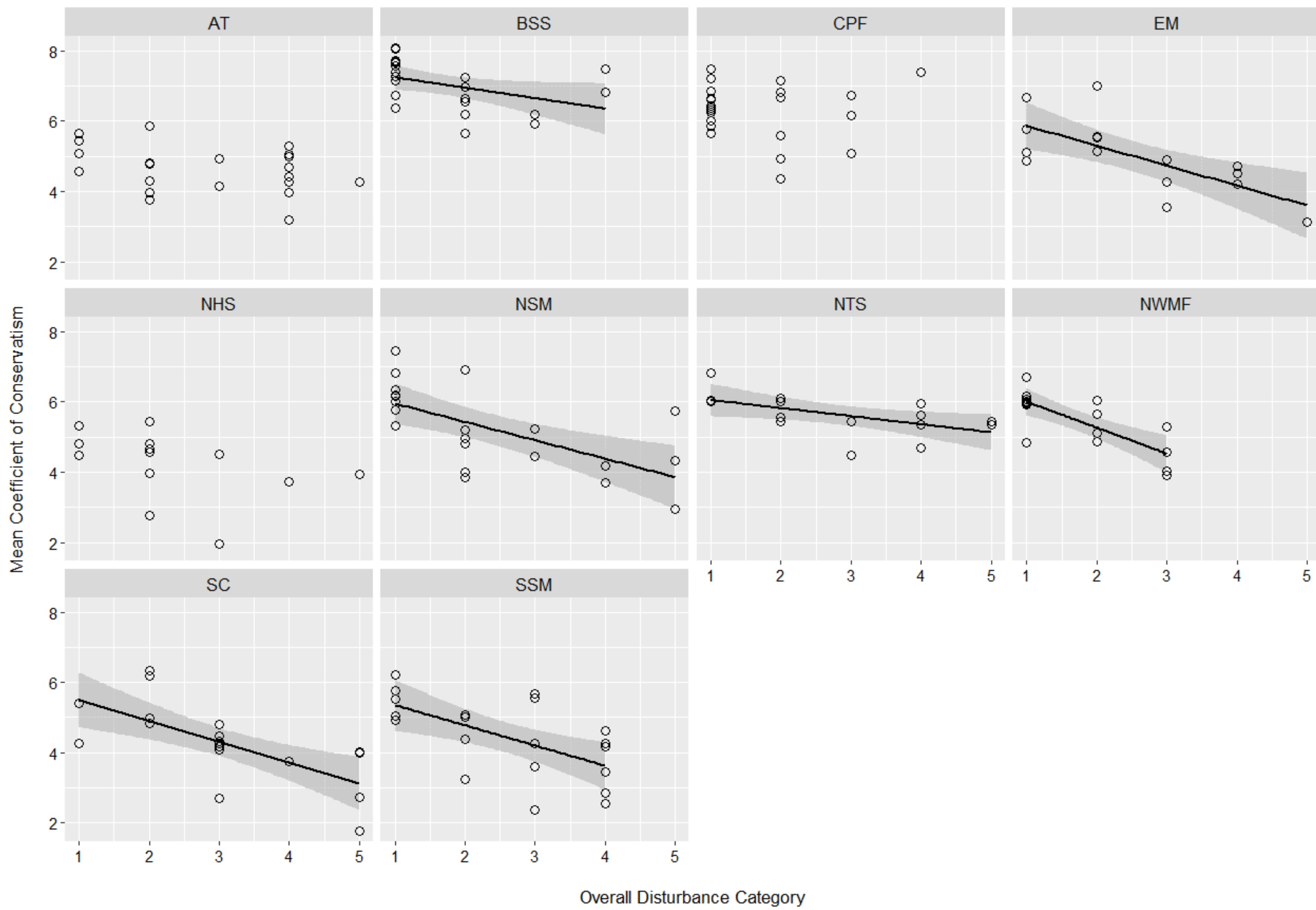


Figure I. Scatterplots of assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Overall Disturbance scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table I.

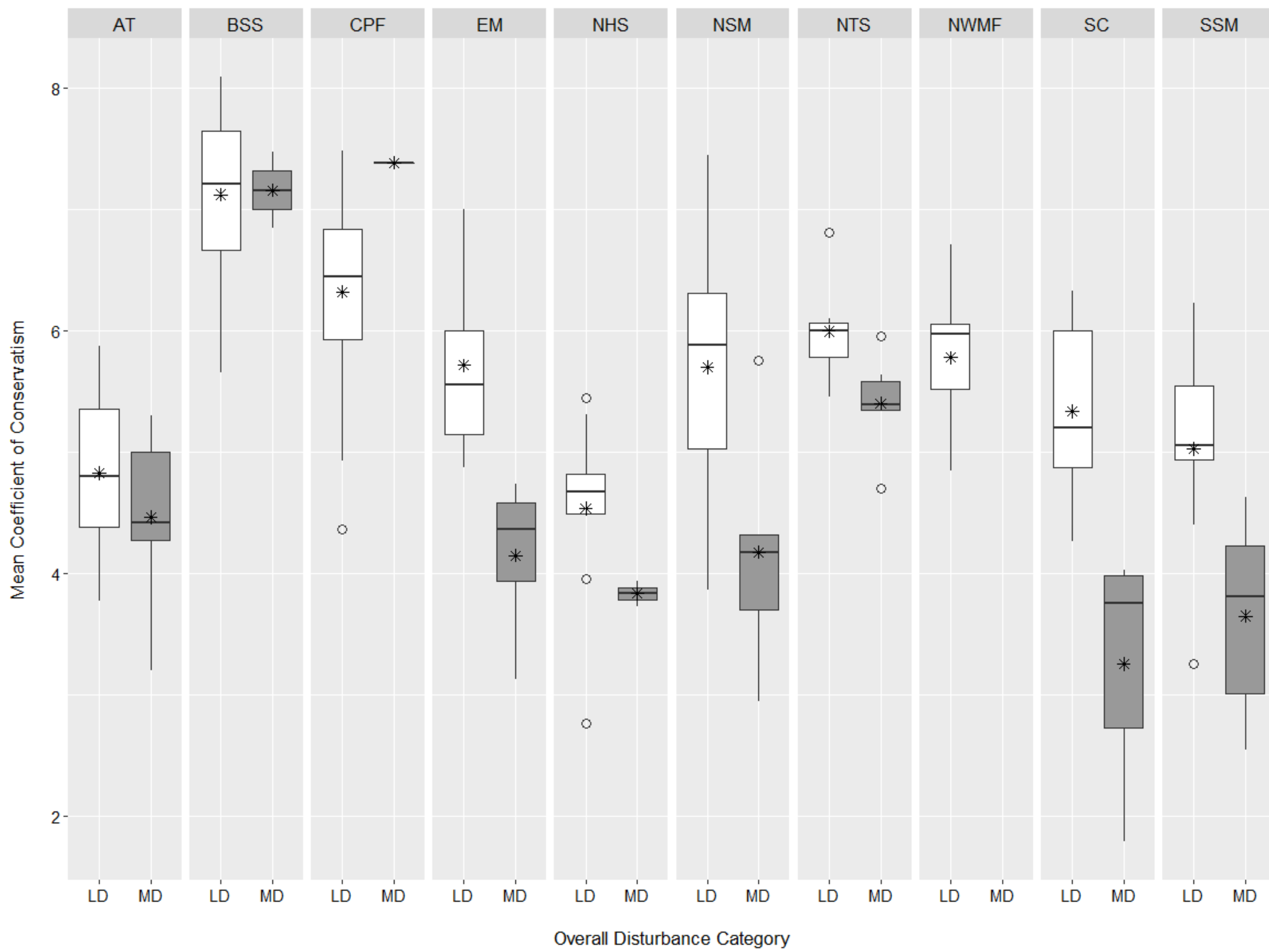


Figure II. Boxplots of Mean Coefficient of Conservatism ($\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Overall Disturbance Scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Overall Disturbance Category by wetland community type are described in Table 3.

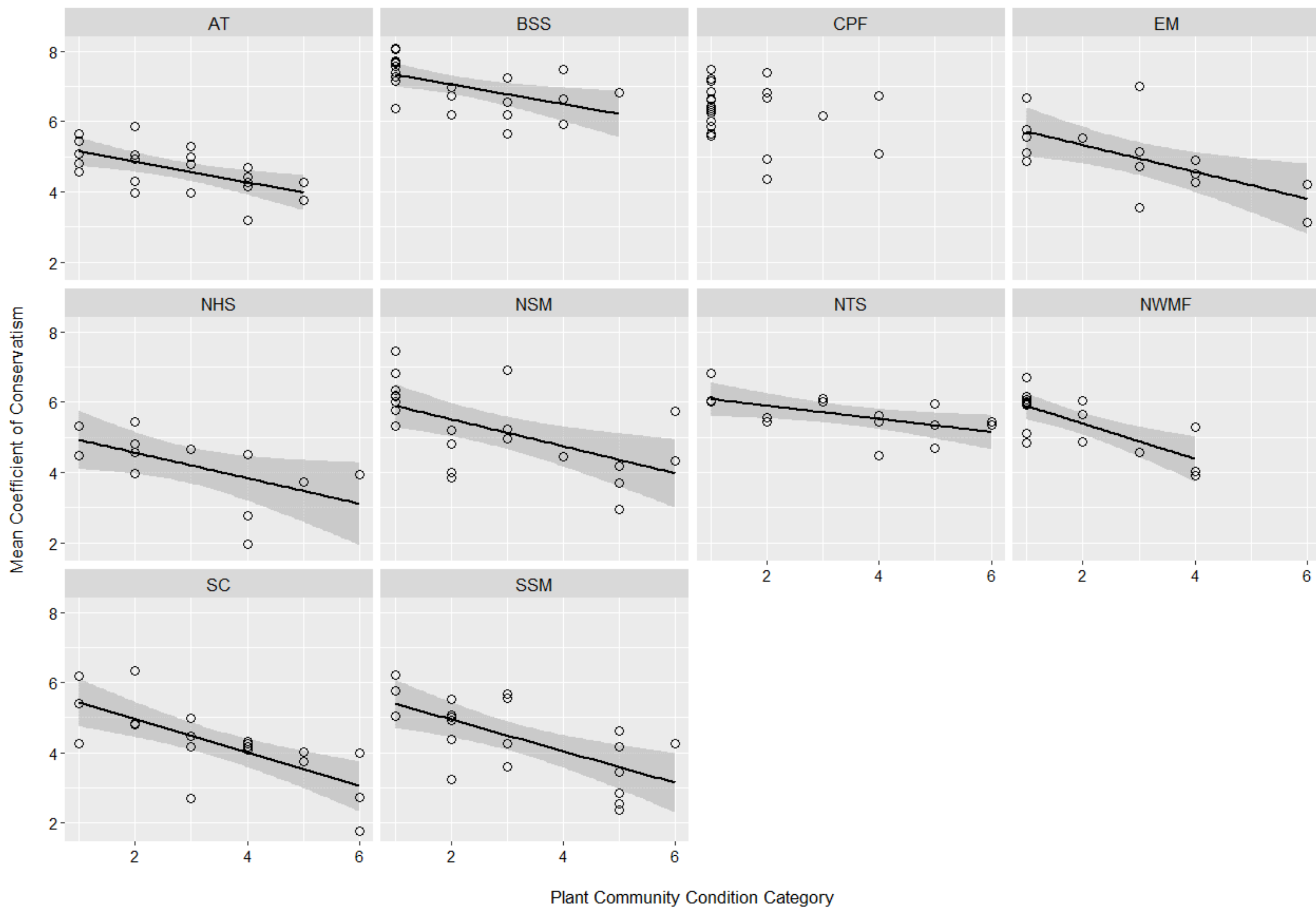


Figure III. Scatterplots of assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Plant Community Condition scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table III.

