Creation of Rare and Unique Wetland Community Quality Thresholds

December 1, 2023

By: Melissa Chung Gibson, Ryan O'Connor, and Sally Gallagher Jarosz

Wisconsin Department of Natural Resources
Bureaus of Water Quality and Waterways
101 South Webster Street
Madison, WI 53703

Cover Photo: Interdunal Wetland among sand dunes of Lake Michigan; Point Beach State Park;
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Preferred Citation:
Gibson, M.C., R.P. O'Connor, and S.G. Jarosz. 2023. Creation of Rare and Unique Wetland Community Quality Thresholds. Final Report to US EPA Region 5, Grant #CD00E02744. Wisconsin Department of Natural Resources. EGAD #3200-2023-08.

This report was prepared by the Wisconsin Department of Natural Resources under Wetland Program Development Grant Number CD 00E02744 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. Mention of trade names and commercial products does not constitute endorsement of their use.

Contact for Further Information

Melissa Chung Gibson	**Ryan O'Connor**	**Sally Gallagher Jarosz**
Bureau of Water Quality	Bureau of Natural Heritage Conservation	Bureau of Water Quality
WI Dept of Natural Resources	WI Dept of Natural Resources	WI Dept of Natural Resources
101 S. Webster St.	101 S. Webster St.	101 S. Webster St.
P.O. Box 7921	P.O. Box 7921	P.O. Box 7921
Madison, WI 53707	Madison, WI 53707	Madison, WI 53707
Melissa.Gibson@Wisconsin.gov	RyanP.OConnor@Wisconsin.gov	Sarah.Jarosz@Wisconsin.gov

Acknowledgements

The authors would like to thank Amy Staffen, John Zaborsky, Maria Lefevre, Allison Willman, Stacy Hron, Kevin Doyle, Zach Kron, Chris Noll, Peter Duerkop, Sharon Fandel, Julie Widholm, Waukesha County Land Conservancy, Camp Minikani staff, JCC Rainbow Day Camp staff, Village of Menomonee Falls, Silver Lake Sportsmens Club, and numerous private landowners who allowed us access to their wetlands.

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1. Introduction

1.1. Background

Over the last decade Wisconsin Department of Natural Resources (hereafter, "Department") has developed numeric standards of wetland floristic quality for 15 of the most common wetland types in the state (Table 1). However, according to the Department's natural heritage program, Wisconsin is home to over 30 recognized wetland community types, many of which have unique plant compositions and are geographically restricted. A survey was completed in the 1970's and early 1980's by the precursor to the Department's State Natural Areas program to identify the locations of many of these unique wetlands but the state has never thoroughly assessed their quality and community composition. Recently, Wisconsin has received multiple proposals to impact some of these rare wetland types but lacked the capacity to formally assess or compare the quality of the wetlands to others in the state. In addition, it has proved difficult to locate similar unique wetland communities to serve as condition references. Because these rare wetland types occasionally intersect with high-profile development proposals and are considered vulnerable due to their restricted distributions, the Department has determined that there is a high need for more information about the locations and conditions of such wetland communities.

Table 1. The 15 wetland communities with established numeric criteria for floristic quality for at least one ecoregion in Wisconsin. Ecoregion refers to the 4 major Omernik Level III Ecoregions in Wisconsin: Northern Lakes and Forests (NLF), North Central Hardwood Forests (NCHF), Southeast WI Till Plains (SETP), and Driftless Area (DA). Central Corn Belt Plains are here included in SETP and Western Corn Belt Plains are included with DA.

Wetland Community		**Available Ecoregions**
Emergent/ Herbaceous	Emergent Marsh	ALL
	Northern Sedge Meadow	NLF, NCHF
	Southern Sedge Meadow	NCHF, DA, SETP
	Wet-Mesic Prairie	SETP
	Calcareous Fen	SETP
Scrub - Shrub	Alder Thicket	NLF, DA
	Muskeg	NLF
	Open Bog	NLF
	Shrub-Carr	ALL
Forested	Black Spruce/ Tamarack Swamp	NLF
	Cedar Swamp (Northern Wet-Mesic Swamp)	NLF, NCHF, SETP
	Floodplain Forest	SETP, DA
	Northern Hardwood Swamp	NLF, NCHF, SETP
	Northern Tamarack Swamp	NCHF
	Southern Hardwood Swamp	SETP

In a collaboration between the Department's Water Quality Monitoring Program, Waterways Program, and Natural Heritage Conservation Program, six rare wetland community types were selected for surveys and analysis: Bog Relicts, Forested Seeps, Interdunal Wetlands, Southern Tamarack Swamps, Wet Prairies, and White Pine-Red Maple Swamps. Of the 16 wetland types in Wisconsin currently lacking numeric standards for

condition (Table 2) these 6 communities were determined to have the greatest need for more information based on their proximity to development, abundance on the landscape, and/or demand for more information to improve restoration outcomes.

Table 2. The 16 recognized wetland communities lacking numeric benchmarks for floristic quality as of 6/2020 in WDNR's Wetland FQA database.

Wetland Community		**Existing Surveys Pre-Grant**	**Notes**
Emergent	Boreal Rich Fen	9	
	Central Poor Fen	22	*Additional data and/or stats work needed to create floristic quality thresholds.*
	Coastal Plain Marsh	0	
	Great Lakes Shore Fen	0	
	Inland Beach	0	
	Interdunal Wetland*	0	
	Moist Sandy Meadow	0	
	Poor Fen	16	*Additional data and/or stats work needed to create floristic quality thresholds.*
	Wet Prairie*	8	*All pre-grant data were from restorations*
Scrub-Shrub	Bog Relict*	0	
Forested	White Pine - Red Maple Swamp*	1	
	Forested Seep*	1	
	Southern Tamarack Swamp*	2	
	Ephemeral Pond	0	
Mixed	Patterned Peatland	0	*Complex of multiple community types*
	Great Lakes Ridge and Swale	0	*Complex of multiple community types*

*Communities with an asterisk were selected for focused effort and completion of additional surveys as part of this grant.

Of the remaining rare community types, three, Boreal Rich Fen, Central Poor Fen, and Poor Fen, have some history of data collection from the undisturbed end but lack data from the disturbed end necessary to create condition benchmarks. Past attempts to develop floristic quality benchmarks for these communities have concluded they may be more difficult than most to find existing in a disturbed state; their acidic substrates may be resistant to alteration up to a point after which change to a different community type is abrupt and they are no longer recognizable. Filling in data collection gaps with a better understanding of how disturbance acts on these communities may allow us to develop condition thresholds in the future.

An additional six wetland types, Coastal Plain Marsh, Great Lakes Shore Fen, Inland Beach, Moist Sandy Meadow, and Patterned Peatland were not selected for this effort due to their comparative rarity on the landscape. In addition, these communities have seen little-to-no historical pressure from development or other direct anthropogenic impacts. Great Lakes Ridge and Swale is a complex of multiple different wetland and upland communities. The wetland communities contained within can be individually assigned to other existing wetland types for condition assessments.

1.2. Grant Objectives

As a collaboration between multiple programs, this project had multiple goals, including:

- Developing numeric criteria for wetland condition based on floristic quality in line with the Department's existing criteria for common wetland types.
- Updating the ecological description of these communities for public use by collecting detailed composition and ecological data.
- Updating the statewide status of communities, many of which have not been assessed since the late 1980's.
- Adding baseline floristic quality data from these communities to the Department's wetland FQA database, wetland monitoring geodatabase, and Element Occurrence tracking database.
- Generating the data needed to update state (S) conservation ranks and start discussions with NatureServe about possibly updating global (G) ranks.

Targeting these communities for intensive sampling will ultimately expand the Department's wetland monitoring capacity by expanding on existing tools for regulatory and management staff. Surveys will provide baseline floristic quality data that can be tracked over time to monitor changes in these vulnerable communities. With this information, we can be better prepared to monitor the condition of these unique wetland communities over time, identify potential future impacts, inform environmental reviews, inform wetland restoration/mitigation projects, and base the Department's regulatory decisions on improved scientific metrics.

2. Methodology

2.1. Methodology Overview

Methods used to collect data and establish numeric benchmarks for floristic quality follows previous work described in Bernthal (2003); Hlina *et al* (2012) and Marti & Bernthal (2019) using the Quality Assurance Project Plan submitted by Hlina & Lisdahl (2012).

To set floristic quality thresholds, data is collected from both least-disturbed (LD), and most-disturbed (MD) examples of a given community (Table 3), with ideally a minimum of 10 replicates in each category. Disturbance level is determined using the Disturbance Factors Checklist (Appendix A) which uses observable human alteration and presence of invasive species to score the wetland for overall disturbance (OD) on a scale of 1 – 5. Least-disturbed wetlands are those that were given scores of 1 or 2 on the Disturbance Factors Checklist, most-disturbed wetlands are those given scores of 4 or 5, while those given a 3 are considered moderately disturbed.

Table 3. Narrative description of Overall Disturbance Scores assigned to each survey and Disturbance Category used to set numeric standards. See Appendix A for the full Disturbance Factors Checklist.

SCORE	Narrative Description	Disturbance Category
1	Non-disturbed: Very few alterations, none greater than low intensity	Least-Disturbed (LD)
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	Moderately Disturbed (MOD)
4	Major: Many alterations, including at least one of high intensity	Most-Disturbed (MD)
5	Severe: Many alterations, including multiple high intensity ones	

Coefficients of Conservatism (C- values) are the basis of vegetation condition assessments and are essentially numerical ratings of a plant species' dependence on intact, unaltered ecological conditions. C- values were assigned to each species in the Wisconsin flora by a panel of Wisconsin botanists using the guidelines shown in Table 4 and published in Bernthal (2003).

Table 4. Narrative description of plant Coefficient of Conservatism (C-value) assignments.

C of C	Degree of conservatism/ intolerance of degraded ecological conditions
0 - 3	Taxa found in a wide variety of plant communities and very tolerant of disturbance.
4 - 6	Taxa typically associated with a specific plant community but tolerate moderate disturbance.
7 - 8	Taxa found in a narrow range of plant communities in advanced stages of succession but can tolerate minor disturbance.
9 - 10	Taxa restricted to a narrow range of ecological conditions, with low tolerance of disturbance.

Vascular plant inventories and areal cover values are converted to metrics using their C-values resulting in two primary floristic quality metrics: mean C-value ($\overline{C}$) and cover-weighted mean C- value ($w\overline{C}$). By sampling wetlands in both most- and least- disturbed categories, the resulting floristic quality metrics can be used to set numeric thresholds for 5 condition tiers. See section 2.5 Statistical Analysis for more details.

2.2. Site Selection

To locate survey sites for each of the 6 wetland communities we used the Wisconsin DNR Natural Heritage Inventory (NHI) database as a starting point. The NHI database tracks element occurrences (EOs) of natural community types, including wetlands, and includes descriptions and waypoints noting plant community condition, composition, and the presence of stressors. Additional sites were identified in the field by searching areas adjacent to known locations, asking external partners, searching the WDNR's Wetland FQA database, and in one case using floristic data collected for the National Wetland Condition Assessment.

2.3. Field Methods

Selected sites were visited by a team of two botanists during the growing seasons of 2022-2023. Precipitation data during these years provided by (NOAA, Statewide Mapping, 2023) and (NOAA, Drought.gov, 2023) show that these years received below-average precipitation with areas of "Moderate Drought" in 2022 when Forested Seeps, Wet Prairie, and White Pine – Red Maple Swamps were surveyed, and areas of "Severe to Extreme Drought" in 2023 when Bog Relict, Southern Tamarack Swamp, and Interdunal Wetlands were surveyed. However, the years immediately preceding (2019-2020) both had anomalously high precipitation likely contributing to high groundwater stores even if sources of water from rain and snowmelt were low.

Data collected during site visits included the following:

1. Full vascular plant inventories using WDNR's Timed-Meander Sampling Protocol for Wetland Floristic Quality Assessment (Trochlell, 2015).
2. WDNRs Disturbance Factor Checklist which notes anthropogenic disturbance factors present in the assessment area and buffer and summarizes these observations as an Overall Disturbance Score on a scale of 1 to 5 (Appendix A; Table 3).
3. Soil observations from a representative point within the AA, including soil texture, depth-to-water table (2023 surveys only), and soil pH with the use of a soil corer and pH meter (Extech ExStick Waterproof pH Pen PH100 or Hellige-Truog Soil pH Tester).
4. GIS point and line data for each survey collected with GPS on cell phones using either ArcGIS Field Maps or the OnX Hunt app.

2.4. Data Management

Survey data from the 6 wetland community types, including species inventories, % areal cover, scores from the Disturbance Factors Checklist, and soil observations, were transferred from FQA calculators in Excel to WDNR's Wetland FQA Database in Access. FQA metrics, including $w\overline{C}$ and $\overline{C}$ were calculated within Access and checked against Excel-calculated results to verify that data was correctly transferred, and programmed calculations were performing as expected. Spatial data was either automatically or manually entered onto a Wetland Monitoring Program Web Map on WDNR's ArcGIS Online Server.