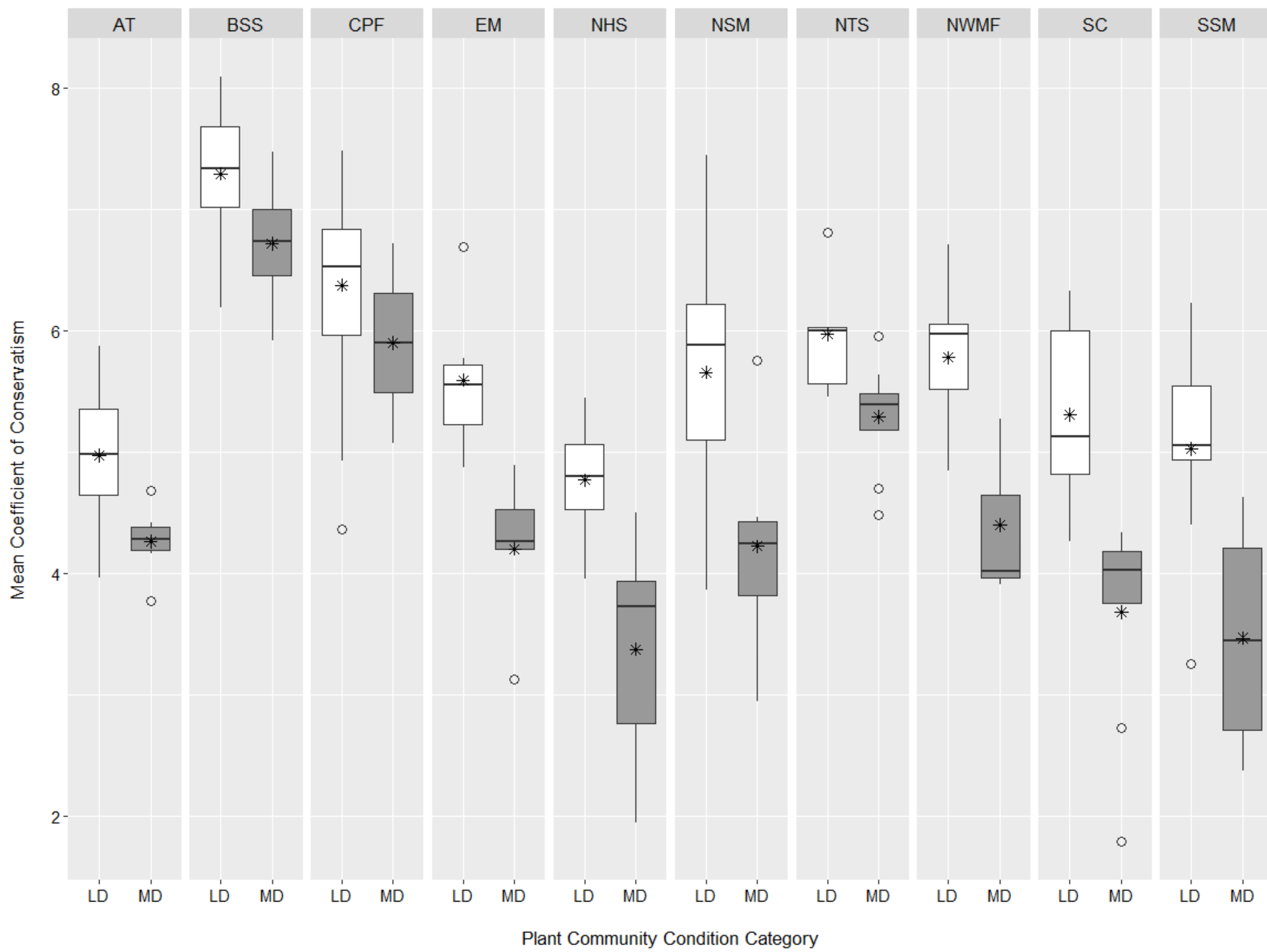


Figure IV. Boxplots of Mean Coefficient of Conservatism ($\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Plant Community Condition scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Plant Community Condition Category by wetland community type are described in Table 3.

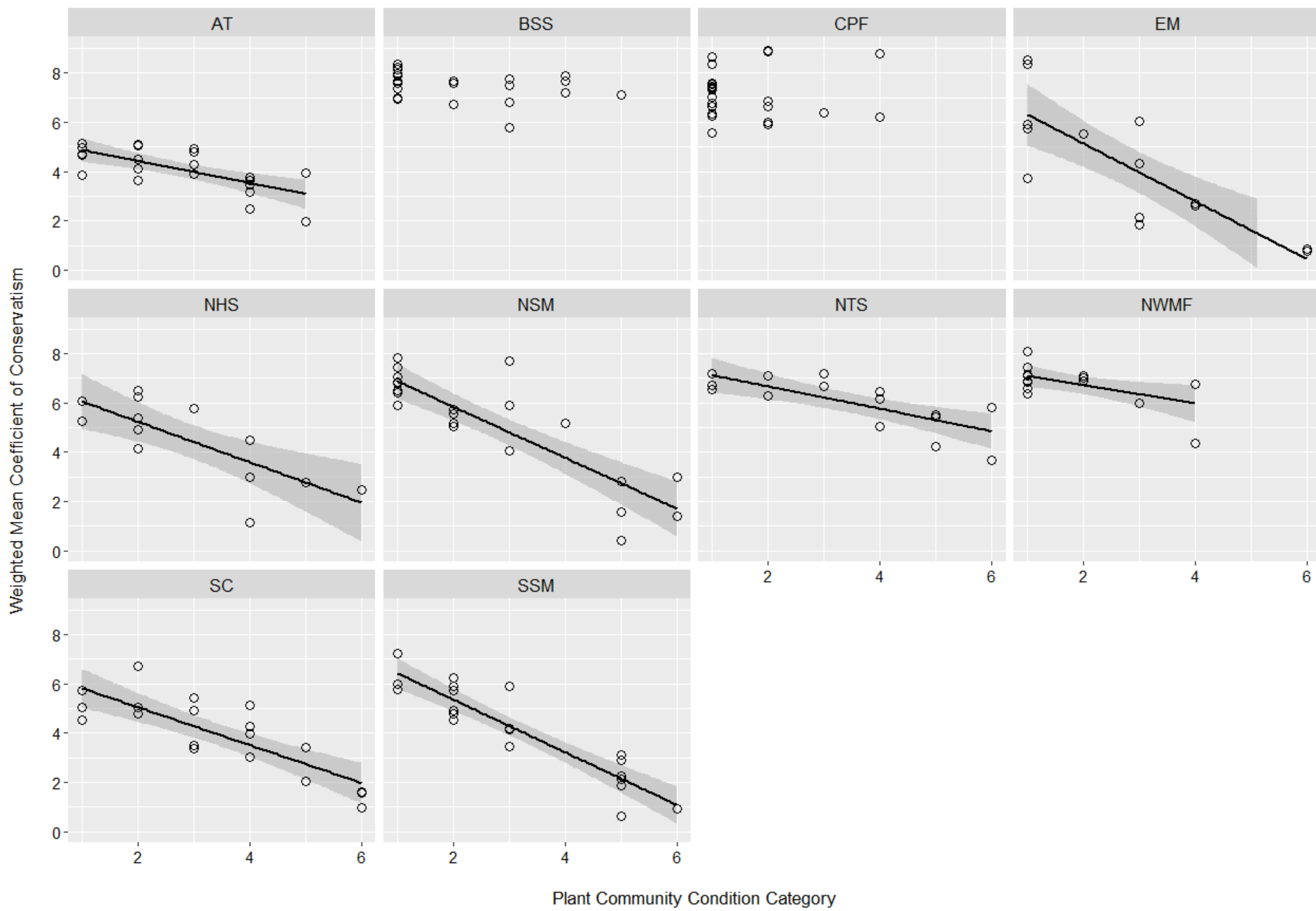


Figure V. Scatterplots of assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Plant Community Condition scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table V.

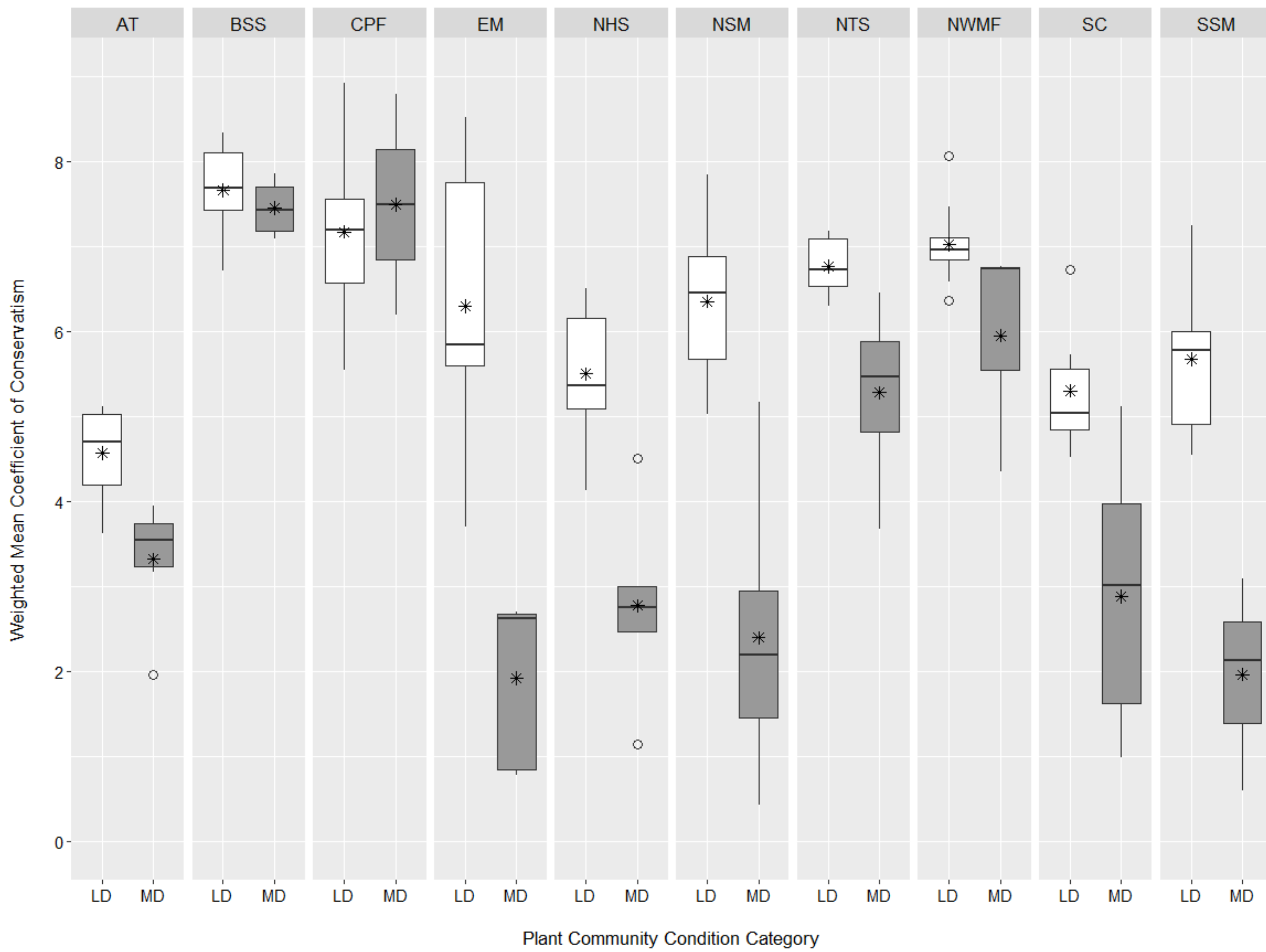


Figure VI. Boxplots of cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Plant Community Condition scores for 10 wetland community types sampled in the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Plant Community Condition Category by wetland community type are described in Table 3.