2.5. Statistical Analyses

Methods to determine numeric floristic quality standards for each of the six wetland community types follow previously developed methods detailed in Hlina et al. (2015) and Marti & Bernthal (2019). All statistical analyses were performed in Excel and are summarized below:

Step 1: Verifying the presence of a relationship between FQA metrics and measures of wetland alteration: For each community type we used scatterplots and linear regression analysis to test the strength of Overall Disturbance (OD) against two FQA metrics, $\overline{C}$ and $w\overline{C}$. Relationships between FQA metrics and alteration gradients were considered sufficiently strong if R^2 values from linear regression analyses were ≥0.30 and statistically significant ($p < 0.05$). Here we followed Marti & Bernthal (2019) in using OD, rather than Plant Community Condition ratings as the primary alteration gradient used to set numeric criteria.

Step 2: Creating "Least Disturbed" and "Most Disturbed" bins: Surveys were placed in bins using the Overall Disturbance (OD) scores assigned to each survey (Table 3). Wetlands rated 1 or 2 for OD were placed in the Least Disturbed group (LD); wetlands rated 4 or 5 were placed in the Most Disturbed group (MD). Wetland surveys assigned a 3 were considered Moderately Disturbed. Moderately disturbed wetlands were not used for benchmark-setting in the past because they were not targeted in data collection, however, when present, we used these scores as part of regression analyses and as a check on the separation of bins. When significant overlap occurred as it did in a few cases, we sought alternative means, such as using % INN species to distinguish categories, or reducing the number of condition tiers we were able to distinguish.

Step 3: Setting numeric cut-offs for 5 tiers of wetland condition based on $\overline{C}$ and $w\overline{C}$ scores: Boxplots were used to analyze the distribution of scores from each bin and a formula used (Table 5) to determine the boundaries of each condition tier using the distribution of Least-Disturbed and Most-Disturbed scores following Marti & Bernthal (2019) and Hlina (2015). The Moderately Disturbed bin was not used to set tier boundaries due to insufficient numbers but when significant overlap occurred in a few cases it was used as a justification to add alternative criteria to separate tiers.

Table 5. Formula used to determine numeric benchmarks of condition based on the distribution of FQA scores from Least Disturbed (LD) to Most Disturbed (MD) wetlands.

Condition Tier	Numeric Benchmark Criteria
Excellent	>25th percentile of LD scores
Good	25th to 75th percentile of LD scores
Fair	From 25th of MD scores to 75th percentile LD scores
Poor	25th to 75th percentile of MD scores
Very Poor	<75th percentile of MD scores

3. Results

3.1. Data Collection Results

From 2021 to 2023 DNR staff completed timed-meander surveys of each of the six community types. With the addition of a small number of existing surveys of these types and several Bog Relict surveys provided by botanists from the Southeast Wisconsin Regional Planning Commission (SEWRPC), data from a total of 140 surveys were collected (Table 6, Figure 1).

Table 6. Number of surveys completed by community type and breakdown into Least-Disturbed (LD), Moderately Disturbed (MOD) and Most-Disturbed (MD) categories. Categories are determined from the Overall Disturbance Score assigned to each wetland (scale of 1 – 5).

		Disturbance Category Breakdown		
Community	**# Surveys**	**LD**	**MOD**	**MD**
Bog Relict	27	21	(1)	5
Forested Seep	28	13	(5)	10
Interdunal Wetlands	27	22	(2)	3
Southern Tamarack Swamp	16	10	(1)	5
Wet Prairie	20	6	(3)	11
White Pine- Red Maple Swamp	22	22	(0)	0

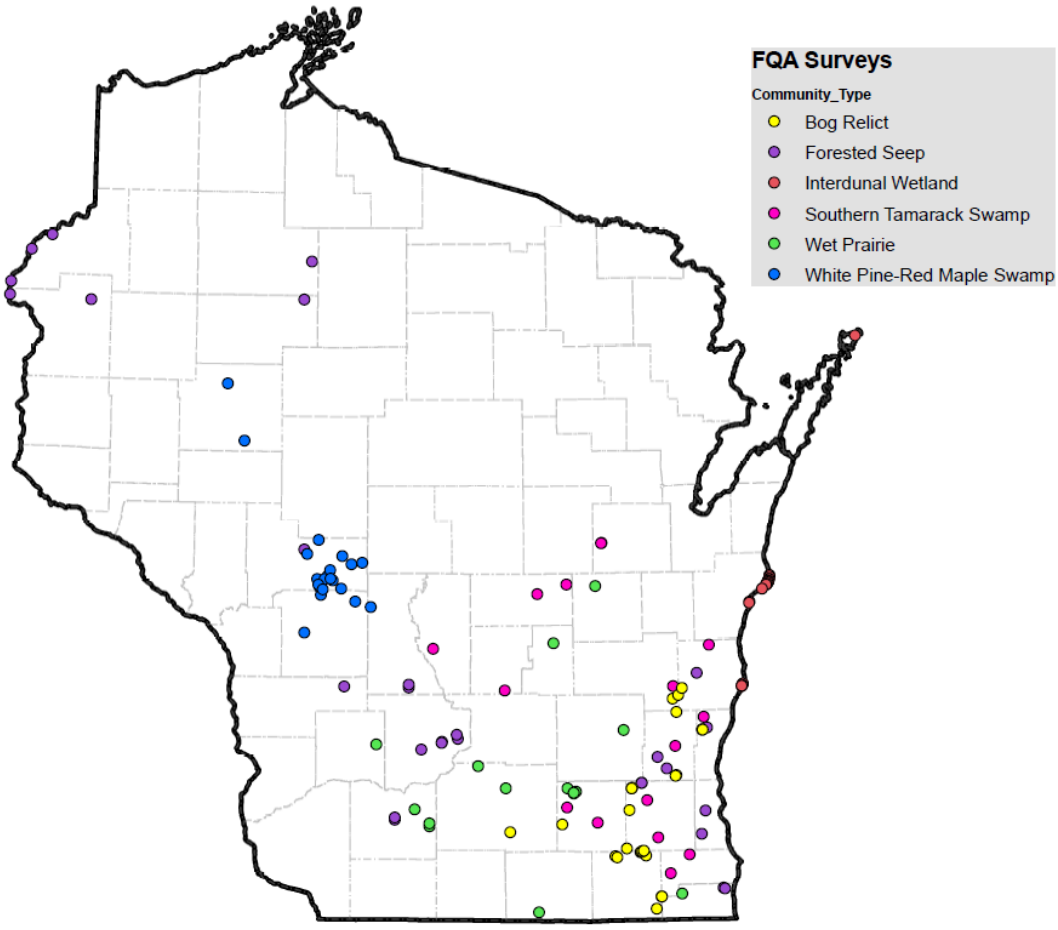

Figure 1. Location of rare and unique wetland community surveys.

Table 7. Species richness results (averaged by assessment area and summed across all assessment areas), average number of dominant species (areal cover ≥10%); Mean Cover-weighted Plant Conservatism; and Mean Relative Cover of Hydrophytes (FAC, FACW, OBL species) for each of the 6 rare community types.

Community	Mean Species Richness	Total Species Richness	Avg. # Dominant Species (10%+ cover)	Mean Plant Conservatism ($w\bar{C}$) *	Mean Hydrophyte Rel. Cover**
Bog Relict	38.0	196	3.2	7.7	0.94
Forested Seep	81.1	401	4.5	5.7	0.74
Interdunal Wetland	44.0	238	2.6	5.0	0.88
Southern Tamarack Swamp	53.4	230	4.5	6.3	0.92
Wet Prairie	61.8	226	3.9	4.3	0.84
White Pine-Red Maple Swamp	46.2	177	5.1	5.8	0.71

*Least-disturbed examples only

**Using NCNE Wetland Indicator Status

Table 8. Summary of field observations of soil properties in the uppermost soil horizons (to 18"); pH readings were at ~1" depth and included a 2nd reading when hummocks or distinct soil horizons were present.

Community	Soil Texture	Soil Hydrology*	Mean pH (Range)
Bog Relict	Sphagnum peat	Saturated to surface except where hummocks provide elevation	4.0 (2.8 – 6.5) Extremely acid
Forested Seep	Sand, sandy clay, to muck and peat	Saturated to surface	6.9 (6.5 -7.5) Neutral
Interdunal Wetland	Sand	Highly variable, ranging from standing water up to 24" deep to water table 27" below soil surface	8.0 (7.5 - 8.0) Moderately alkaline
Southern Tamarack Swamp	Mucky peat, occasionally peat	Soils saturated to surface or moist and water table up to 16" below the surface.	5.6 (3.7 – 7.8) Moderately acid
Wet Prairie	Mineral (loam to clay) to mucky mineral	Soils moist but seldom saturated.	7.7 (7.5 - 8.0) Slightly alkaline
White Pine-Red Maple Swamp	Peat over sand	Usually saturated to surface except where hummocks provide elevation and in hydromesic areas transitioning to upland.	4.8 (4.0 - 5.5) Very strongly acid

* Soil hydrology summarizes the results of a single observation of each wetland at the time of the floristic survey (between June – September). Survey years (2022 -23) had below-average precipitation including areas of moderate to severe drought conditions.

Table 9. Top 6 species by importance value (IV) found in surveys of 6 rare wetland communities. IV is calculated as an average of species' relative cover and relative frequency in the community. Wetland examples of each type that were degraded to the extent that they were better described as a ruderal wetland or other community type were excluded.

Bog Relict		**Southern Tamarack Swamp**	
1. *Sphagnum* spp.	Peat moss species	1. *Larix laricina*	Tamarack
2. *Chamaedaphne calyculata*	Leatherleaf	2. *Ilex verticillata*	Common winterberry
3. *Larix laricina*	Tamarack	3. *Toxicodendron vernix*	Poison sumac
4. *Dulichium arundinaceum*	Three-way sedge	4. *Frangula alnus*	Glossy buckthorn
5. *Ilex verticillata*	Common winterberry	5. *Acer rubrum*	Red maple
6. *Frangula alnus*	Glossy buckthorn	6. *Thelypteris palustris*	Marsh fern
Forested Seep		**Wet Prairie**	
1. *Impatiens capensis*	Orange jewelweed	1. *Spartina pectinata*	Prairie cord grass
2. *Symphyotrichum lateriflorum*	Side-flowering aster	2. *Carex stricta*	Tussock sedge
3. *Glyceria striata*	Fowl manna grass	3. *Oxypolis rigidior*	Common water-dropwort
4. *Ulmus americana*	American elm	4. *Euthamia graminifolia*	Grass-leaved goldenrod
5. *Symplocarpus foetidus*	Skunk-cabbage	5. *Solidago canadensis*	Canadian goldenrod
6. *Acer saccharum*	Sugar maple	6. *Solidago gigantea*	Giant goldenrod
Interdunal Wetland		**White Pine - Red Maple Swamp**	
1. *Juncus balticus*	Baltic rush	1. *Osmundastrum cinnamomeum*	Cinnamon fern
2. *Euthamia graminifolia*	Grass-leaved goldenrod	2. *Pinus strobus*	Eastern white pine
3. *Dichanthelium acuminatum* var. *fasciculatum*	Hairy panic grass	3. *Acer rubrum*	Red maple
4. *Potentilla anserina*	Silverweed	4. *Sphagnum* sp.	Peat moss
5. *Salix myricoides*	Bayberry willow	5. *Maianthemum canadense*	Canada mayflower
6. *Solidago gigantea*	Giant goldenrod	6. *Rubus hispidus*	Bristly dewberry

3.2. Plant Community Results

3.2.1. Bog Relict

The NHI database listed only 14 existing Bog Relicts in total, however, 27 surveys were ultimately completed in this category from 22 separate bog depressions. All 14 existing sites were visited by DNR staff or botanists at the Southeast WI Regional Planning Commission, with multiple surveys resulting from some sites. In addition, 6 new sites were discovered in the Lulu Lake Natural Area and Kettle Moraine State Forest (Southern Unit and Mukwonago Unit). Another source of Bog Relicts were 6 sites previously classified as Southern Tamarack Swamps but recategorized following surveys.

For the most part "moat" areas on the edge of bog basins were not surveyed and were considered a separate community type associated with the Bog Relict. These areas were best described as poor fens, sedge meadow, floating-leaf marsh, or shrub-carr in undisturbed areas, or ruderal marsh dominated by hybrid cattail in disturbed examples. Occasionally, however moats resembling poor fen (areas with abundant wiregrass sedges and less *Sphagnum* and ericaceous shrubs) were included as part of the Bog Relict community.

<u>Soil and Vegetation Observations</u>

Of all the communities, Bog Relict plants had the highest mean conservatism, the highest proportion of cover by hydrophytes, but the lowest species richness, with only 38 species found per survey on average (Table 7).

Bog Relicts were the wettest and most acidic of the wetland communities: Soil pH measurements ranged from 2.8 to 6.5 but averaged 4.0 or "Extremely acidic" (Table 8). Bog hollows were generally slightly less acidic (up to ±1 pH) compared to the top of *Sphagnum*-dominated hummocks. Soils were deep, scarcely decomposed (fibric or hemic) *Sphagnum* peat, often light brown in color. *Sphagnum* peat sometimes exceeded the depth of our soil corer, but on other sites overlayed unconsolidated peat or mucky peat within the top 18". Soils in Bog Relicts invaded by glossy buckthorn or hybrid cattail had muck or mucky peat soils.

The most important species by Importance Value (combined relative cover and relative frequency) in Bog Relicts (Table 9) were various species of *Sphagnum* moss and the ericaceous shrub leatherleaf (*Chamaedaphne calyculata*). *Sphagnum* moss areal cover ranged from 50% to 99% of assessment areas. Tamarack (*Larix laricina*) cover ranged widely, with anywhere from zero to 60% cover. While not diverse in comparison to other wetland types, Bog Relicts were host to a large proportion of rare and conservative plant species, including two species of sundew (*Drosera intermedia and D. rotundifolia*), five species of cotton grass (*Eriophorum angustifolium, E. gracile, E. tenellum, E. vaginatum, and E. virginicum*), three species of orchid (*Arethusa bulbosa, Calopogon tuberosus, Pogonia ophioglossoides*), muck sedge (*Carex limosa*), downy willow-herb (*Epilobium strictum*; special concern species according to Wisconsin Natural Heritage Program; hereafter "SC" (WDNR, 2021), and seven-angle pipewort (*Eriocaulon aquaticum).*

Disturbance Factors

Many Bog Relicts were in protected areas in the Kettle Moraine SF or State Natural Areas where they may have experienced historical impacts from past attempts to farm the bogs and immediate area, but now appear very stable. However, the absence of natural disturbance from fire may be affecting Bog Relicts negatively by allowing unchecked dominance by *Sphagnum* moss and leatherleaf, reducing diversity. One site that had been mossed in the past provided some evidence for this- the mossed area had higher diversity and floristic quality than the surrounding un-mossed areas. In addition, Bog Relicts rated a "2" for Overall Disturbance averaged slightly higher w$\overline{C}$ scores than those rated "1".

Bog relicts that were not as protected had active plowing in the adjacent upland draining to the bog, and often ditches or gullies in the upland draining to the depression. While a core undisturbed area still exists, it has gotten smaller over time with the fringe areas impacted by hybrid cat-tail or glossy buckthorn, and the moat area, typically a wetter community- emergent marsh or poor fen- has expanded compared to historical imagery. Aerial imagery of several sites shows a widened moat area at the base of drainage channels from the upland.

The 5 most-disturbed Bog Relicts were taken from bog areas experiencing some eutrophication and stormwater inputs from the upland edge and were invaded by either hybrid cat-tail or glossy buckthorn, the worst of which were best categorized as Ruderal Marsh or Ruderal Shrub Swamp; however, they all retained some elements of a bog flora, e.g., *Sphagnum* moss, and/or leatherleaf. Most disturbed examples were found on the outer edges of a core area that remained essentially intact, with the intact areas surveyed separately.

Sites invaded by glossy buckthorn had extremely low diversity and drained, mucky peat soils, contrasting with deep *Sphagnum* peat found on undisturbed sites. Glossy buckthorn seemed to be one of the few non-native plants that could tolerate the acidic, low nutrient conditions found in bogs. While they are likely much slower to get started than in more nutrient rich areas, once established they appear to effectively drain the soil through transpiration and enrich the soil through leaf litter, both of which favor its own growth and inhibit *Sphagnum* moss.

Overall, the greatest threats to Bog Relict sites, based on our site visits and the use of aerial and LiDAR imagery to assess the buffer, were ongoing eutrophication from uplands, especially where plowed fields drain to bogs

through artificial or natural channels; and glossy buckthorn invasion, which drastically changes the hydrology and nutrient dynamics. Fire suppression may also be contributing to a loss of species richness.

3.2.2. Forested Seep

Least-disturbed examples of Forested Seep were identified using both previously document EO and NHI's database of waypoint notes of previous NHI surveys that noted good-quality forested seeps. In total, 13 least-disturbed sites were sampled in the field ranging from southeast Wisconsin to northwest Wisconsin.

Most disturbed examples of Forested Seep were identified using a database of waypoint notes of previous NHI surveys and the help of partners including The Nature Conservancy and Southeast Wisconsin Regional Planning Commission with first-hand knowledge of candidate sites. In total, 15 sites of intermediate to most disturbance were sampled in the field, primarily in south-central and southeast Wisconsin. One target site was reclassified as a Clay Seepage Bluff.

Soil and Vegetation Observations

Forested Seeps were the most floristically diverse (mean species richness = 81.1, and a total of 401 species identified; Table 7) of the 6 communities both within and between assessment areas likely owing to the diversity in hydrology and chemistry at small scales created by seeps and springs. Forested Seeps also had the most widespread occurrence across the state, adding to the large number of total species. Forested Seeps were also the only community with neutral pH soils of the group (Table 8) which likely contributes to a more diverse, generalist flora. The most dominant plant species were forested wetland generalists, *Impatiens capensis, Symphyotrichum lateriflorum, and Glyceria striata* (Table 9). However, looking only at the dominants overlooks the many rare and conservative plant species found in these wetlands. For instance, uncommon and rare ferns (*Deparia acrostichoides, Homalosorus pycnocarpos* (SC), and *Dryopteris goldiana*); rare sedges *(Carex laevivaginata* (state endangered species according to Wisconsin Natural Heritage Program; hereafter "END"), *Carex laxiculmis, Carex prasina* (SC)) and several others including *Chrysosplenium americanum, Symphyotrichum prenanthoides, Poa paludigena* (SC), *Thalictrum revolutum* (SC), and *Eurybia furcata* (state threatened species according to Wisconsin Natural Heritage Program; hereafter "THR").

Disturbance Factors

Impacts leading to degradation of Forested Seeps noted on forms included both Emerald Ash Borer and Dutch Elm disease reducing canopy cover, historical grazing, excavation of springs for water sources, run-off and sedimentation where alteration has occurred upslope or where a loss of canopy cover has occurred, heavy buckthorn cover leading to peat oxidation, deer browse, and invasive worms. The most abundant invasive non-natives were common buckthorn (*Rhamnus cathartica*), garlic mustard (*Alliaria petiolata*), and multiflora rose (*Rosa multiflora*).

3.2.3. Interdunal Wetland

Interdunal Wetlands were selected from the NHI database, which included 6 EOs. The more extensive sites are located along the Lake Michigan shoreline. Of the sites on the Lake Superior shoreline, the majority are on islands in the Apostle Islands National Lakeshore, owned and managed by the National Park Service, require extensive travel by boat to reach, and face minimal potential anthropogenic impacts. Thus, we focused on sites along Lake Michigan.

Least-disturbed sites contained numerous discrete wetland pockets. We treated each separate wetland basin as a unique assessment area. In total we surveyed 24 assessment areas in the least disturbed and moderately distrubed tiers. Interdunal wetlands varied greatly in size, ranging from up to 3 acres in size to just 0.01 acres, though typically were between 0.1 and 0.5 acres. In each instance, the entire basin was surveyed. Because

Interdunal Wetland vegetation varies greatly with water depth, we also measured depth of standing water in the deepest part of the basin, or depth to water table if below the soil surface. Most-disturbed examples of Interdunal Wetland were searched for in developed areas with appropriate shoreline geology. Three sites were located and surveyed.

Soil and Vegetation Observations

Interdunal Wetlands had a consistently sandy, moderately alkaline substrate, but hydrology varied considerable from wetland to wetland (Table 8). Water table observations were equally divided between "near surface", within the top 12", and below 12". In addition, a single wetland (with the lowest floristic quality scores) had 2 feet of standing water at the center of the basin. Interdunal Wetlands with water table recorded at the surface at the time of the survey averaged higher floristic quality scores than other water levels.

Interdunal wetlands were smaller in size than other wetlands we surveyed yet still hosted higher plant diversity than Bog Relicts. However, they had the lowest average number of dominant species >10% at 2.6 species (Table 7). Species dominating Interdunal Wetlands had high variation in C-value, with smooth sawgrass (*Cladium mariscoides*) found on 8 sites with a C-value of 10, and hairy panic grass (*Dichanthelium acuminatum* var. *fasciculatum; C-value = 2*) found on 22 sites, despite no differences in perceived disturbance levels.

The two species with the highest frequency, though not necessarily highest cover in Interdunal Wetlands were Baltic rush (*Juncus balticus*) and grass-leaved goldenrod (*Euthamia graminifolia*) followed by bayberry willow (*Salix myricoides)* and silverweed (*Potentilla anserina*) (Table 9). Rare and highly conservative plants found within Interdunal Wetlands include the rare willows (*Salix cordata;* END) and *S. myricoides*, *Clinopodium arkansanum (SC), Calamovilfa longifolia (THR), Triglochin palustris (SC),* and *Prunus pumila.*

Disturbance Factors

Most-disturbed sites tended to have high stormwater input, often with a storm drain leading directly into the wetland. They also tended to have a high areal cover of non-native invasive species, exacerbated by both nutrient enrichment and their location in a disturbed urban environment with a high concentration of non-native invasive propagules in the local landscape. Narrow-leaved cattail and non-native Phragmites (*Phragmites australis* var. *australis*) were the most frequently encountered invasive species and had with the highest areal cover.

3.2.4. Southern Tamarack Swamp

Southern Tamarack Swamps were selected from NHI's database which included 54 EOs. From this list, we selected the 20 most extreme examples at the intact and most-disturbed ends of the spectrum based on data associated with each EO. Other sources of data included 2 existing Southern Tamarack Swamps surveyed as part of a watershed study in Waushara County, a National Wetland Condition Assessment site surveyed in 2021, and two sites that were originally targeted as Bog Gelicts and later reclassified. However, ultimately only 16 surveys remained in this category after 6 were transferred to the Bog Relict category and 4 were later disqualified due to low cover of tamarack.

We found that several of the Southern Tamarack Swamps we targeted had lost significant amounts of tamarack and were not surveyed or were eliminated later in the analysis. Tamarack loss in several cases was due to factors that affected only the tamarack (likely disease and/or winter freeze-out of roots) and was not reflected in the floristic quality of the remaining vegetation. Ultimately these sites were eliminated from analysis. Such sites were better described as shrub-carr, hardwood swamp, or sedge meadow. Only sites with disturbance factors such as drainage, flooding, or eutrophication affecting all vegetation in the wetland were used in the analysis in the most-disturbed category and totaled only 5 sites. Of these, three had minimal cover of tamarack (but

evidence of dead tamaracks) and two had abundant tamarack but were impacted by glossy buckthorn or hybrid cat-tail invasion. Many were best described as Ruderal Shrub Swamps.

Soil and Vegetation Observations

Southern Tamarack Swamps were nearly as persistently wet as Bog Relicts, with 92% mean relative cover of hydrophytes (Table 7) and moist-to-saturated black mucky peat soils typical (Table 8). While tamarack was a required species in this community two species were highly associated and found in nearly every example: common winterberry (*Ilex verticillata*) and poison sumac (*Toxicodendron vernix*) (Table 9). Southern Tamarack Swamps often had small pockets of bog species, particularly where open and near the water's edge, including purple pitcher plant (*Sarracenia purpurea)*, cotton grasses, bog willow, bog rosemary, and bogbean. The herb layer was variable but common species include marsh fern (*Thelypteris palustris*), tufted loosestrife (*Lysimachia thyrsiflora*), and northern water-horehound (*Lycopus uniflorus*).

Disturbance Factors

Standing dead, fallen dead, and tree-top die-off of tamarack was common. Specific reasons were unknown but were likely due to disease, winter freeze-out of roots, windstorms, or a combination exacerbated by climate change. Other tree deaths in this community were attributed to Emerald Ash Borer and Dutch Elm disease. The presence of extensive ditching was commonly associated with lower quality tamarack swamps as were impoundments associated with lakes and wildlife habitat.

Glossy buckthorn was the most dominant invasive in Southern Tamarack Swamps, also a contributor to drained soils via evapotranspiration and low diversity; followed by *Typha X glauca* in flooded examples, for example on the edges of impounded lakes, or where surface water from was draining to the site.

3.2.5. Wet Prairies

Least-disturbed examples of Wet Prairie were identified using the Wisconsin DNR Natural Heritage Inventory database. All previously documented wet prairies in the state were investigated and surveyed in the field where warranted. In addition, all State Natural Areas named for a "wet prairie" were surveyed in the field. In total 30 sites were surveyed, resulting in seven wet prairie communities confirmed in the field. Numerous sites were determined to not contain wet prairie but were rather more accurately classified as a variety of related communities including Wet-Mesic Prairie, Sand Prairie, Sedge Meadow, and Calcareous Fen. Determinations were made using the DNR wetland key to natural communities and detailed natural community descriptions. One additional least disturbed site was sampled as part of a separate project and the data incorporated into analysis for the purposes of establishing floristic quality benchmarks.

Most-disturbed examples of Wet Prairie were taken from pre-existing surveys assigned to the "Ruderal Wet Meadow" community. Ruderal Wet Meadows are non-forested wetlands that are significantly altered by past disturbance. They are typically dominated by non-native grasses such as reed canary grass with greater than 75% non-native cover or, if non-native species have less coverage, native species are indicative of disturbance (O'Connor, 2022). Of the 95 Ruderal Wet Meadow surveys in the Wetland FQA Database we selected those that were representative of degraded Wet Prairie based on their geographic location in the Southeastern WI Till Plains and Driftless Area ecoregions and presence of remnant Wet Prairie flora, such as *Spartina pectinata*, *Pycnanthemum virginianum*, *Helenium autumnale*, *Helianthus grosseserratus*, or *Euthamia graminifolia*. We found 10 surveys that met these criteria. Two additional moderately disturbed sites were sampled as part of a separate project and the data incorporated into analysis for the purposes of establishing floristic quality benchmarks.