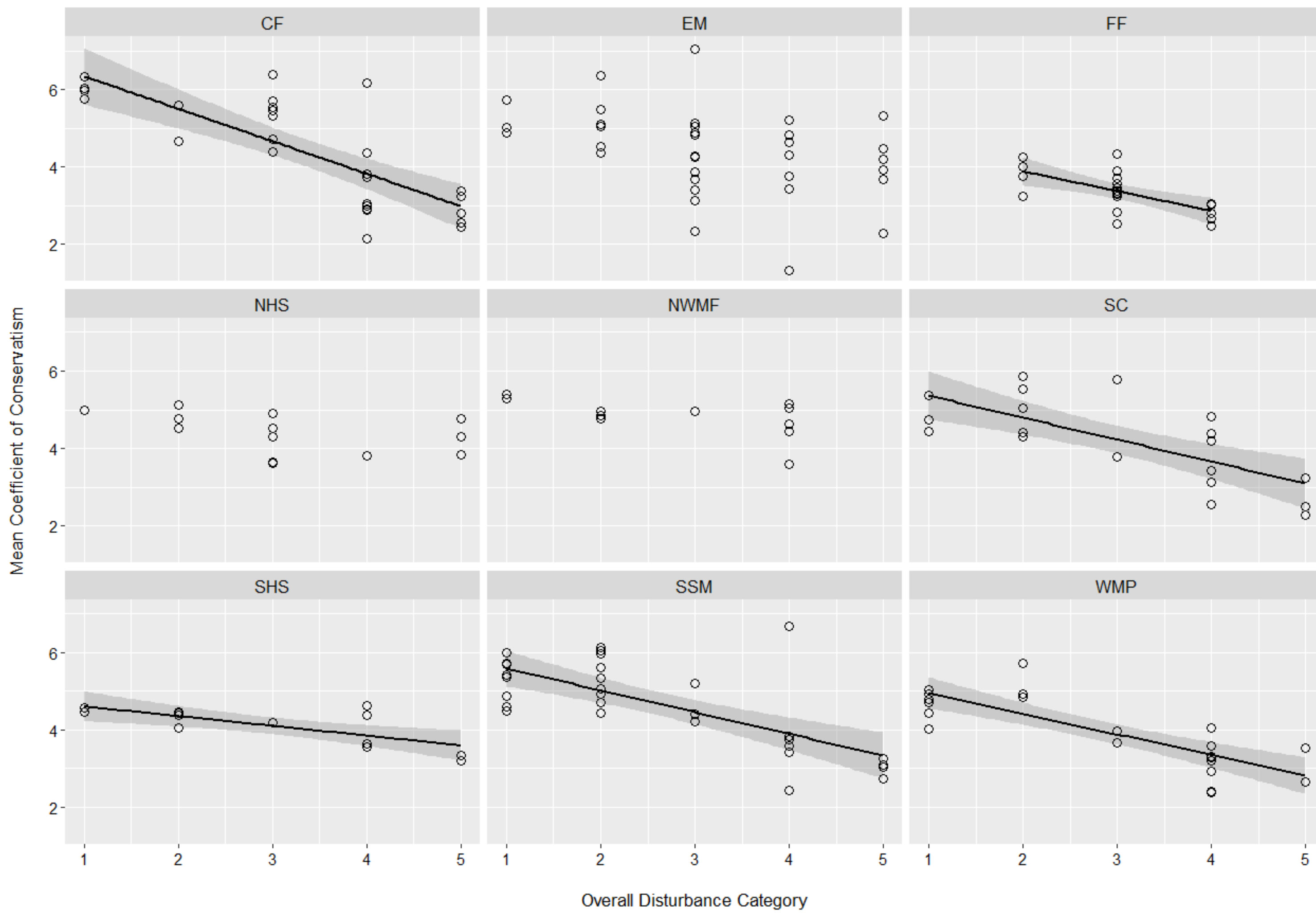


Figure VII. Scatterplots of assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Overall Disturbance scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table VII.

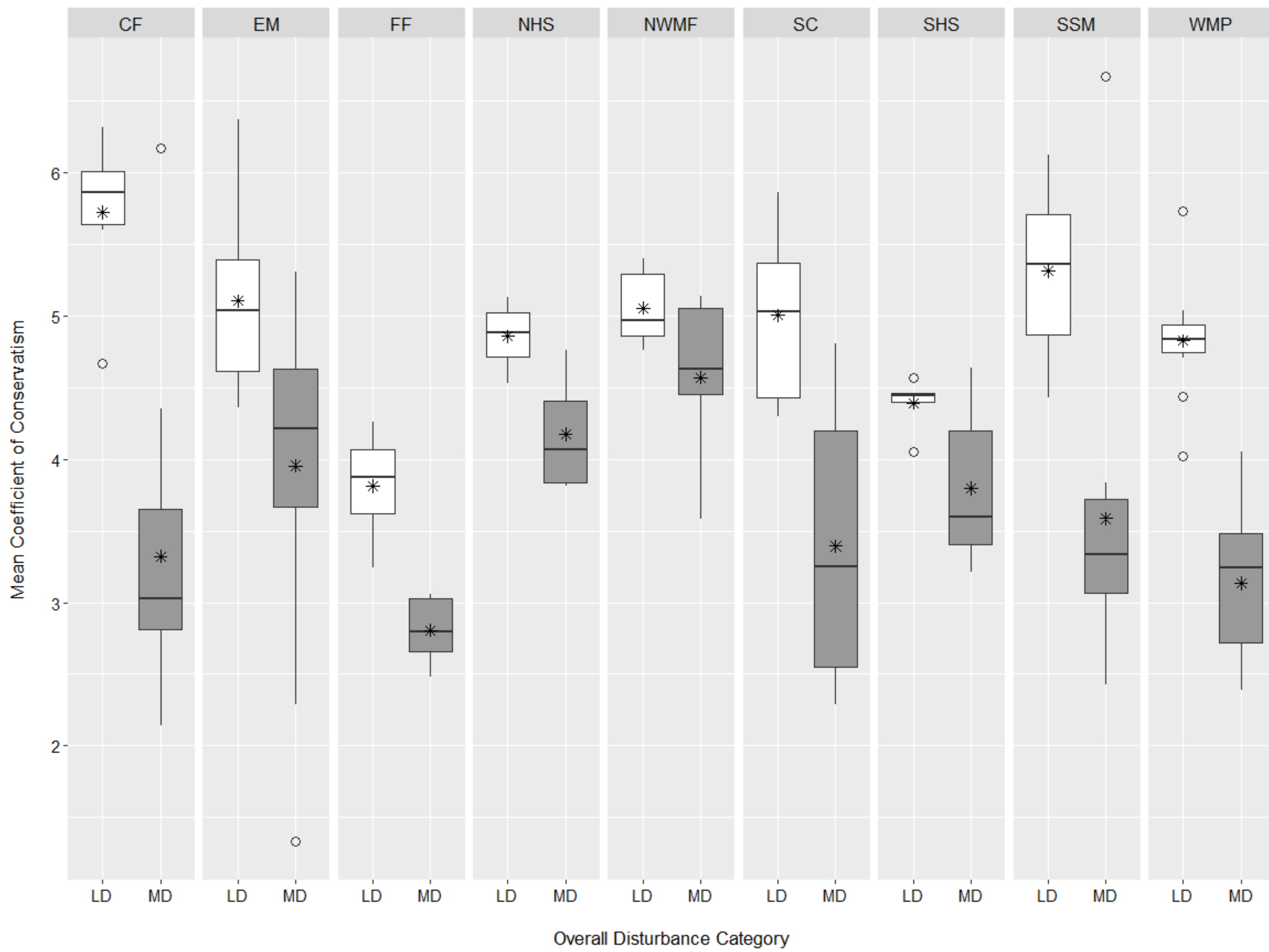


Figure VIII. Boxplots of Mean Coefficient of Conservatism ($\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Overall Disturbance Scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plain Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Overall Disturbance Category by wetland community type are described in Table 6.

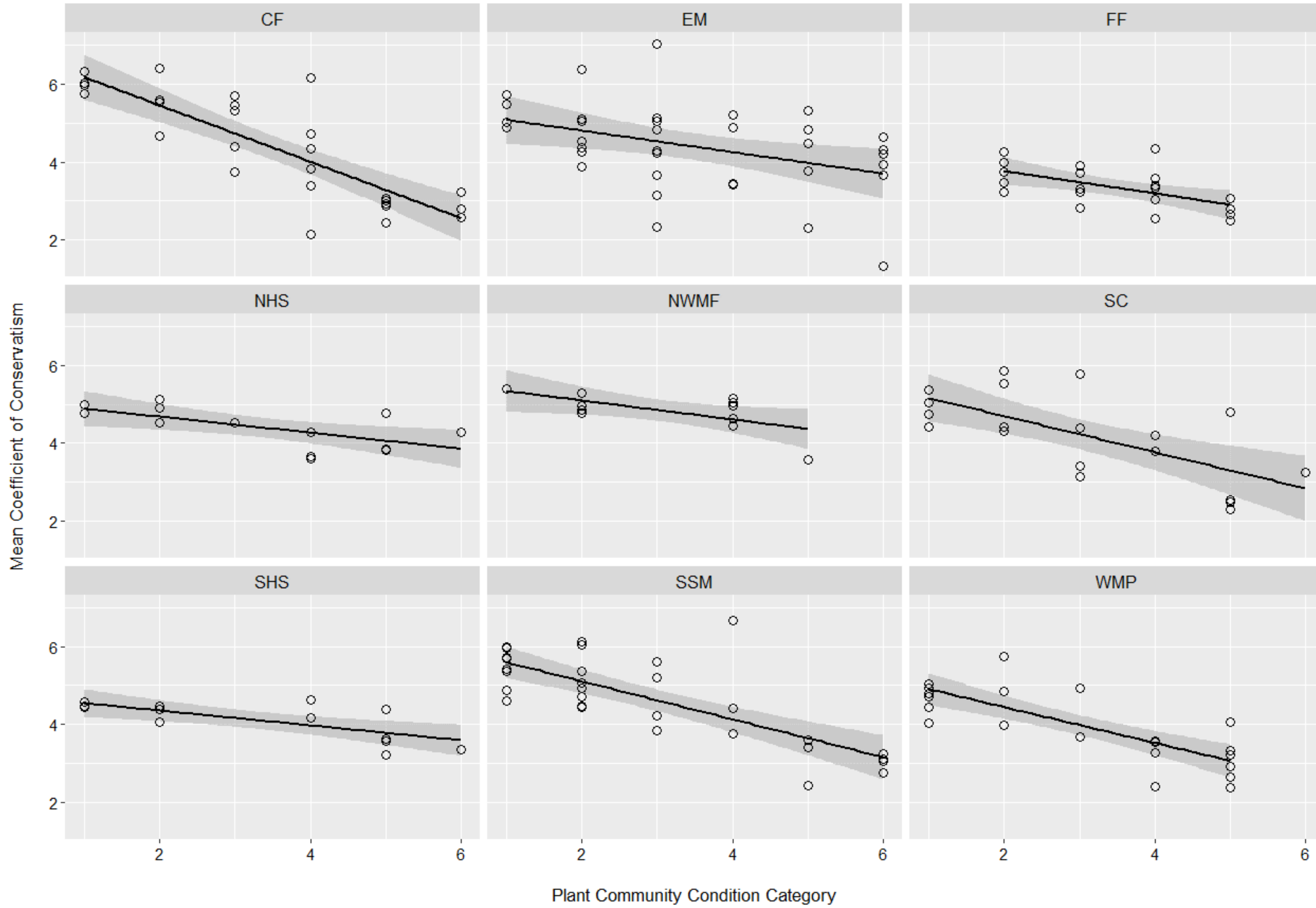


Figure IX. Scatterplots of assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Plant Community Condition scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table IX.