Soil and Vegetation Observations

Soils were mineral loams to clays though occasionally mucky mineral soils were present. Soil pH consistently fell in the slightly to moderately alkaline category (Table 8). The Wet Prairie flora had the lowest mean conservatism (mean $w\overline{C}$ = 4.3) of the communities we surveyed, likely due to the comparatively richer soils and less persistently wet conditions allowing generalists to occupy the community (Table 7). However, many rare conservative species were found, included eastern prairie fringed orchid (*Platanthera leucophaea*; END), great plains lady's tresses (*Spiranthes magnicamporum*; SC), Leiberg's panic grass (*Dichanthelium leibergii*), narrow-leaved loosestrife (*Lysimachia quadriflora*), prairie Indian- plantain (*Arnoglossum plantagineum*; THR), flat-stemmed spikerush (*Eleocharis compressa*; SC), white blue-eyed grass (*Sisyrinchium albidum*; SC), and smooth phlox (*Phlox glaberrima*; END).

Disturbance Factors

Historical ditching, plowing, and grazing is common in these rich soils, inputs from from uphill water sources as well as invasion by reed canary grass, red-top, common buckthorn are additional disturbance factors in Wet Prairie. In addition, fire suppression allows native shrubs, in particular dogwoods (*Cornus* spp.), to encroach.

3.2.6. White Pine-Red Maple Swamp

Least-disturbed examples of White Pine- Red Maple Swamp were identified using the Wisconsin DNR Natural Heritage Inventory database and State Natural Areas. In total, 21 least-disturbed sites were sampled in the field, representing all but one of the previously documented high-quality examples of this type in the state.

We searched for most disturbed examples with assistance from local field biologists, but all sites visited were determined to be narrow ecotones between disturbed upland pine forests and adjacent wetlands and not characteristic of the White Pine- Red Maple Swamp community. Like other communities with highly acidic soils and *Sphagnum* peat, White Pine- Red Maple Swamps appear to resist invasion by most non-native species except for glossy buckthorn. Most of the documented cases of disturbance resulted in historical conversion of sites to cranberry farms. It is likely that small most-disturbed examples could be found adjacent to roads, cranberry farms, and developed areas with additional resources.

Soil and vegetation observations

White Pine – Red Maple Swamps had the lowest relative cover by hydrophytes (0.71) of the wetlands (Table 7) and was second only to Bog Relicts in soil acidity, with an average pH of 4.8 (Table 8). Floristically, this community type had the lowest total species richness with only 177 species identified across all surveys (Table 7). This may be attributed to the restricted range of this community type as well as the absence of most-disturbed examples. However, the highly acidic, low nutrient environment likely plays a role in restricting many generalist species. Interestingly this community had the highest number of dominant species with cover ≥ 10% (5.1; Table 7). In addition to the shared dominance of white pine and red maple, shrub-layer species reaching high cover included huckleberry (*Gaylussacia baccata*), tag alder (*Alnus incana*), and winterberry (*Ilex verticillata*). In the herb-layer, cinnamon fern (*Osmundastrum cinnamomeum*), long sedge (*Carex folliculata*), skunk cabbage (*Symplocarpus foetidus*), and royal fern (*Osmunda regalis*) were common. Conservative species included *Thelypteris simulata*, bog species such as *Maianthemum trifolium, Kalmia polifolia, Carex magellanica*, both cranberry species, as well as *Torreyochloa fernaldii*, and *Cypripedium acaule*.

3.3. Regression Results: Floristic Quality vs Anthropogenic Disturbance

The relationship between w$\overline{C}$ results and Overall Disturbance (OD) scores (Table 10; Appendix B) showed a strong and significant (R^2 = 0.62 to 0.88; p = 0.00) inverse relationship in all communities except interdunal wetlands which had a weak but significant (R^2 = 0.24; p = 0.00) relationship. Relationships between $\overline{C}$ and OD scores were weaker overall (R^2 = 0.18 – 0.60) but sufficiently strong and significant for all communities except White Pine – Red Maple Swamp which was only weakly related (R^2 = 0.19) but still significant at the 0.05 level. Mean (unweighted) C- value ($\overline{C}$) had weaker relationships with OD (R^2 = 0.19 to 0.56), but all had a significant relationship (p = 0.0 to 0.04).

Using the cut-off for a minimum significant relationship of R^2 ≥0.30 and p ≤ 0.05, these results suggest that benchmarks for w$\overline{C}$ and $\overline{C}$ are both reasonable measures of anthropogenic alteration for four communities: Bog Relict, Forested Seep, Southern Tamarack Swamp, and Wet Prairie. However, two communities have only one metric that can be used: $\overline{C}$ for Interdunal Wetlands and w$\overline{C}$ for White Ppne – Red Maple Swamps.

Table 10. Results of regression analyses of w$\overline{C}$ and $\overline{C}$ against Overall Disturbance scores including the significance of the linear regression.

		w$\overline{C}$		$\overline{C}$	
Community	**n**	**R^2**	**P-value**	**R^2**	**P-value**
Bog Relict	27	0.73*	0.00*	0.30*	0.00*
Forested Seep	28	0.82*	0.00*	0.56*	0.00*
Interdunal Wetlands	27	0.24	0.00*	0.60*	0.00*
Southern Tamarack Swamp	16	0.89*	0.00*	0.51*	0.00*
Wet Prairie	20	0.88*	0.00*	0.39*	0.00*
White Pine- Red Maple Swamp	22	0.62*	0.00*	0.19	0.04*

* Regression results with asterisk met the criteria for a significant relationship between floristic quality and disturbance (R^2 ≥0.30; p ≤ 0.05).

3.4. Condition Benchmarks for $\overline{C}$

Results for least and most-disturbed wetlands were graphed onto box plots (Appendix C) to identify previously established thresholds (Table 3) Condition thresholds for mean C-value ($\overline{C}$) for are shown in Table 11. White Pine – Red Maple Swamp is the only community for which we were unable to identify condition tiers, due to absence of data from the disturbed end and poor correlation with disturbance found among the remaining data.

Bog Relict, Southern Tamarack Swamp, and Wet Prairie had the lowest R^2 values among the 6 communities and had problems with overlap of $\overline{C}$ scores between disturbance categories in the middle to low ranges though overall they had significant correlations with Overall Disturbance scores. To address this, we used an additional criterion to strengthen the ability to distinguish condition categories. Because % INN cover (absolute cover of non-native species) was a strong factor distinguishing the disturbance bins (Figure 2) and feasible to add to assessments even if individual cover was not assessed, this was added as a solution to cases in which $\overline{C}$ alone had poor discrimination ability.

Table 11. Suggested Mean C-value ($\overline{C}$) criteria to distinguish 5 condition tiers. Ecoregion refers to the Omernik Level III Ecoregion to which the numeric criteria apply, including Northern Lakes and Forests (NLF), North Central Hardwood Forests (NCHF), Driftless Area (DA), Southeastern Wisconsin Till Plains (SETP), and Central Corn Belt Plains (CCBP).

Community	Ecoregions	Excellent	Good	Fair	Poor	Very Poor
Bog Relict*	SETP	>7.0	6.5 – 7.0 OR 5.1 – 6.4 +INN <15%	5.1 – 6.4 + INN ≥15< 30%	5.1 – 5.8 + INN ≥ 30%	<5.1
Forested Seep	All	>5.2	4.6 – 5.2	4.0 – 4.5	3.0 – 3.9	< 3.0
Interdunal Wetlands	SETP, NCHF	>4.3	3.6 – 4.3	3.0 – 3.5	2.0 – 2.9	<2.0
Southern Tamarack Swamp*	SETP, NCHF	>6.2	4.9 – 6.2 +INN ≤ 10%	4.0 – 5.2 INN ≤ 50%	4.0 – 5.2 INN > 50%	<4.0
Wet Prairie*	SETP, DA, CCBP	>4.9	4.3 – 4.9	3.1 – 4.2 INN <50%	3.1 – 4.2 INN ≥50%	<1.1
White Pine- Red Maple Swamp	NLF, NCHF, DA	NA	NA	NA	NA	NA

*This community type requires additional criterion for %INN cover (non-native cover) to distinguish between some tiers. The use of the term "INN" is consistent with common wetland compensatory mitigation practice.

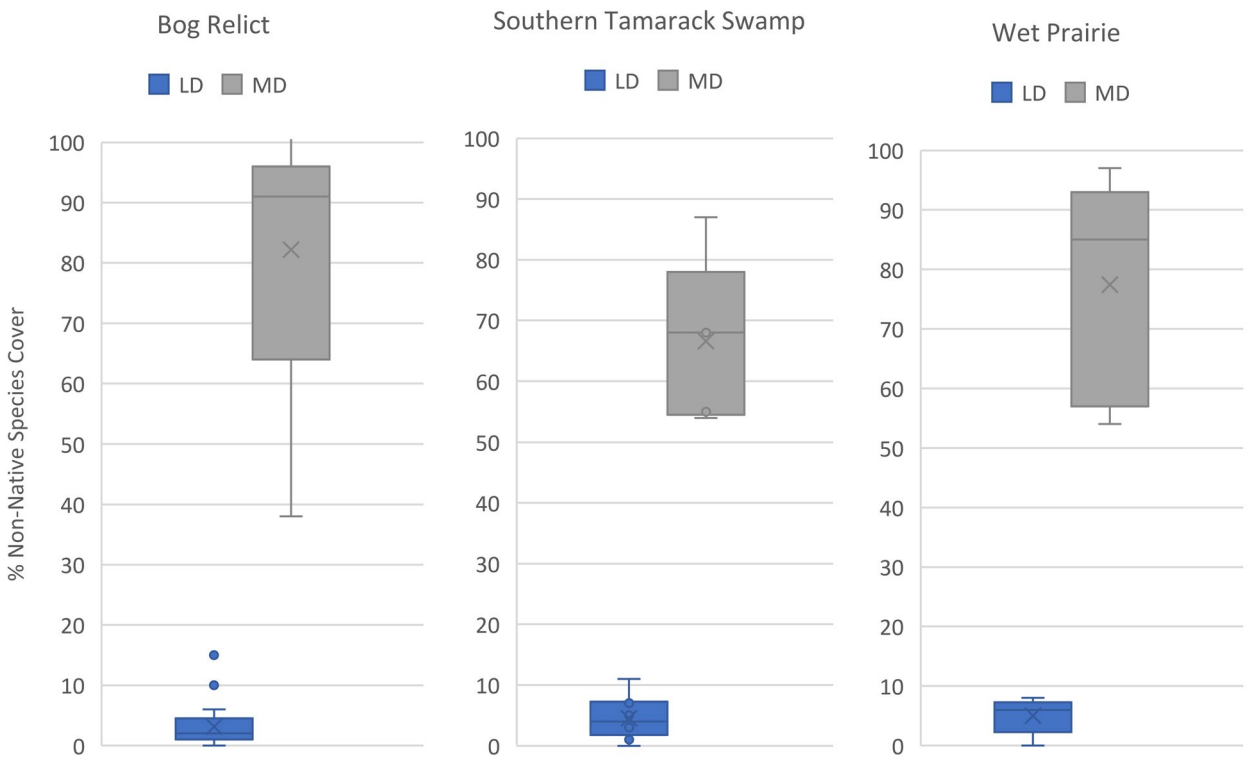

*Figure 2. Absolute cover INN (non-native species) in least- and most-disturbed wetlands from three communities. Bog Relict INN species were primarily glossy buckthorn (*Frangula alnus*) and hybrid cattail (*Typha X glauca*); Southern Tamarack Swamp INN species were glossy buckthorn, common buckthorn (*Rhamnus cathartica*) or hybrid cattail; and Wet Prairie INN species were primarily reed canary grass (*Phalaris arundinacea*).*

3.5. Condition Benchmarks for w$\overline{C}$

Condition benchmarks for 5 condition tiers (Table 12) were identified using on the distribution of w$\overline{C}$ scores in least- and most-disturbed surveys.

We were unable to use w$\overline{C}$ to develop condition tiers for Interdunal Wetlands due to its poor relationship with disturbance, indicated by the large and overlapping range of w$\overline{C}$ values for least- and moderately disturbed examples (Appendix C) and the absence of sufficient representation of MD examples. In addition, numeric criteria for White Pine – Red Mmple Swamp are only available for the Excellent and Good tiers due to the absence of data from moderate and least-disturbed wetlands of this community type.

Table 12. Suggested w$\overline{C}$ criteria to distinguish 5 condition tiers. Ecoregion refers to the Omernik Level III Ecoregion to which the numeric criteria apply, including Northern Lakes and Forests (NLF), North Central Hardwood Forests (NCHF), Driftless Area (DA), Southeastern Wisconsin Till Plains (SETP), and Central Corn Belt Plains (CCBP).

Community	Ecoregions	Excellent	Good	Fair	Poor	Very Poor
Bog Relict	SETP, DA	>8.3	7.2 – 8.3	4.3 – 7.1	2.2 – 4.2	<2.2
Forested Seep	All	>6.1	4.6 - 6.1	3.5 - 4.5	2.5 -3.4	<2.5
Interdunal Wetlands	SETP, NCHF	NA	NA	NA	NA	NA
Southern Tamarack Swamp	SETP, NCHF, DA	>6.6	6.1 - 6.6	3.9 – 6.0	3.3 – 3.6	<3.3
Wet Prairie	SETP, DA, CCBP	>5.4	4.4 - 5.4	1.9 - 4.3	1.1 - 1.8	<1.1
White Pine- Red Maple Swamp	NLF, NCHF, DA	>6.2	5.7 - 6.2	----------<5.7----------		

3.6. Updated Community Descriptions and Community Key

Using the detailed floristic data with accompanying soil observations collected for each of the 6 rare communities, Department staff in the Natural Heritage Conservation program were able to update both the community descriptions (Appendix D and available on the DNR website within each specific community page) and the Key to Wisconsin Wetland Communities (Appendix E and available to the public on the DNR website as Version 1.4).

4. Discussion

This project resulted in a significant progress in the Department's goal to provide tools to assess wetlands of all types in Wisconsin. With the data collected from the six rare wetland communities we were able to establish numeric criteria for both $\overline{C}$ and w$\overline{C}$ across the full range of condition for Bog Relict, Forested Seep, Southern Tamarack Swamp, and Wet Prairie. Interdunal Wetland will have numeric standards for the $\overline{C}$ metric alone; and White-Pine Red Maple Swamp has numeric standards only for w$\overline{C}$ and only for the Excellent and Good tiers. With numeric criteria and floristic data for these 6 rare wetland types, there remain only a handful of rare types for which we still have no data or condition criteria, including Coastal Plain Marsh, Great Lakes Shore Fen, Ephemeral Pond, Inland Beach, and Moist Sandy Meadow.

The greatest weakness in our data collection was the low number of wetlands we were able to capture in the most-disturbed range. The absence of data from this range led to a gap in our ability to distinguish the middle and lower condition tiers for White-Pine Red Maple Swamp. For other communities, Bog Relicts, Interdunal

Wetlands, and Southern Tamarack Swamps which had more data from the undisturbed end of the spectrum than the disturbed end, we were able to identify numeric criteria for all tiers, but we accept that the lower tiers may be less reliable and subject to adjustment with more data. However, we are confident that the surveys we did collect spanned a full range of disturbance, reflected in the high levels of significance that were found in the relationship between disturbance rating and floristic quality for most communities (Table 10).

A large part of the reason for the low numbers in the disturbed range can be attributed to the limited number of known locations for these rare communities but limited field staff time was another factor limiting our ability to correct imbalances. For instance, when collecting data to set benchmarks for the more common and widespread communities, a separate team was employed to seek out and survey disturbed wetlands.

Other reasons are specific to the community type; location on the landscape may determine how protected they have been since they were originally identified, and their unique soil chemistry may cause differences in how they respond to alterations. For instance, many peatlands appear resistant to disturbance, especially invasive species, due to their highly acidic soils which deter more generalist species- to the extent that it is rare to see a moderately disturbed example, a site in transition. Communities that gradually become invaded by non-native, or more tolerant species are easier to identify in a disturbed state, but those that appear stable until reaching a tipping point may transition abruptly to a different but still native community type. For instance, a bog that becomes impounded or receives nutrient inputs may abruptly transition to a high-quality emergent marsh. These communities are difficult to find in a disturbed state in which there are still indicators of its original community type. Past work setting benchmarks for Open Bog, Black Spruce Swamp, and Central Poor Fen, all acidic, nutrient-poor communities, were met with a similar problem (Marti & Bernthal 2019).

5. Next Steps

Numeric criteria for distinguishing condition categories for these six community types, and the floristic and site data collected will be entered into the Wetland FQA database and shared with internal and external partners. These benchmarks will be incorporated into existing floristic benchmarks utilized by Department staff for regulatory, monitoring, and restoration purposes.

The benchmarks established here may be revisited and re-calculated when new wetlands within any of these community types are surveyed if there is belief that the new data will likely shift the benchmarks or break lumped categories out into separated benchmarks. Opportunities to improve numeric criteria for Fair, Poor, and Very Poor categories especially, will be sought out.

Remaining gaps in our ability to assess wetland floristic condition include the five rare wetland types shown in Table 2 (Boreal Rich Fen, Coastal Plain Marsh, Great Lakes Shore Fen, Inland Beach, Moist Sandy Meadow, and Ephemeral Pond) and aquatic wetland communities (shallow open water wetlands). Some of these communities may have too few sites within Wisconsin to generate statistically-sound benchmarks. In addition, gaps still exist for certain level III ecoregions among common wetland types (Table 1). For some of these more common types, including Alder Thickets, Central Poor Fens, Boreal Rich Fens, and Poor Fens, data exists but is not yet sufficient to overcome unique hurdles specific to these communities and their relationship with disturbance. Future discussion, analysis, and data collection is necessary to fill in these gaps.

Natural heritage state rarity ranks (S-ranks) will be updated for all six communities using NatureServe's rank calculator following mapping of known least disturbed sites into the NHI database. Global rarity ranks (G-ranks) will be updated where feasible in coordination with NatureServe and other states and provinces in which these communities occur. These ranks help guide and prioritize conservation and protection efforts.

Updates to WDNR's Wetland FQA Methodology from this effort in the future may include a re-evaluation of areal cover estimation practice by allowing the use of 0.1 as the lowest % areal cover allowable (currently the Timed-meander survey SOP states that 1% is the lowest allowable value). Data taken during the 2022 and 2023 field seasons were calculated using both methods. Future analysis will reveal if we can transition to using 0.1% without changing previously calculated numeric benchmarks.

Additional analyses that could come from this project in the future includes an evaluation of the use of *Sphagnum* moss at the genus level in floristic quality assessments. At least 3 of the communities included in this project (Bog Relict, Southern Tamarack Swamp, and White Pine – Red Maple Swamp) included significant amounts in *Sphagnum* moss in their flora which was recorded at the genus level. In addition, samples of *Sphagnum* moss from Bog Relicts were collected to identify at a future date. Although this data was not used to set numeric criteria for condition, the collected data can be used to evaluate the utility of using a single C-value for *Sphagnum* moss or to determine if some minimum identification at the subgenus level is necessary.

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7. Appendices

A. Disturbance Factors Checklist

B. Regression results: $\overline{C}$ and $w\overline{C}$ vs. Overall Disturbance

C. Box plots of $\overline{C}$ and $w\overline{C}$ results by Disturbance Category

D. Updated Natural Community Descriptions

E. Updated Key to Wisconsin Wetland Natural Communities

Appendix A. Wetland Disturbance Factors Checklist

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? *Consider each Stressor. Check the box if current stressors are observed in the AA (Assessment Area) or within a 30m Buffer (around the AA).* *Check the Historic box if a stressor is evident but occurred in the past.* *Rank the level of impact as L (low), M (medium) or H (high).*	Ditch				
	Tile				
	Dike				
	Water Control				
	Dredging				
	Filling/grading				
	Excavation				
	Clear/Selective cut*				
	Herb removal				
	Entire Vegetation stratum removal				
	Mowing/Grazing				
	Plowing/Ag				
	Sedimentation				
	StormH20 input				
	Eutrophication				
	Motor vehicle use				
	Road/RR/trails				
Note and describe any additional stressors. *Buffer (30m): For buffer stressors, note how much of the buffer area was observed and any other explanatory notes.*	Invasive Animals**				
	Other Stressors: Buffer Notes:				

Tree Age Class: *Wooded wetlands: Estimate the degree of logging disturbance.* *Age is approximated by the average size (dbh) of the <u>taller</u> 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 areal cover □ (2) Sparse: 2-5% areal cover □ (3) Medium: 6-25% areal cover □ (4) Extensive: 26-50% areal cover □ (5) Very Extensive: >50% areal cover
	Invasive Plant 2:	□ (1) Present: 1% or less areal cover □ (2) Sparse: 2-5% areal cover □ (3) Medium: 6-25% areal cover □ (4) Extensive: 26-50% areal cover □ (5) Very Extensive: >50% areal cover
	Invasive Plant 3:	□ (1) Present: 1% or less areal cover. □ (2) Sparse: 2-5% areal cover □ (3) Medium: 6-25% areal cover □ (4) Extensive: 26-50% areal cover □ (5) Very Extensive: >50% areal cover

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

Overall Disturbance: *Based on <u>all</u> 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: <u>*Based on the vegetation survey*</u>*, 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: *Additional comments related to disturbance and plant community condition:*

Appendix B: Regression Results: $\overline{C}$ and $w\overline{C}$ vs. Overall Disturbance

FIgure B1. Bog Relict

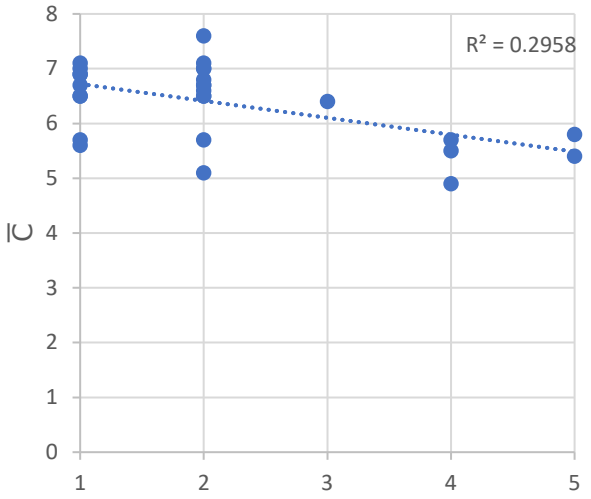


Figure B2. Forested Seep

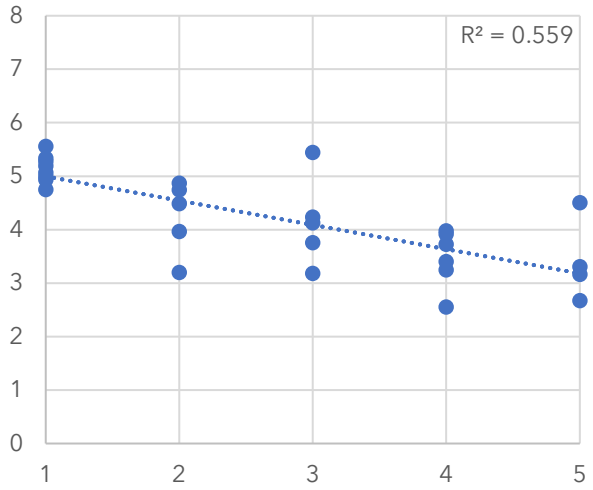


Figure B3. Interdunal Wetland

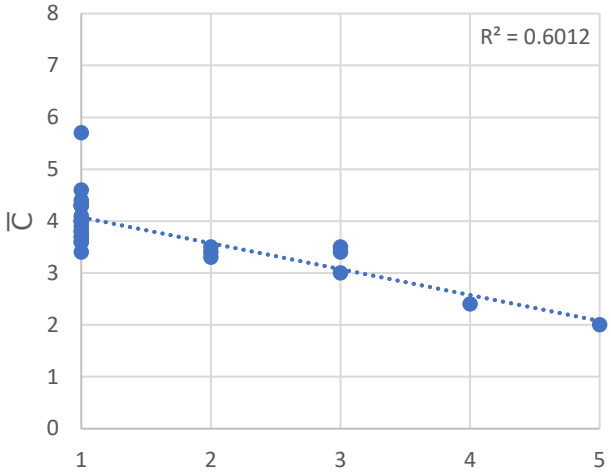


Figure B4. Southern Tamarack Swamp

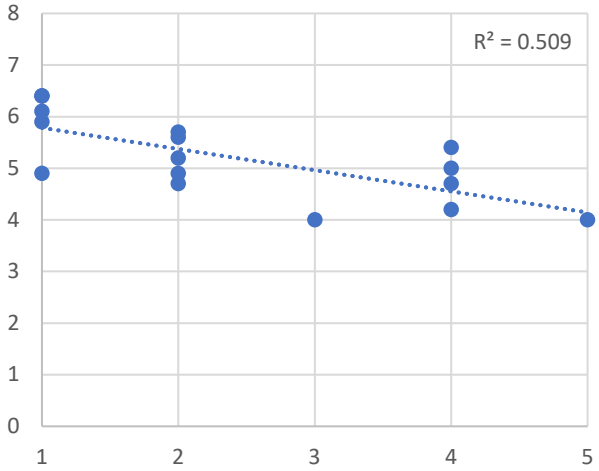


Figure B5. White Pine - Red Maple Swamp

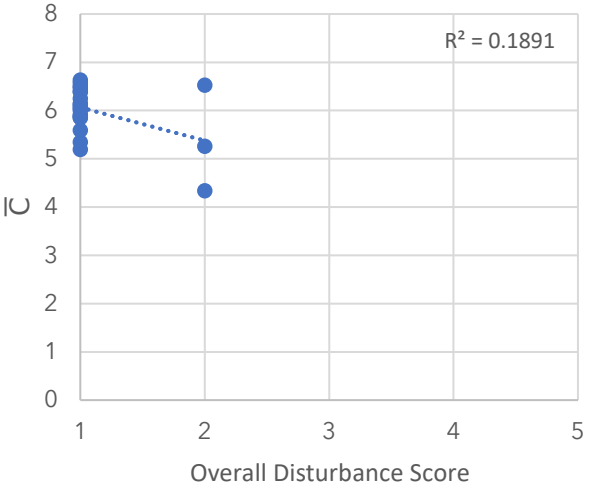
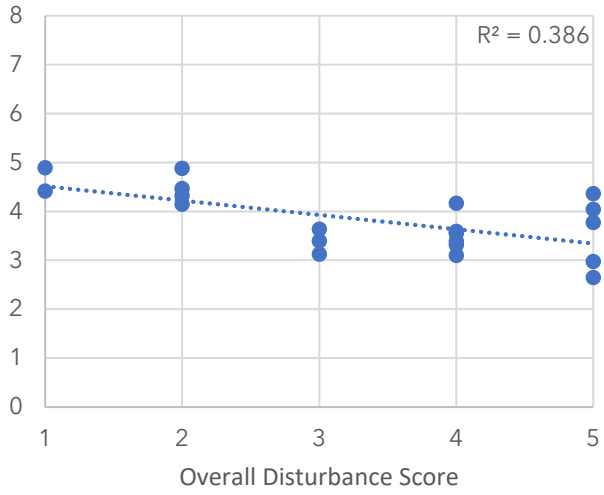


Figure B6. Wet Prairie



Figures B1-B6. Regression results showing mean C values vs overall disturbance scores by wetland community.