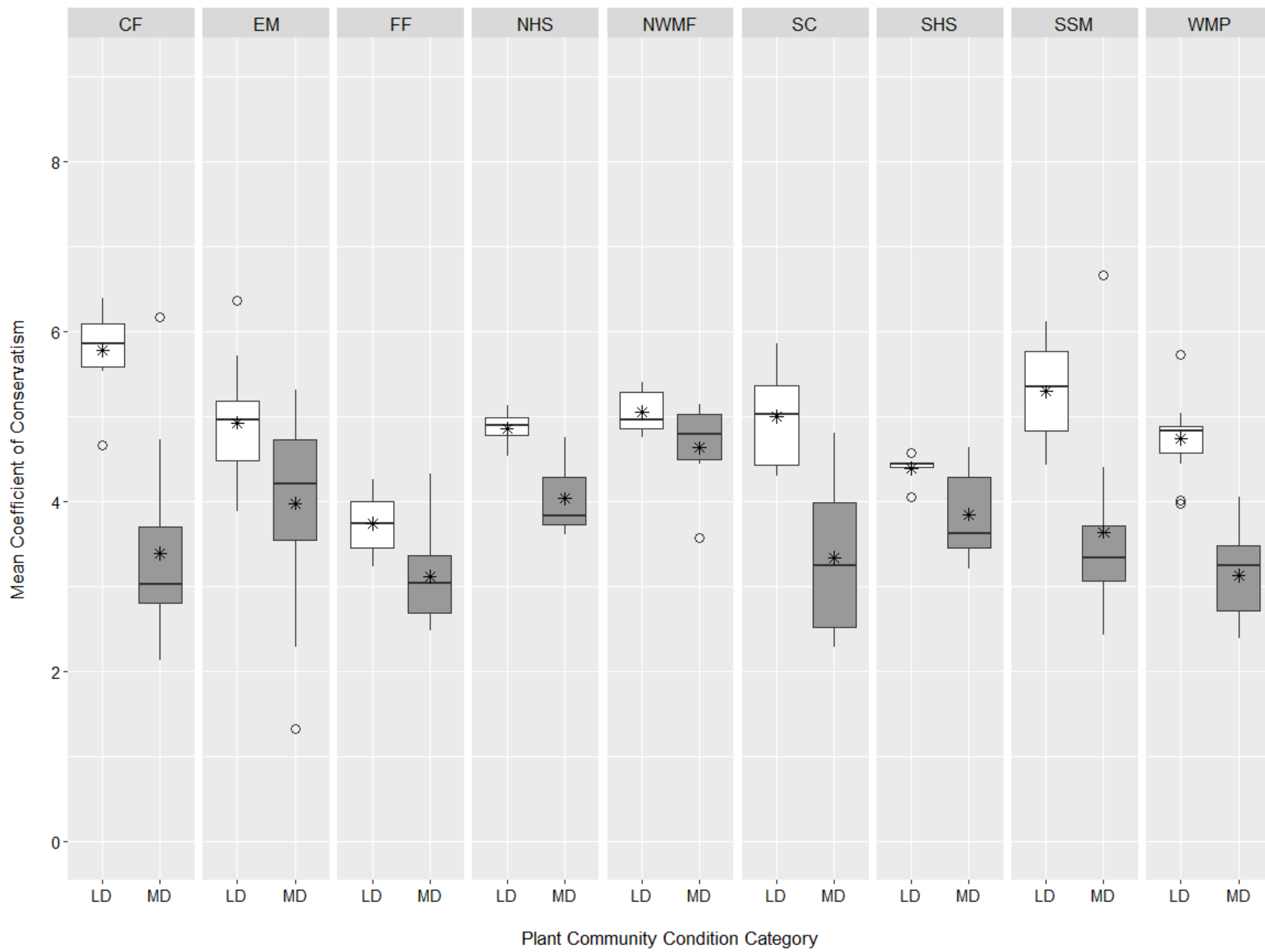


Figure X. Boxplots of Mean Coefficient of Conservatism ($\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Plant Community Condition scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Plant Community Condition Category by wetland community type are described in Table 6.

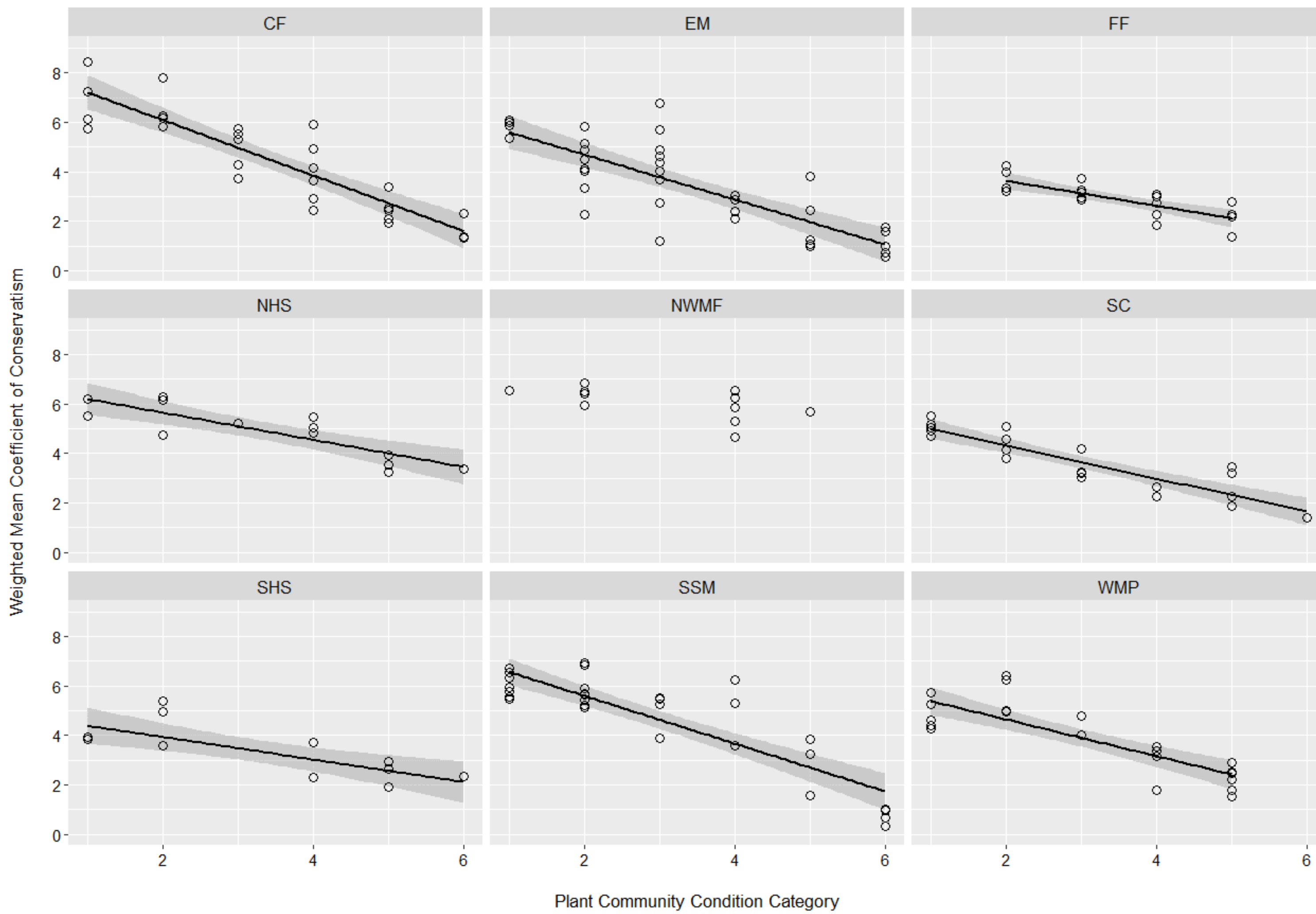


Figure XI. Scatterplots of assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Plant Community Condition scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results ($\alpha = 0.05$). Community type abbreviations and regression statistical information are displayed in Table XI.