Figure B7. Bog Relict

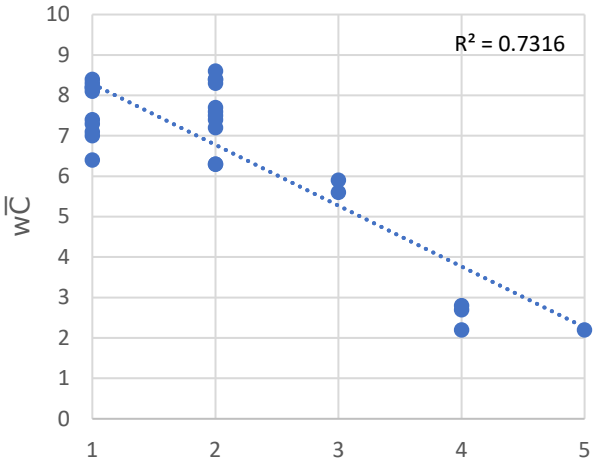


Figure B8. Forested Seep

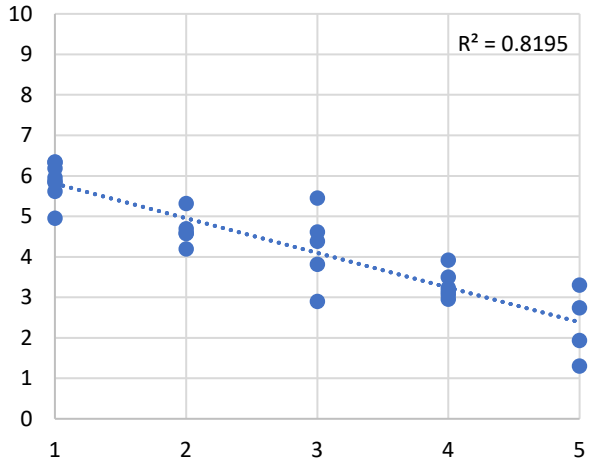


Figure B9. Interdunal Wetlands

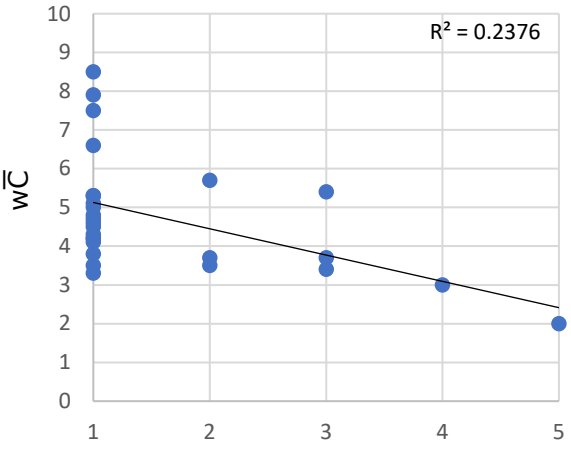


Figure B10. Southern Tamarack Swamp

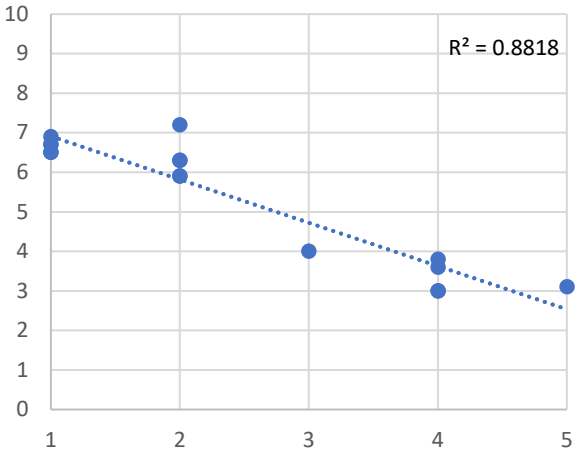


Figure B11. Wet Prairie

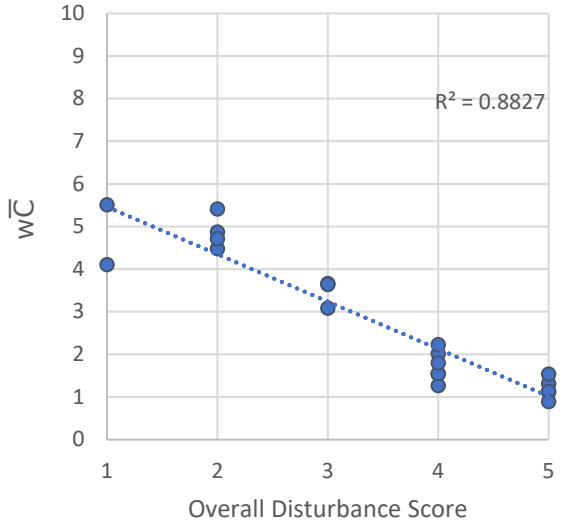
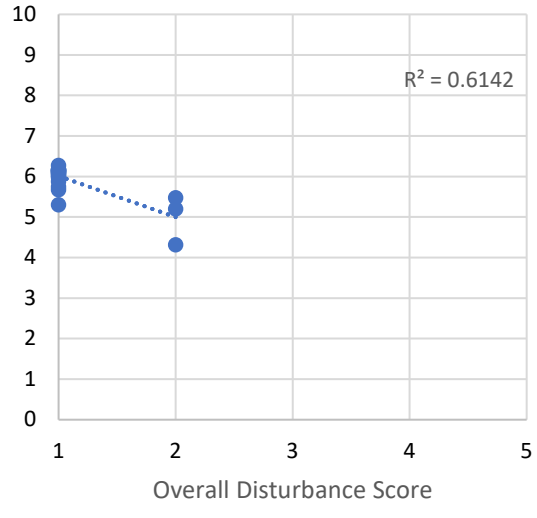


Figure B12. White Pine - Red Maple Swamp



Figures B7-B12. Regression results showing weighted mean C values vs overall disturbance scores by wetland community.

Appendix C: Box Plots of $\overline{C}$ and w$\overline{C}$ Results by Disturbance Category

Figure C1. Bog Relict

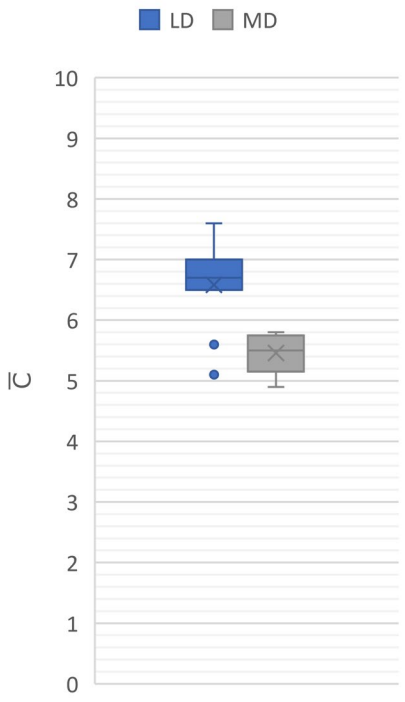


Figure C2. Forested Seep

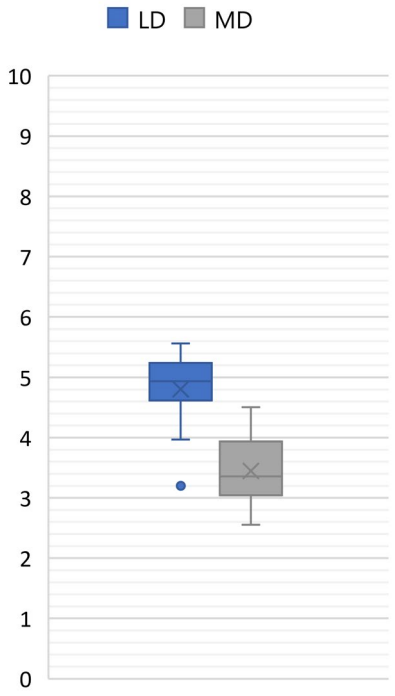


Figure C3. Interdunal Wetland

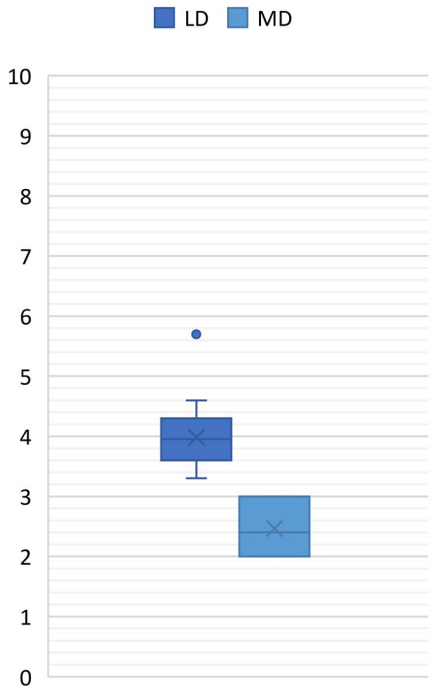


Figure C4. Southern Tamarack Swamp

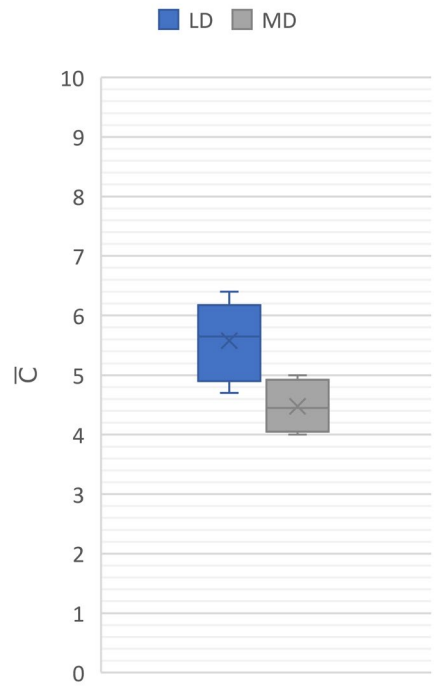


Figure C5. Wet Prairie

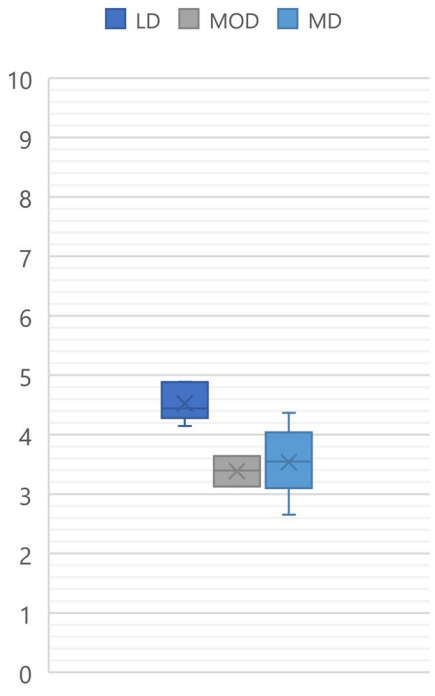
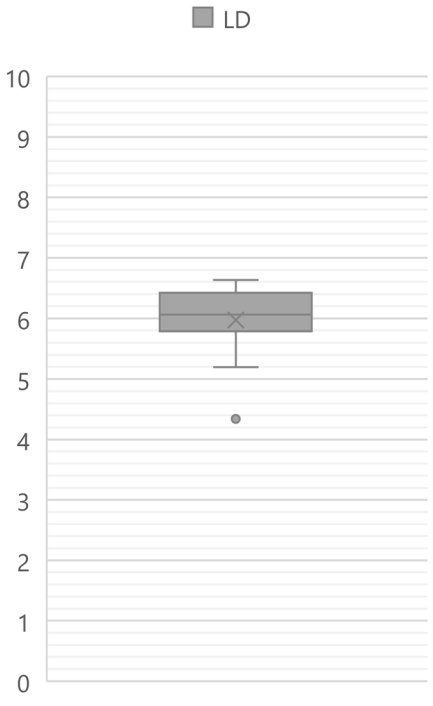


Figure C6. White Pine- Red Maple Swamp



Figures C1-C6. Boxplots of Mean C ($\overline{C}$) scores from Least Disturbed and Most Disturbed wetland communities. Wet Prairie additionally shows Moderate Scores (OD = 3) which overlapped strongly with Most Disturbed scores.