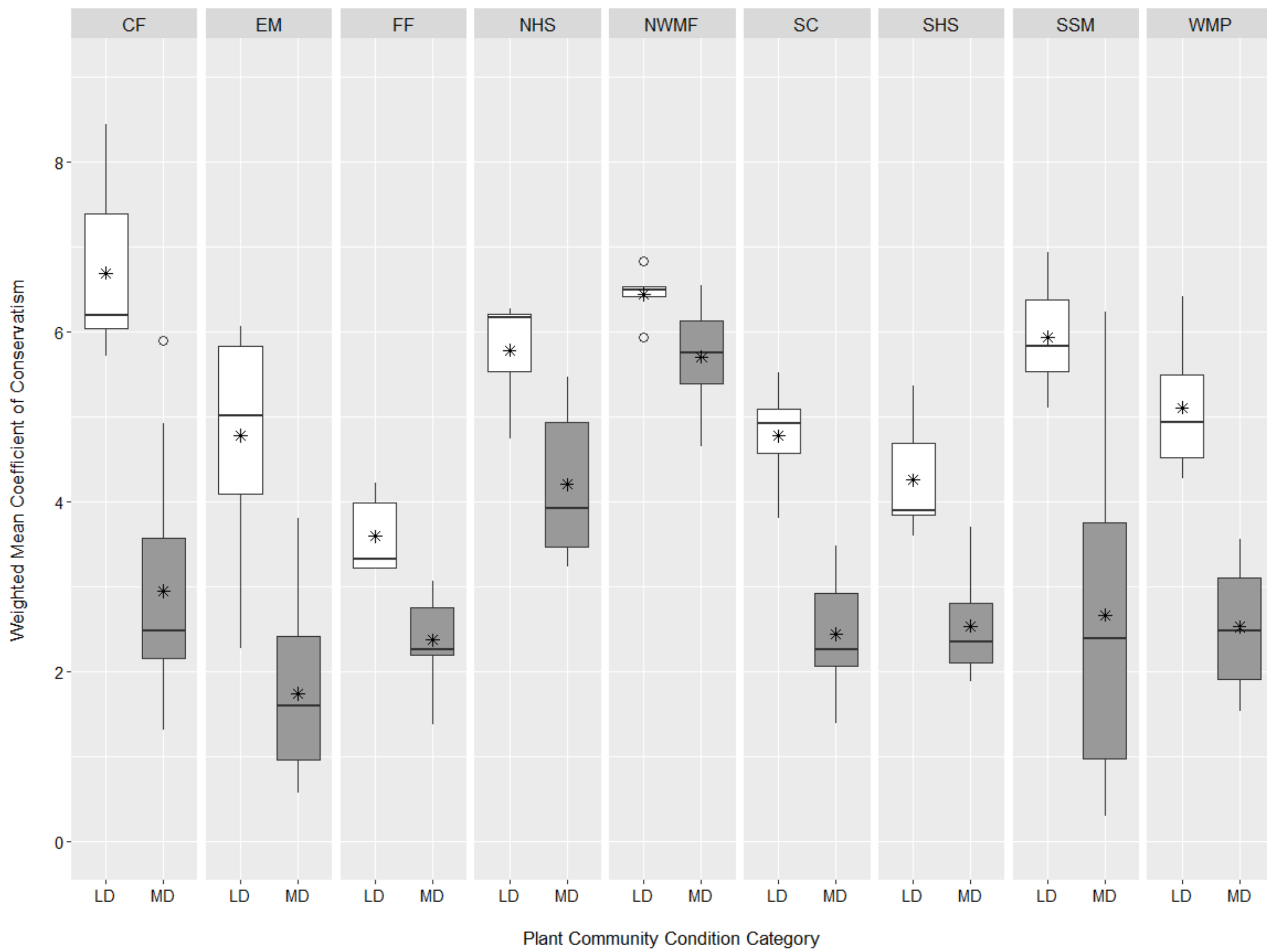


Figure XII. Boxplots of cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Plant Community Condition scores for 9 wetland community types sampled in the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Plant Community Condition Category by wetland community type are described in Table 6.

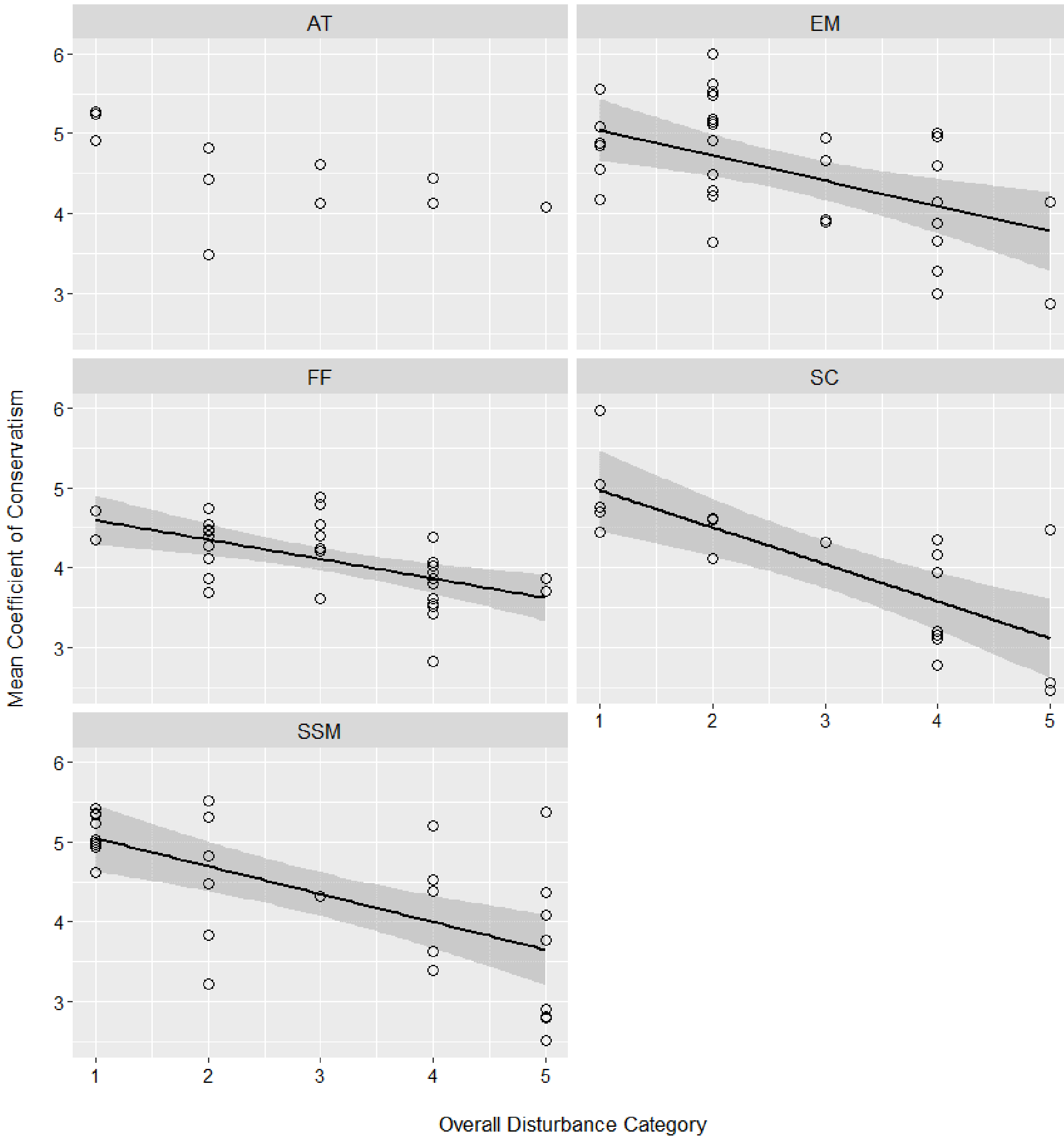


Figure XIII. Scatterplots of assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Overall Disturbance scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table XIII.

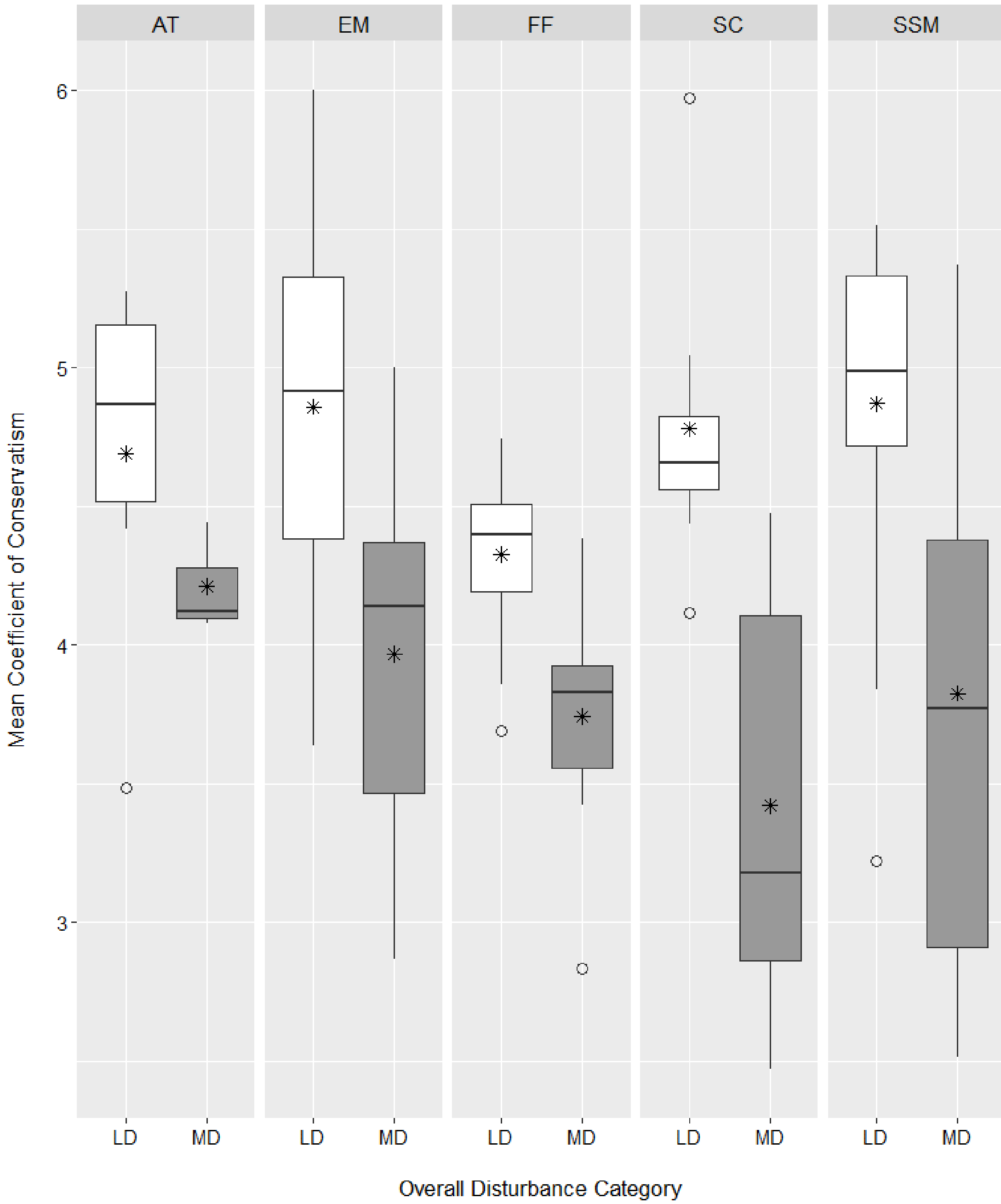


Figure XIV. Boxplots of Mean Coefficient of Conservatism ($\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Overall Disturbance Scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Overall Disturbance Category by wetland community type are described in Table 9.