Figure C7. Bog Relict

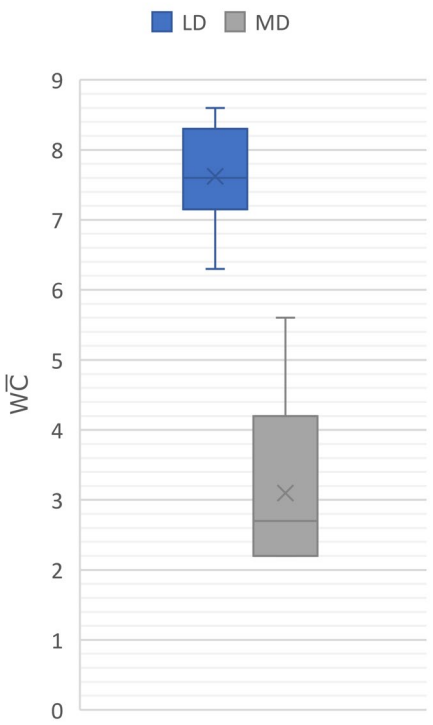


Figure C8. Forested Seep

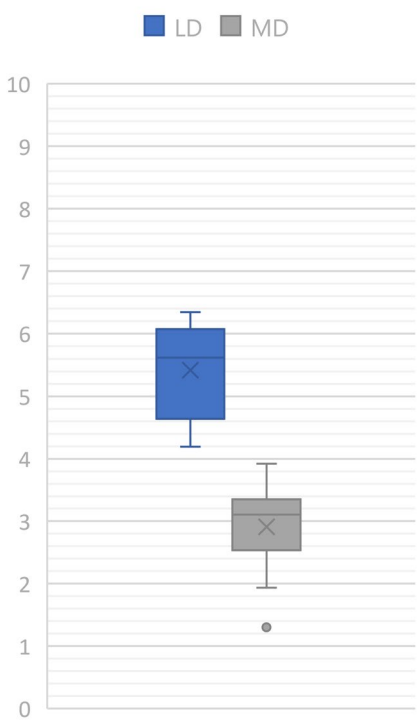


Figure C9. Interdunal Wetlands

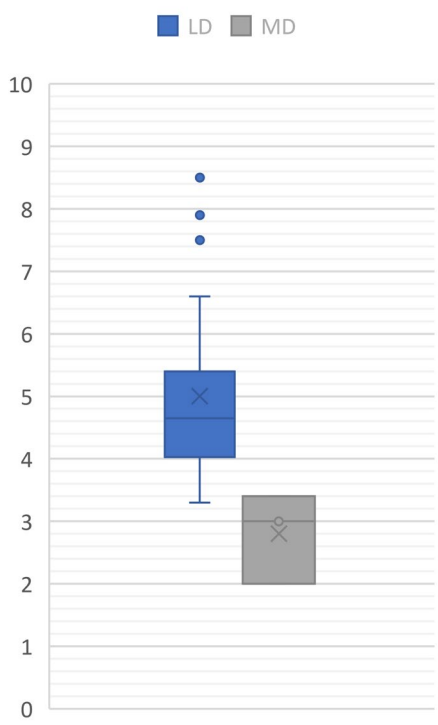


Figure C10. Southern Tamarack Swamp

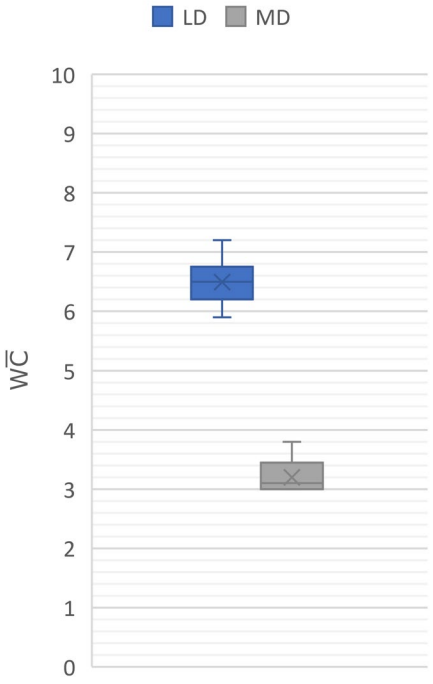


Figure C11. Wet Prairie

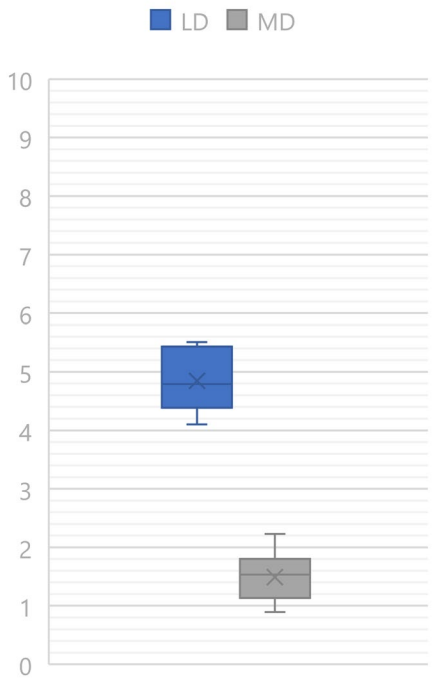
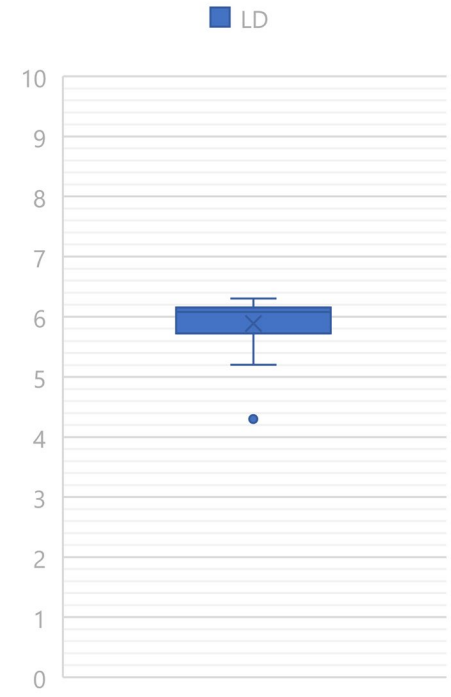


Fig C12. White Pine - Red Maple Swamp



Figures C7-C12. Boxplots of $\overline{wC}$ (Weighted Mean C-Value) scores from Least-Disturbed (LD) and Most-Disturbed (MD) wetland communities used to set 5 condition tiers.

Appendix D: Updated Natural Community Descriptions

Through this effort we have been able to better understand the composition, landscape setting, and natural distribution of these wetland types throughout Wisconsin. The information below will be updated on the DNR's NHC community descriptions websites.

Bog Relict

Bog relicts are peatlands found in kettle basins in interlobate and end moraine regions in southern Wisconsin that developed under a cooler climate after glaciers retreated. They can also occur in the Driftless Region but are very uncommon in that landscape and limited to a handful of known sites. Bog relicts tend to be heavily dominated by leatherleaf and occasionally huckleberry with a continuous layer of Sphagnum moss, though large areas of bog or poor fen sedges (i.e., *Carex oligosperma*, *Carex lasiocarpa*) may be present at some sites.

Tamarack may be present either on the margins of more open sites or in the interior, but rarely forms a continuous canopy. Tall shrubs include poison sumac and bog birch, though density and cover are variable. Many sites have a narrow moat with more minerotrophic species where groundwater seepage and runoff from uplands meets the wetland edge.

Bog relicts support a number of bog and poor fen species typically found further north, including small cranberry (*Vaccinium oxycoccos*), large cranberry (*Vaccinium macrocarpon*), rose pogonia (*Pogonia ophioglossoides*), tawny cotton-grass (*Eriophorum virginicum*), bog St. John's-wort (*Triadenum fraseri*), and insectivorous plants such as roundleaf sundew (*Drosera rotundifolia*), spoon-leaf sundew (*Drosera intermedia*), pitcher plant (*Sarracenia purpurea*), and intermediate bladderwort (*Utricularia intermedia*). Many of these bog relict indicators are at or near the southern edge of their range in southern Wisconsin and are evidence of these sites being relicts of a past, cooler climate.

Acidic wetlands with a floating sedge mat in southern Wisconsin are also included in the bog relict concept. While they have many similarities to poor fen, the latter is widely defined as a northern plant community occurring in a cool climate, whereas sites south of Wisconsin's tension zone are considered climate relicts, and thus, "bog" relicts, despite their similar flora.

Soils in bog relicts are deep, saturated Sphagnum peat and are usually very strongly to ultra acidic (pH 3.0 – 5.0). Mosses are abundant and can form large hummocks comprised of *Sphagnum magellanicum* (bog moss), members of the *Sphagnum recurvum* group, and *Polytrichum strictum* (strict haircap moss). Local poor fen pools can contain *Sphagnum cuspidatum* (feathery bog moss or drowned kittens).

Key Environmental Factors; Similar Communities

Bog relict is defined as a peatland south of Wisconsin's climatic tension zone that is dominated by ericaceous shrubs (especially leatherleaf and/or huckleberry) and a nearly continuous layer of Sphagnum moss (at least 40% cover, and often approaching 90% cover or more). Tamarack may be present but does not form a dense continuous canopy. More open sites can resemble a poor fen with high cover of *Carex lasiocarpa* but are still considered bog relicts, having developed under a cooler climate and containing more northerly bog and poor fen species.

Bog relict is closely related to southern tamarack swamp, from which it is distinguished by its high cover of leatherleaf and huckleberry, high cover Sphagnum moss, and deep peat soils that have very low pH (3.0-5.0). In contrast, southern tamarack swamps have much lower cover of leatherleaf and huckleberry, usually sparse and discontinuous cover of Sphagnum (<40% cover, usually much less) and mucky peat soils that are weakly to moderately acidic (pH >5.5). Tamarack coverage is also usually higher in southern tamarack swamps, though the decline of tamarack in southern Wisconsin may mask this difference. Other hardwood species may also be present such as red maple, yellow birch, American elm, and black ash. The tall shrub layer is also more well-developed in a tamarack swamp, especially with locally dense poison sumac, winterberry, and occasionally speckled alder.

Bog relict has many similarities with poor fen, open bog, and muskeg, but these are considered northern plant communities found in or north of Wisconsin's climatic tension zone.

Forested Seep

Forested seeps are shaded groundwater seepage areas with active spring discharges located within a matrix of upland hardwood forests. They are usually small in size, often only a few acres or less. However, under the right geological conditions such as broad seepage slopes, they can cover much larger areas. Seeps often coalesce into small babbling streamlets but can also occur in smaller pockets at the base of slopes, just above larger wetlands or rivers. They occur in a variety of landscape settings including moraines, river valleys along the margins of sandy outwash plains and lakeplains, and small steep-sided valleys in the Driftless Area. Soils are usually muck to mucky peat over a deeper sandy clay layer.

The canopy is usually dominated by black ash (*Fraxinus nigra*) and yellow birch (*Betula alleghaniensis*) with lesser amounts of basswood (*Tilia americana*). Surrounding uplands are usually dominated by mesic hardwoods such as sugar maple (*Acer saccharum*), red oak (*Quercus rubra*), and basswood, which often overhang smaller seeps and can contribute significantly to overall canopy cover. Small trees are usually occasional, especially musclewood (*Carpinus caroliniana*), American elm (*Ulmus americana*), mountain maple (*Acer spicatum*), and alternate-leaved dogwood (*Cornus alternifolia*).

The groundlayer is often lush and includes groundwater-loving species such as skunk cabbage (*Symplocarpus foetidus*), marsh marigold (*Caltha palustris*), golden saxifrage (*Chrysosplenium americanum*), swamp saxifrage (*Micranthes pennsylvanica*), and brome-like sedge (*Carex bromoides*). Sites often also reflect their upland matrix forest and contain mesic forbs such as lady fern (*Athyrium filix-femina*), wild geranium (*Geranium maculatum*), miterwort (*Mitella diphylla*) and zig-zag goldenrod (*Solidago flexicaulis*) alongside common wetland species such as jewelweed (*Impatiens capensis*), wood nettle (*Laportea canadensis*), fowl manna grass (*Glyceria striata*) and various asters (e.g., *Symphyotrichum lateriflorum*, *S. puniceum*).

Key Environmental Factors; Similar Communities

Forested seeps are characterized by the presence of active springs, prevalence of groundwater-loving herbaceous plants, and their occurrence within an upland forest setting. They are floristically most similar to northern hardwood swamps, which may have many of the same wetland species, but forested seeps are usually smaller in size, occur on or are bordered by moderately to steep slopes, and contain more actively flowing springs that quickly coalesce into small babbling streamlets. Forested seeps are prevalent on moraines, in Driftless Area valleys, and along slopes above major rivers. In contrast, northern hardwood swamps tend to occur in larger wetland basins on poorly drained till plains and lake plains in glaciated regions.