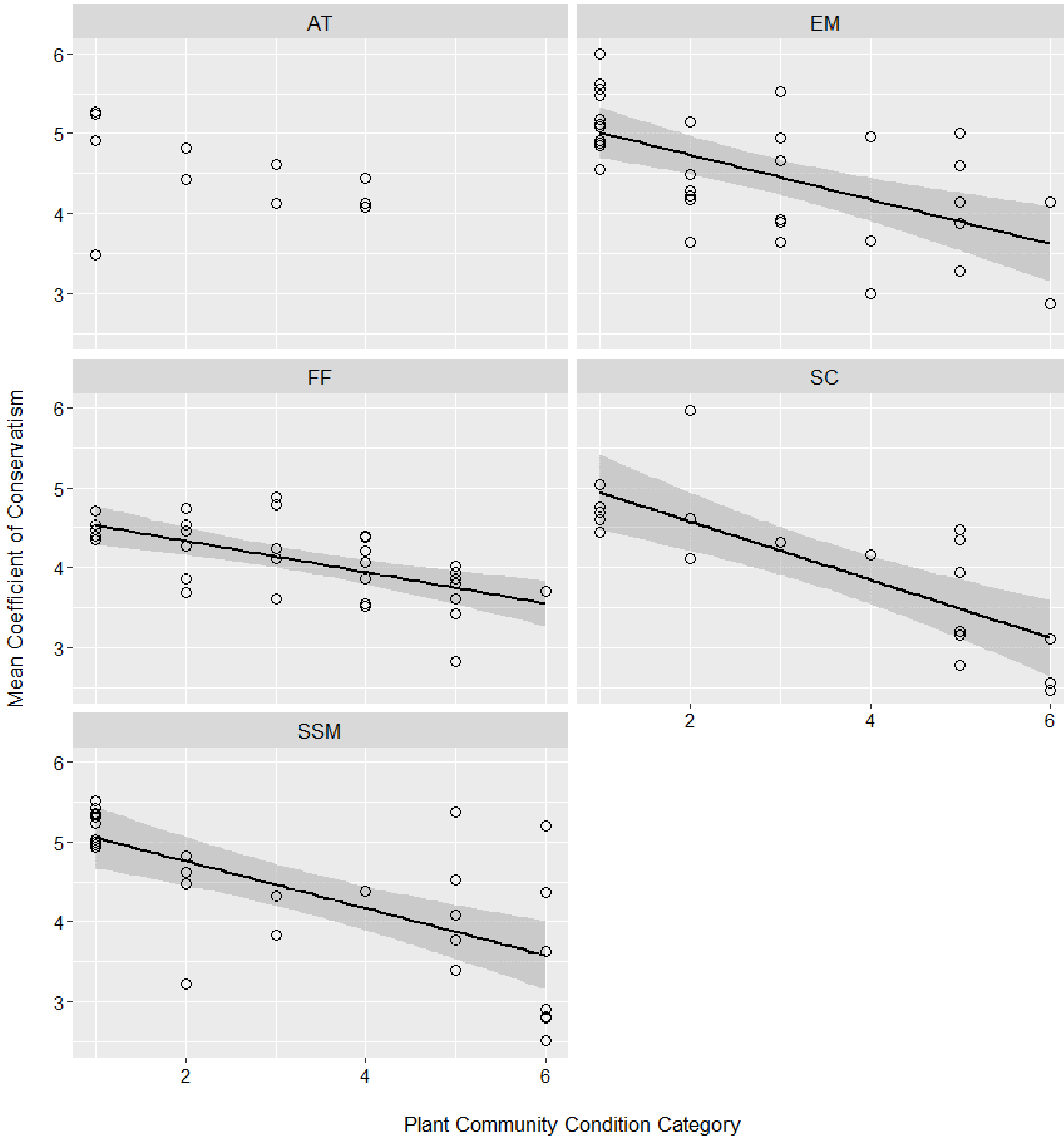


Figure XV. Scatterplots of assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Plant Community Condition scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table XV.

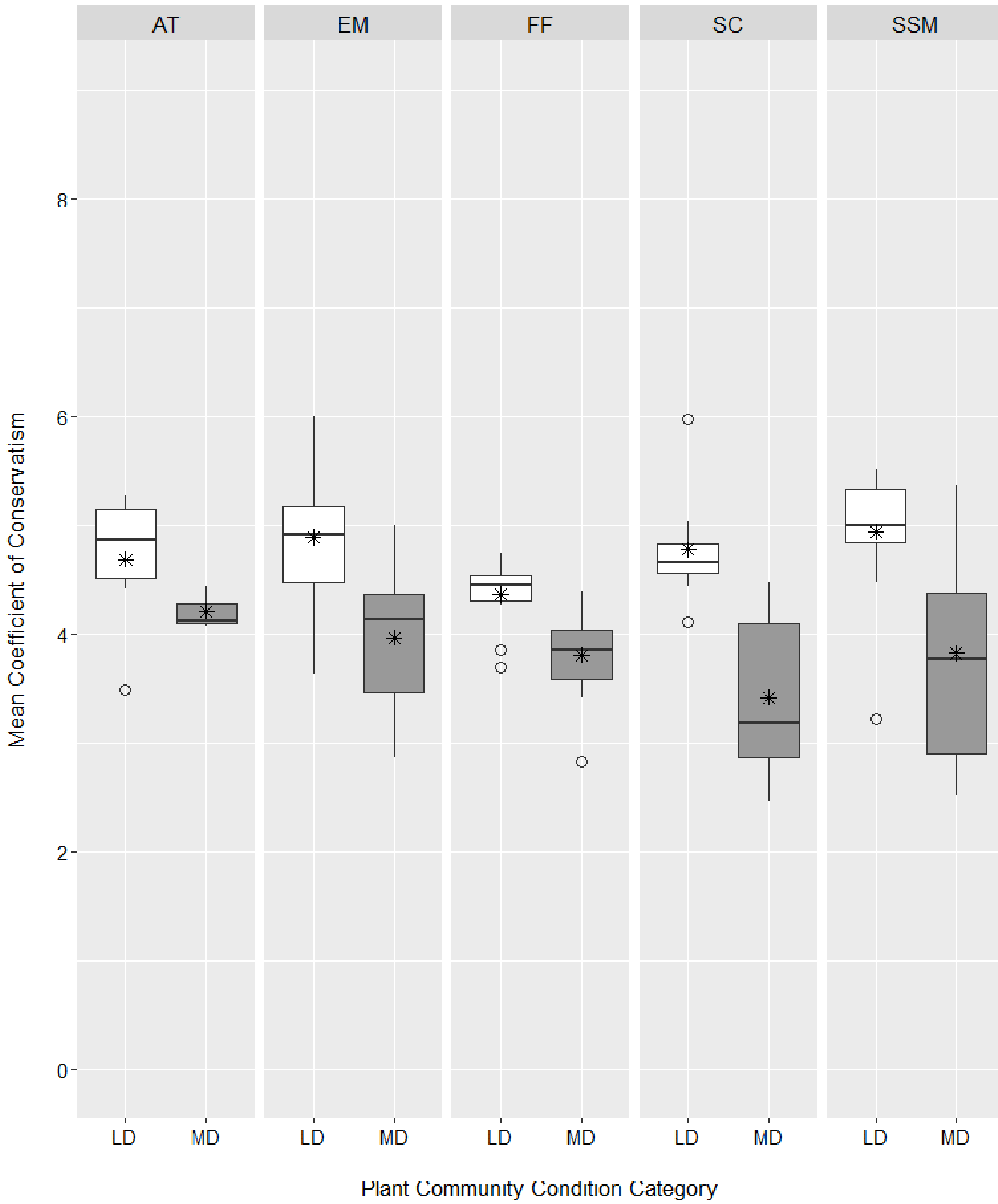


Figure XVI. Boxplots of Mean Coefficient of Conservatism ($\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Plant Community Condition scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Plant Community Condition Category by wetland community type are described in Table 9.

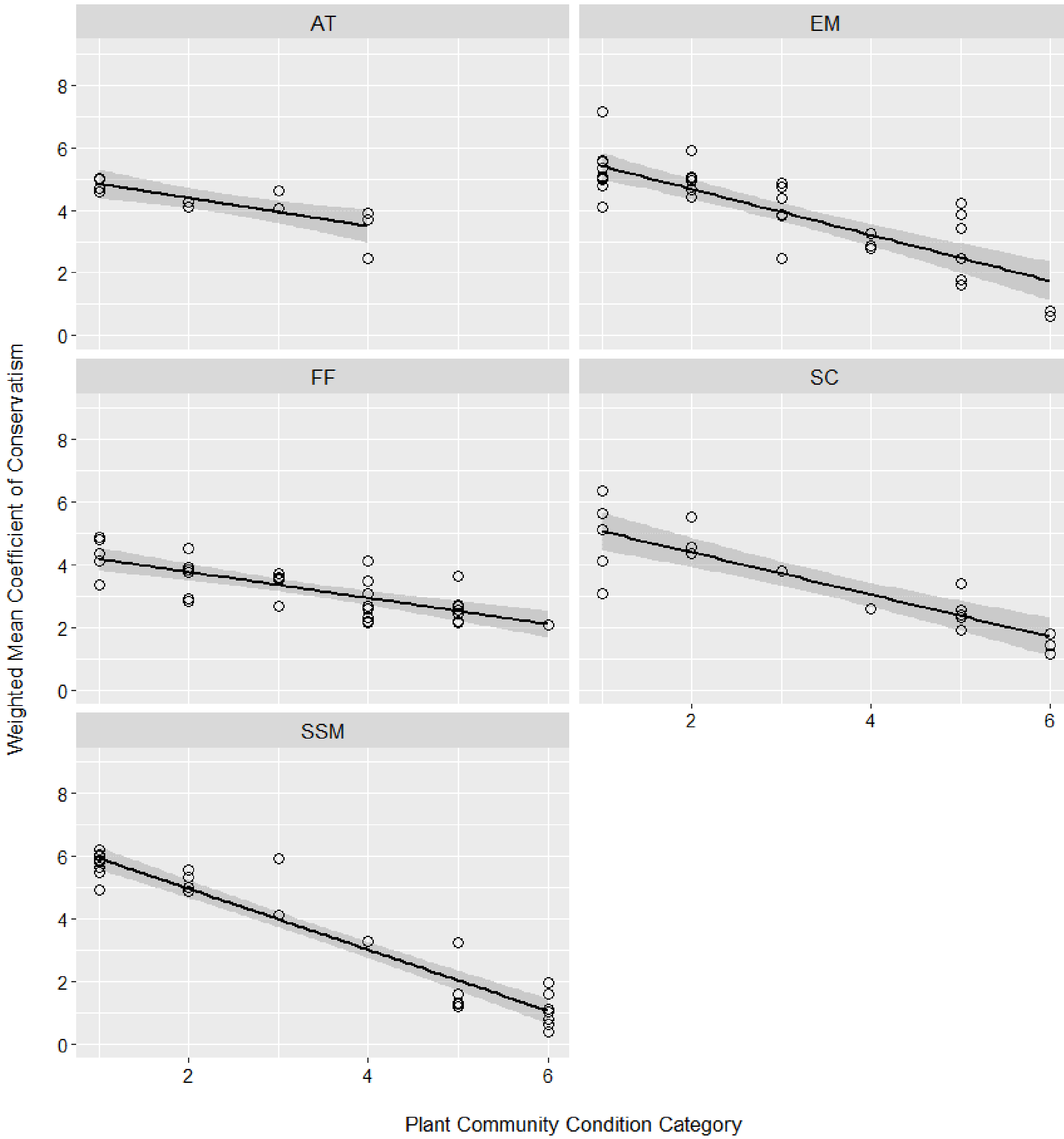


Figure XVII. Scatterplots of assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Plant Community Condition scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Linear regressions with 95% confidence intervals (gray shading) are displayed for communities with significant regression results (α = 0.05). Community type abbreviations and regression statistical information are displayed in Table XVII.

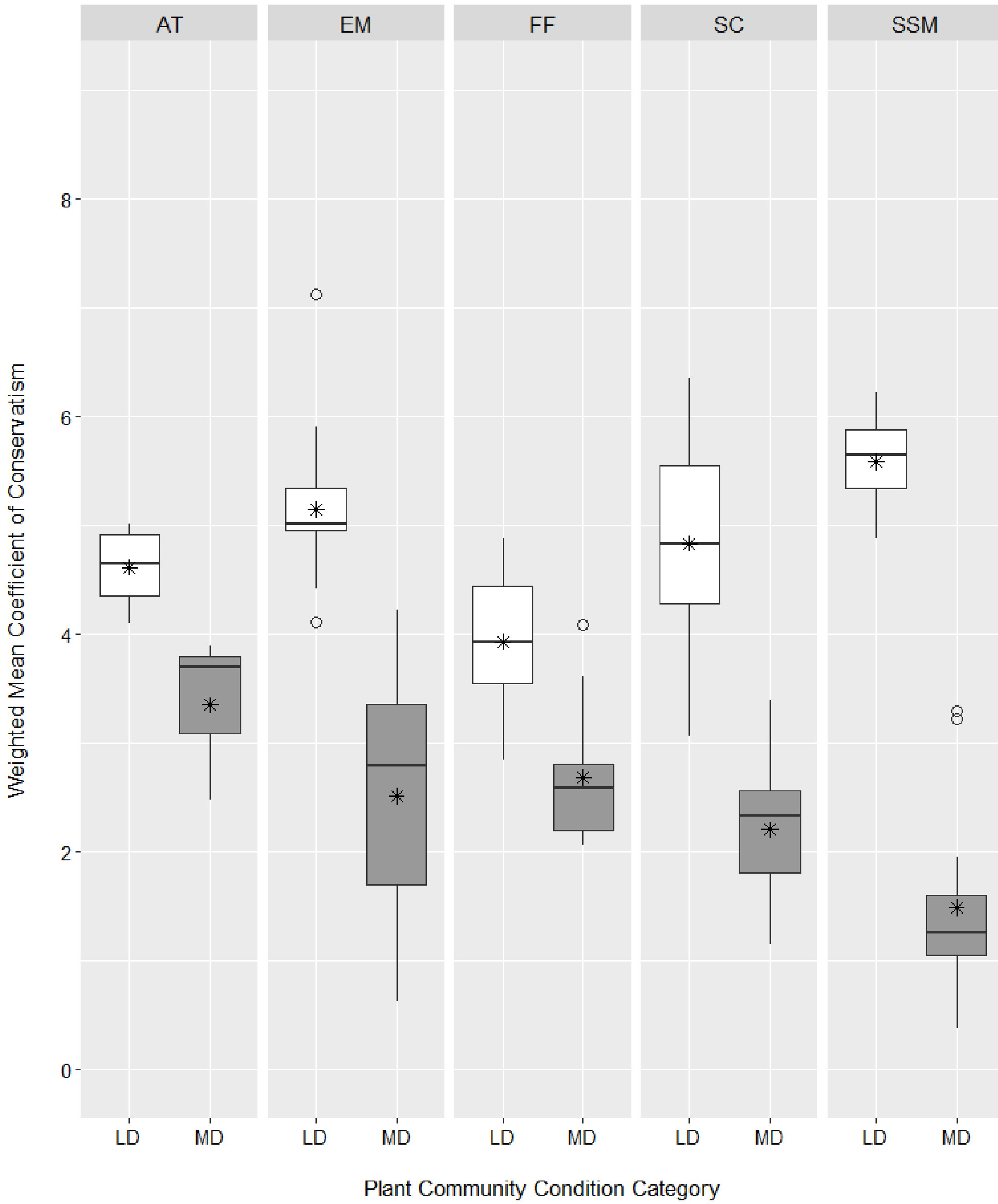


Figure XVIII. Boxplots of cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for least (LD; white) and most disturbed (MD; dark gray) wetland assessment areas based on Plant Community Condition scores for 5 wetland community types sampled in the Wisconsin Omernik Level III Driftless Area Ecoregion. Boxes represent the 75th and 25th percentiles of score distributions, lines represent 95% confidence intervals, and stars indicate mean values for each category. Community type abbreviations and number of samples for each Plant Community Condition Category by wetland community type are described in Table 9.

Table I. Linear regression model results for Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Overall Disturbance scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y = -0.181x + 5.15	0.13	0.114
Black Spruce Swamp (BSS)	y = -0.296x + 7.54	0.18	**0.048**
Central Poor Fen (CPF)	y = -0.042x + 6.39	0	0.835
Emergent Marsh (EM)	y = -0.566x + 6.43	0.5	**0.003**
Northern Hardwood Swamp (NHS)	y = -0.345x + 5.02	0.17	0.157
Northern Sedge Meadow (NSM)	y = -0.523x + 6.47	0.42	**0.002**
Northern Tamarack Swamp (NTS)	y = -0.23x + 6.28	0.32	**0.029**
Northern Wet Mesic Forest (NWMF)	y = -0.737x + 6.73	0.6	**0.000**
Shrub Carr (SC)	y = -0.593x + 6.09	0.47	**0.001**
Southern Sedge Meadow (SSM)	y = -0.575x + 5.93	0.37	**0.004**

Table II. Preliminary Floristic Quality Assessment benchmarks using Mean Coefficient of Conservatism ($\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)*	---	---	---	---	---
Black Spruce Swamp (BSS)*	---	---	---	---	---
Central Poor Fen (CPF)*	---	---	---	---	---
Emergent Marsh (EM)	> 6.0	5.2 - 6.0	4.6 - 5.1	3.9 - 4.5	< 3.9
Northern Hardwood Swamp (NHS)*	---	---	---	---	---
Northern Sedge Meadow (NSM)	> 6.3	5.1 - 6.3	4.3 - 5.0	3.7 - 4.2	< 3.7
Northern Tamarack Swamp (NTS)	> 6.1	5.9 - 6.1	5.6 - 5.8	5.3 - 5.5	< 5.3
Northern Wet Mesic Forest (NWMF)**	> 6.0		5.5 - 5.9	< 5.5	
Shrub Carr (SC)	> 6.0	5.0 - 6.0	4.0 - 4.9	2.7 - 3.9	< 2.7
Southern Sedge Meadow (SSM)	> 5.5	5.0 - 5.5	4.2 - 4.9	3.0 - 4.1	< 3.0

*Type did not have significant inverse relationship with Overall Disturbance; no benchmarks currently suggested

** Tiers calculated using Least Disturbed 75th and 25th %

Table III. Linear regression model results for Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Plant Community Condition scores based on the Disturbance Factors Checklist. Bolded values indicate significance at α = 0.05.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y = -0.292x + 5.43	0.36	**0.004**
Black Spruce Swamp (BSS)	y = -0.28x + 7.61	0.29	**0.010**
Central Poor Fen (CPF)	y = -0.194x + 6.63	0.05	0.293
Emergent Marsh (EM)	y = -0.381x + 6.09	0.4	**0.011**
Northern Hardwood Swamp (NHS)	y = -0.362x + 5.28	0.33	**0.040**
Northern Sedge Meadow (NSM)	y = -0.384x + 6.28	0.34	**0.006**
Northern Tamarack Swamp (NTS)	y = -0.187x + 6.26	0.33	**0.025**
Northern Wet Mesic Forest (NWMF)	y = -0.501x + 6.38	0.54	**0.001**
Shrub Carr (SC)	y = -0.475x + 5.9	0.52	**0.000**
Southern Sedge Meadow (SSM)	y = -0.451x + 5.85	0.43	**0.002**

Table IV. Preliminary Floristic Quality Assessment benchmarks using Mean Coefficient of Conservatism ($\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion based on Plant Community Condition Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)	> 5.3	4.7 - 5.3	4.4 - 4.6	4.2 - 4.3	< 4.2
Black Spruce Swamp (BSS)	> 7.7	7.1 - 7.7	7.0	6.5 - 6.9	< 6.5
Central Poor Fen (CPF)*	---	---	---	---	---
Emergent Marsh (EM)	> 5.7	5.3 - 5.7	4.5 - 5.2	4.2 - 4.4	< 4.2
Northern Hardwood Swamp (NHS)	> 5.1	4.6 - 5.1	3.9 - 4.5	2.8 - 3.8	< 2.8
Northern Sedge Meadow (NSM)	> 6.2	5.2 - 6.2	4.4 - 5.1	3.8 - 4.3	< 3.8
Northern Tamarack Swamp (NTS)	> 6.0	5.7 - 6.0	5.5 - 5.6	5.2 - 5.4	< 5.2
Northern Wet Mesic Forest (NWMF)	> 6.0	5.6 - 6.0	4.6 - 5.5	4.0 - 4.5	< 4.0
Shrub Carr (SC)	> 6.0	4.9 - 6.0	4.2 - 4.8	3.8 - 4.1	< 3.8
Southern Sedge Meadow (SSM)	> 5.5	5.0 - 5.5	4.2 - 4.9	2.7 - 4.1	< 2.7

*Type did not have significant inverse relationship with Plant Community Condition; no benchmarks currently suggested

Table V. Linear regression model results for Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Plant Community Condition scores based on the Disturbance Factors Checklist. Bolded values indicate significance at α = 0.05.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y = -0.446x + 5.31	0.48	**0.000**
Black Spruce Swamp (BSS)	y = -0.16x + 7.83	0.12	0.119
Central Poor Fen (CPF)	y = 0.03x + 7.12	0	0.899
Emergent Marsh (EM)	y = -1.173x + 7.48	0.66	**0.000**
Northern Hardwood Swamp (NHS)	y = -0.822x + 6.88	0.58	**0.002**
Northern Sedge Meadow (NSM)	y = -1.034x + 7.92	0.74	**0.000**
Northern Tamarack Swamp (NTS)	y = -0.454x + 7.57	0.58	**0.001**
Northern Wet Mesic Forest (NWMF)	y = -0.371x + 7.46	0.32	**0.022**
Shrub Carr (SC)	y = -0.769x + 6.58	0.68	**0.000**
Southern Sedge Meadow (SSM)	y = -1.069x + 7.49	0.84	**0.000**

Table VI. Preliminary Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III North Central Hardwood Forests Ecoregion based on Plant Community Condition Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)	> 5.0	4.3 - 5.0	3.7 - 4.2	3.2 - 3.6	< 3.2
Black Spruce Swamp (BSS)*	---	---	---	---	---
Central Poor Fen (CPF)*	---	---	---	---	---
Emergent Marsh (EM)	> 7.7	5.7 - 7.7	2.7 - 5.6	0.8 - 2.6	< 0.8
Northern Hardwood Swamp (NHS)	> 6.2	5.2 - 6.2	3.0 - 5.1	2.5 - 2.9	< 2.5
Northern Sedge Meadow (NSM)	> 6.9	5.8 - 6.9	2.9 - 5.7	1.5 - 2.8	< 1.5
Northern Tamarack Swamp (NTS)	> 7.1	6.5 - 7.1	5.9 - 6.5	4.8 - 5.9	< 4.8
Northern Wet Mesic Forest (NWMF)	> 7.1	6.9 - 7.1	6.8	5.5 - 6.7	< 5.5
Shrub Carr (SC)	> 5.6	4.9 - 5.6	4.0 - 4.8	1.6 - 3.9	< 1.6
Southern Sedge Meadow (SSM)	> 6.0	5.0 - 6.0	2.6 - 4.9	1.4 - 2.5	< 1.4

*Type did not have significant inverse relationship with Plant Community Condition; no benchmarks currently suggested

Table VII. Linear regression model results for Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Overall Disturbance scores based on the Disturbance Factors Checklist. Bolded values indicate significance at α = 0.05.

Plant community type	Regression equation	r^2	p
Calcareous Fen (CF)	y= -0.84x + 7.18	0.61	**0.000**
Emergent Marsh (EM)	y= -0.36x + 5.56	0.15	**0.018**
Floodplain Forest (FF)	y= -0.51x + 4.9	0.42	**0.002**
Northern Hardwood Swamp (NHS)	y= -0.18x + 4.97	0.2	0.124
Northern Wet Mesic Forest (NWMF)	y= -0.22x + 5.45	0.31	0.075
Shrub Carr (SC)	y= -0.57x + 5.93	0.54	**0.000**
Southern Hardwood Swamp (SHS)	y= -0.25x + 4.86	0.52	**0.005**
Southern Sedge Meadow (SSM)	y= -0.56x + 6.15	0.5	**0.000**
Wet-Mesic Prairie (WMP)	y= -0.53x + 5.49	0.64	**0.000**

Table VIII. Preliminary Floristic Quality Assessment benchmarks using Mean Coefficient of Conservatism ($\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Calcareous Fen (CF)	> 6.0	5.7 - 6	3.7 - 5.6	2.8 - 3.6	< 2.8
Emergent Marsh (EM)*	---	---	---	---	---
Floodplain Forest (FF)	> 4.1	3.7 - 4.1	3.0 - 3.6	2.7 - 2.9	< 2.7
Northern Hardwood Swamp (NHS)*	---	---	---	---	---
Northern Wet Mesic Forest (NWMF)*	---	---	---	---	---
Shrub Carr (SC)	> 5.4	4.5 - 5.4	4.2 - 4.4	2.6 - 4.1	< 2.6
Southern Hardwood Swamp (SHS)	> 4.5	4.5	4.2 - 4.4	3.4 - 4.1	< 3.4
Southern Sedge Meadow (SSM)	> 5.7	5.0 - 5.7	3.7 - 4.9	3.1 - 3.6	< 3.1
Wet-Mesic Prairie (WMP)	> 4.9	4.8 - 4.9	3.5 - 4.7	2.7 - 3.4	< 2.7

*Type did not have significant inverse relationship with Overall Disturbance; no benchmarks currently suggested

Table IX. Linear regression model results for Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Plant Community Condition scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Calcareous Fen (CF)	y= -0.72x + 6.9	0.69	**0.000**
Emergent Marsh (EM)	y= -0.28x + 5.36	0.17	**0.012**
Floodplain Forest (FF)	y= -0.29x + 4.34	0.34	**0.007**
Northern Hardwood Swamp (NHS)	y= -0.21x + 5.09	0.43	**0.016**
Northern Wet Mesic Forest (NWMF)	y= -0.24x + 5.58	0.41	**0.035**
Shrub Carr (SC)	y= -0.46x + 5.63	0.47	**0.001**
Southern Hardwood Swamp (SHS)	y= -0.19x + 4.73	0.51	**0.006**
Southern Sedge Meadow (SSM)	y= -0.49x + 6.08	0.58	**0.000**
Wet-Mesic Prairie (WMP)	y= -0.46x + 5.36	0.62	**0.000**

Table X. Preliminary Floristic Quality Assessment benchmarks using Mean Coefficient of Conservatism ($\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion based on Plant Community Condition Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Calcareous Fen (CF)	> 6.1	5.7 - 6.1	3.7 - 5.6	2.8 - 3.6	< 2.8
Emergent Marsh (EM)*	---	---	---	---	---
Floodplain Forest (FF)	> 4.0	3.6 - 4.0	3.4 - 3.5	2.7 - 3.3	< 2.7
Northern Hardwood Swamp (NHS)	> 5.0	4.9 - 5.0	4.3 - 4.8	3.7 - 4.2	< 3.7
Northern Wet Mesic Forest (NWMF)*	---	---	---	---	---
Shrub Carr (SC)	> 5.4	4.5 - 5.4	4.0 - 4.4	2.5 - 3.9	< 2.5
Southern Hardwood Swamp (SHS)	> 4.5	4.5	4.3 - 4.4	3.5 - 4.2	< 3.5
Southern Sedge Meadow (SSM)	> 5.8	4.9 - 5.8	3.7 - 4.8	3.1 - 3.6	< 3.1
Wet-Mesic Prairie (WMP)	> 4.9	4.7 - 4.9	3.5 - 4.6	2.7 - 3.4	< 2.7

*Type did not have significant inverse relationship with Plant Community Condition; no benchmarks currently suggested

Table XI. Linear regression model results for Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Plant Community Condition scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Calcareous Fen (CF)	y= -1.12x + 8.33	0.8	**0.000**
Emergent Marsh (EM)	y= -0.91x + 6.51	0.65	**0.000**
Floodplain Forest (FF)	y= -0.51x + 4.63	0.62	**0.000**
Northern Hardwood Swamp (NHS)	y= -0.55x + 6.75	0.72	**0.000**
Northern Wet Mesic Forest (NWMF)	y= -0.29x + 6.93	0.34	0.061
Shrub Carr (SC)	y= -0.67x + 5.65	0.81	**0.000**
Southern Hardwood Swamp (SHS)	y= -0.46x + 4.84	0.58	**0.002**
Southern Sedge Meadow (SSM)	y= -0.97x + 7.53	0.76	**0.000**
Wet-Mesic Prairie (WMP)	y= -0.74x + 6.12	0.69	**0.000**

Table XII. Preliminary Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Southeast Wisconsin Till Plains Ecoregion based on Plant Community Condition Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Calcareous Fen (CF)	> 7.4	6.1 - 7.4	3.6 - 6.0	2.2 - 3.5	< 2.2
Emergent Marsh (EM)	> 5.8	4.2 - 5.8	2.4 - 4.1	1.0 - 2.3	< 1.0
Floodplain Forest (FF)	> 4.0	3.3 - 4.0	2.8 - 3.2	2.2 - 2.7	< 2.2
Northern Hardwood Swamp (NHS)	> 6.2	5.6 - 6.2	4.9 - 5.5	3.5 - 4.8	< 3.5
Northern Wet Mesic Forest (NWMF)*	---	---	---	---	---
Shrub Carr (SC)	> 5.1	4.7 - 5.1	2.9 - 4.6	2.1 - 2.8	< 2.1
Southern Hardwood Swamp (SHS)	> 4.7	4.0 - 4.7	2.8 - 3.9	2.1 - 2.7	< 2.1
Southern Sedge Meadow (SSM)	> 6.4	5.6 - 6.4	3.8 - 5.5	1.0 - 3.7	< 1.0
Wet-Mesic Prairie (WMP)	> 5.5	4.6 - 5.5	3.1 - 4.5	1.9 - 3.0	< 1.9

*Type did not have significant inverse relationship with Plant Community Condition; no benchmarks currently suggested

Table XIII. Linear regression model results for Wisconsin Omernik Level III Driftless Area Ecoregion assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Overall Disturbance scores based on the Disturbance Factors Checklist. Bolded values indicate significance at α = 0.05.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y= -0.23x + 5.09	0.34	0.058
Emergent Marsh (EM)	y= -0.32x + 5.36	0.27	**0.001**
Floodplain Forest (FF)	y= -0.24x + 4.84	0.32	**0.001**
Shrub Carr (SC)	y= -0.46x + 5.43	0.58	**0.000**
Southern Sedge Meadow (SSM)	y= -0.35x + 5.39	0.41	**0.000**

Table XIV. Preliminary Floristic Quality Assessment benchmarks using Mean Coefficient of Conservatism ($\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Driftless Area Ecoregion based on Overall Disturbance Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)*	---	---	---	---	---
Emergent Marsh (EM)	> 5.3	4.5 - 5.3	4.4	3.5 - 4.3	< 3.5
Floodplain Forest (FF)	> 4.5	4.3 - 4.5	3.9 - 4.2	3.6 - 3.8	< 3.6
Shrub Carr (SC)	> 4.8	4.7 - 4.8	4.1 - 4.6	2.9 - 4.0	< 2.9
Southern Sedge Meadow (SSM)	> 5.3	4.8 - 5.3	4.4 - 4.7	2.9 - 4.3	< 2.9

*Type did not have significant inverse relationship with Overall Disturbance; no benchmarks currently suggested

Table XV. Linear regression model results for Wisconsin Omernik Level III Driftless Area Ecoregion assessment area Mean Coefficient of Conservatism ($\overline{C}$) scores versus Plant Community Condition scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y= -0.18x + 4.92	0.17	0.203
Emergent Marsh (EM)	y= -0.28x + 5.29	0.37	**0.000**
Floodplain Forest (FF)	y= -0.2x + 4.72	0.39	**0.000**
Shrub Carr (SC)	y= -0.36x + 5.31	0.61	**0.000**
Southern Sedge Meadow (SSM)	y= -0.29x + 5.35	0.46	**0.000**

Table XVI. Preliminary Floristic Quality Assessment benchmarks using Mean Coefficient of Conservatism ($\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Driftless Area Ecoregion based on Plant Community Condition Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)*	---	---	---	---	---
Emergent Marsh (EM)	> 5.2	4.6 - 5.2	4.4 - 4.5	3.5 - 4.3	< 3.5
Floodplain Forest (FF)	> 4.5	4.4 - 4.5	4.0 - 4.3	3.6 - 3.9	< 3.6
Shrub Carr (SC)	> 4.8	4.7 - 4.8	4.1 - 4.6	2.9 - 4.0	< 2.9
Southern Sedge Meadow (SSM)	> 5.3	4.9 - 5.3	4.4 - 4.8	2.9 - 4.3	< 2.9

*Type did not have significant inverse relationship with Plant Community Condition; no benchmarks currently suggested

Table XVII. Linear regression model results for Wisconsin Omernik Level III Driftless Area Ecoregion assessment area cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores versus Plant Community Condition scores based on the Disturbance Factors Checklist. Bolded values indicate significance at $\alpha = 0.05$.

Plant community type	Regression equation	r^2	p
Alder Thicket (AT)	y= -0.45x + 5.28	0.63	**0.003**
Emergent Marsh (EM)	y= -0.73x + 6.15	0.7	**0.000**
Floodplain Forest (FF)	y= -0.41x + 4.59	0.56	**0.000**
Shrub Carr (SC)	y= -0.67x + 5.74	0.76	**0.000**
Southern Sedge Meadow (SSM)	y= -0.97x + 6.9	0.91	**0.000**

Table XVIII. Preliminary Floristic Quality Assessment benchmarks using cover-weighted Mean Coefficient of Conservatism ($w\overline{C}$) scores for wetland communities of the Wisconsin Omernik Level III Driftless Area Ecoregion based on Plant Community Condition Categories from the Disturbance Factors Checklist.

	Preliminary Suggested Tiered Aquatic Life Use (TALU) Category				
	Least Disturbed			Most Disturbed	
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Plant community type	"Excellent"	"Good"	"Fair"	"Poor"	"Very Poor"
Alder Thicket (AT)	> 4.9	4.5 - 4.9	3.8 - 4.4	3.1 - 3.7	< 3.1
Emergent Marsh (EM)	> 5.3	5.1 - 5.3	3.4 - 5.0	1.7 - 3.3	< 1.7
Floodplain Forest (FF)	> 4.4	3.7 - 4.4	2.8 - 3.6	2.2 - 2.7	< 2.2
Shrub Carr (SC)	> 5.5	4.4 - 5.5	2.6 - 4.3	1.8 - 2.5	< 1.8
Southern Sedge Meadow (SSM)	> 5.9	5.4 - 5.9	1.6 - 5.3	1.1 - 1.5	< 1.1

WISCONSIN
DEPT. OF NATURAL RESOURCES