Northern wet-mesic forests (i.e., cedar swamps) also frequently have seepy areas and can occasionally occur on or at the base of slopes. However, here seeps are embedded in a larger wetland community with groundwater-fed hydrology, rather than being embedded in an upland forest. Thus, seeps occurring within a larger northern wet-mesic forest are simply considered part of the cedar swamp community.

Forested seeps have hydrologic similarities to springs and spring runs, but as defined in Wisconsin, the latter tends be associated with more open wetlands and often contain sun-loving plants such as watercress (*Nasturtium officinale*), cut-leaved water parsnip (*Berula erecta*), and common great angelica (*Angelica atropurpurea*) rather than shade-tolerant plants within a forested context.

Interdunal Wetlands

Interdunal wetlands occupy damp hollows within active dune fields along the Great Lakes shores. They may also occur where moving sand encroaches on nearby wetlands, surrounding and isolating all or portions of them. The vegetation is variable and is highly dependent on the size and shape of the wetland. Water depth in the wetland also strongly

influences plant composition, and water levels fluctuate with Great Lakes water levels. The same site can have deep pools of standing water some years and be nearly dry in others.

The wettest zones tend to have species such as twig-rush (*Cladium mariscoides*), hard-stem bulrush (*Schoenoplectus acutus*), and soft-stem bulrush (*S. tabernaemontani*). Sedges are also often a component of the standing water zone (e.g., *Carex aquatilis*, *C. lasiocarpa*, *C. oligosperma*). Sites on the Apostle Islands may also support the rare Michaux's sedge (*Carex michauxii*). Wetter zones are also prone to invasion by aggressive non-native species such as narrow-leaved cattail (*Typha angustifolia*) and Phragmites (*Phragmites australis* ssp. *australis*). If deep standing water is present, aquatic plants such as water-shield (*Brasenia schreberi*) and duckweed (*Lemna* spp.) may also occur.

The saturated soil zone can be extensive, supporting indicators such as little green sedge (*Carex viridula*), golden-fruited sedge (*Carex aurea*), Baltic rush (*Juncus balticus*), northern green rush (*Juncus alpinoarticulatus*), silverweed (*Potentilla anserina*), spike-rushes (especially *Eleocharis elliptica* and *E. quinqueflora*), ladies-tress orchids (*Spiranthes cernua* and *S. magnicamporum*), and false-foxgloves (*Agalinis paupercula* and *A. tenuifolia*).

Finally, the driest zone grading up to the dune is often dominated by hairy panic grass (*Dichanthelium acuminatum* var. *fasiculatum*). Sites on the drier end of the spectrum may lack the wetter species and be predominantly dominated by Baltic rush, silverweed, and hairy panic grass. Depth to water table can be quite variable in these drier sites, ranging from six inches to well over 24 inches. Nevertheless, these sites can be recognized as interdunal wetlands due to the presence of at least moderately hydrophytic vegetation that does not grow in the surrounding sand dunes.

Notably, due to the proximity to water, interdunal wetlands are often ringed by trees such as white pine, northern white-cedar, paper birch, balsam poplar, and the non-native invasive Scots pine. Shrubs are also occasional but rarely dominant. During prolonged periods of low water, young trees and shrubs can invade and establish in the wetland but are quickly killed when water levels return to normal levels.

Overall, interdunal wetlands and the dune systems that they occur in are rare and not well developed in Wisconsin compared to Michigan where the prevailing winds and nearshore currents are conducive to moving large quantities of sand along stretches of shorelines with active dune fields. High-quality examples of interdunal wetlands in Wisconsin are known from fewer than ten locations. Despite their rarity and limited distribution, these wetlands provide important habitat for many uncommon plant species and provide resting and feeding areas for migrating and resident water birds.

Key Environmental Factors; Similar Communities

Interdunal wetlands are distinguished by their location between dune ridges along the Great Lakes. They may superficially resemble northern sedge meadows, emergent marshes, or ephemeral ponds, but those communities rarely, if ever, occur in wet swales or hollows between sand dunes.

Southern Tamarack Swamp

Formerly known as tamarack rich swamp, this forested minerotrophic wetland community is dominated by tamarack (*Larix laricina*). Other hardwoods may also be present such as paper birch (*Betula papyrifera*), yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), black ash (*Fraxinus nigra*), and American elm (*Ulmus americana*). The understory is more diverse and structurally complex than in the more acid spruce-dominated swamps or southern bog relicts and includes nutrient-demanding species such as speckled alder (*Alnus incana*), mountain holly (*Ilex mucronatus*), common winterberry (*Ilex verticillata*), and poison sumac (*Toxicodendron vernix*). The latter is often the most abundant tall shrub in many southern tamarack swamps.

Sites are usually supported by groundwater seepage and can include plants such as marsh-marigold (*Caltha palustris*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), and skunk-cabbage (*Symplocarpus foetidus*). Sphagnum moss can be present in low amounts but is discontinuous and never dominant. Soils reflect the minerotrophic groundwater influence and are usually muck to mucky peat and are weakly to moderately acidic (pH >5.5).

Historically, southern tamarack swamps occurred extensively in parts of southeastern Wisconsin and on the eastern margin of Glacial Lake Wisconsin. Many of them were drained and cleared for agricultural purposes. Intact examples are now uncommon but occur in a wide variety of settings, such as on the margins of lakes or streams, at the base of moraines, in outwash areas, and in a few Driftless Area stream valleys. With the decline of tamarack in southern Wisconsin due to climate change, insect pests, fire suppression, and invasive species, many sites are transitioning to other community types.

Key Environmental Factors; Similar Communities

Southern tamarack swamps are characterized by their minerotrophic organic soils of weakly to moderately acidic (pH >5.5) muck to mucky peat, canopy dominated by tamarack and swamp hardwood associates, and prevalence of tall shrubs, especially poison sumac. They are most similar to bog relicts, but bog relicts have more acidic peat soils (pH 3.0-5.0), much higher coverage of Sphagnum moss (>40% cover, often approaching 90% cover) and higher coverage of ericaceous shrubs, especially leatherleaf and huckleberry. Bog relicts may have a sparse to moderate tamarack canopy but lack the hardwood associates and abundance of nutrient demanding shrubs.

Southern tamarack swamps have many species in common with northern hardwood swamps but the latter is usually dominated by hardwoods with tamarack usually sparse to absent. While northern hardwood swamps are more common in northern Wisconsin, they can be found scattered throughout southern Wisconsin in areas of calcareous groundwater seepage.

Southern tamarack swamps are also similar to northern tamarack swamps but the latter tends to be more acidic with a lower prevalence of strong calciphiles like poison sumac. Although the two communities are generally confined respectively to the southern and northern parts of the state, they do overlap somewhat in the Central Sands region. Although this region is within and south of Wisconsin's climatic tension zone, northern tamarack swamps are common in the ancient lakebed of Glacial Lake Wisconsin where flat, acid peatlands are underlain by nutrient-poor sands. Just to the east in the end moraines above the ancient lakeplain, southern tamarack swamps predominate due to the more minerotrophic groundwater seeping through the calcareous glacial deposits. Thus, nutrient status and the relative abundance of nutrient-demanding species is more useful than latitude in differentiating the two communities.

White Pine-Red Maple Swamp

This forested wetland community primarily occurs in the Central Sand Plains Ecological Landscape on the bed of Glacial Lake Wisconsin. These swamps occur along the upper reaches of low gradient headwaters streams and at the wetland-upland interface on the margins of the large acid peatlands that are prominent features in central Wisconsin. Soils are peat over acidic sands. Small, disjunct White Pine-Red Maple Swamps can also occur rarely in other areas of the state in areas with similar soils and geology, such as on sandy glacial lake plains and outwash valleys.

As the name suggests, the canopy is dominated by Eastern white pine (*Pinus strobus*) with a subcanopy of red maple (*Acer rubrum*). Yellow birch (*Betula allegheniensis*) and tamarack (*Larix laricina*) can also present in lesser amounts, though some sites grade into tamarack-dominated peatlands. Common understory shrubs are speckled alder (*Alnus incana*), common winterberry (*Ilex verticillata*), huckleberry (*Gaylussacia baccata*), and, in the low shrub layer, bristly dewberry (*Rubus hispidus*). In the ground layer, cinnamon fern (*Osmunda cinnamomea*) is often abundant. Other common herbaceous plants include skunk cabbage (*Symplocarpus foetidus*), gold thread (*Coptis trifolia*), starflower (*Trientalis borealis*), partridge berry (*Mitella repens*), Canada mayflower (*Maianthemum canadense*), and two disjuncts from the eastern United States, bog fern (*Thelypteris simulata*) and long sedge (*Carex folliculata*). Sphagnum mosses and liverworts are common and, in some sites, can form an almost continuous carpet over extensive areas.

Seepages and spring runs are often present in these swamps, providing important microhabitats for invertebrates, herptiles, and plants. This community occupies a landscape position between wet acid peatlands forested with tamarack and black spruce (*Picea mariana*), and dry, upland Central Sands pine-oak forests. Transitions to the upland forests can

be abrupt, with a sudden shift in the dominance of understory composition of wetland shrubs, herbs, and mosses, to dominance by bracken fern (*Pteridium aquilinum*), blueberries (*Vaccinium angustifolium and V. myrtilloides*), and Pennsylvania sedge (*Carex pensylvanica*). White Pine-Red Maple Swamps support an unusual mix of faunal species with high conservation value (e.g., Red-shouldered Hawk, amphibians, reptiles, and many species of neotropical migrant birds) due in part to their spatially variable microsites, high levels of ground cover, connectivity between wetland and upland communities, and uncommon structural features including large conifers and coarse woody debris.

Key Environmental Factors; Similar Communities

White Pine-Red Maple Swamps are forested wetlands characterized by acidic organic soils over acidic sand and a canopy dominated by white pine, usually with a subcanopy of red maple. In Wisconsin, they primarily occur in the Central Sand Plains Ecological Landscape. They may occur adjacent to northern tamarack swamps, but tamarack is not dominant in the White Pine-Red Maple Swamp. They sometimes contain springy areas or areas with groundwater seepage but are distinguished from forested seeps by their larger size and the fact that they are embedded in large wetland complexes in the Central Sands Plains as opposed to being small and embedded in upland hardwood forests.

Wet Prairie

Wet prairie is a tall grassland community that tends to occur on ecotones between more upland wet-mesic prairie and wetter sedge meadow. Soils are mineral, usually clay, sandy clay, or sandy clay loam, sometimes with a layer of loam (rarely mucky mineral) above. They occur most often on glacial lakeplain landforms but can also be found in wetland pockets on till plains and other landforms. Wet prairies are almost always small in size, seldom reaching more than a few acres except in large, intact lakeplain prairies.

Wet prairie is dominated by graminoids such as Canada bluejoint grass (*Calamagrostis canadensis*) and prairie cordgrass (*Spartina pectinata*) along with tussock sedge (*Carex stricta*) and yellow-headed fox sedge (*Carex annectens*). Other sedges may also be present such as running marsh sedge (*Carex sartwellii*), Bebb's sedge (*Carex bebbii*), marsh straw sedge (*Carex tenera*), and woolly sedge (*Carex pellita*). Big bluestem (*Andropogon gerardii*) is also often present in low amounts but is never dominant. In contrast to wet-mesic prairies, prairie grasses typically found in drier habitats are usually absent from wet prairies, such as Indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*).

Indicator forbs include winged loosestrife (*Lythrum alatum*) and cowbane (*Oxypolis rigidior*), though they are seldom abundant. Other more common forbs include species found in wet-mesic prairies such as swamp thistle (*Cirsium muticum*), mountain-mint (*Pycnanthemum virginianum*), yellow-headed coneflower (*Ratibida pinnata*), prairie dock (*Silphium terebinthinaceum*), Riddell's goldenrod (Solidago riddellii), New England aster (*Symphyotrichum novae-angliae*), Culver's root (*Veronicastrum virginicum*), and golden Alexander's (*Zizia aurea*) alongside forbs found in wetter habitats such as tall sunflower (*Helianthus giganteus*), giant goldenrod (*Solidago gigantea*), tall meadow-rue (*Thalictrum dasycarpum*), spotted Joe-pye-weed (*Eutrochium maculatum*), and grass-leaved goldenrod (*Euthamia graminifolia*). In general, the vegetation in wet prairies tends to be taller, and more rank and robust compared to either wet-mesic prairies or sedge meadows.

Key Environmental Factors; Similar Communities

Wet prairie is characterized by its grass and sedge dominance on moist mineral soils. They often occur as a fringe along the upland edge of sedge meadows or emergent marshes or on the lower edge of wet-mesic prairies. They can be distinguished from wet-mesic prairies by their higher water table (usually within 12 inches of the surface during a normal year), taller (usually 3 feet or more), more rank vegetation, and higher prevalence of grasses and forbs associated with wetter habitats such as bluejoint grass, prairie cord grass, Joe-Pye-weed, boneset (*Eupatorium perfoliatum*), common water hemlock (*Cicuta maculata*), swamp milkweed (*Asclepias incarnata*), and water smartweed

(*Persicaria amphibia*). In addition, wet prairies lack grasses found in drier habitats such as Indian grass, little bluestem, and prairie dropseed.

Wet prairie also shares similarities with southern sedge meadow, though sedge meadows tend to occur on organic soils (rarely mineral soils) while wet prairies almost always occur on mineral soils. Wet prairies also have a higher prevalence of grasses such as prairie cordgrass, bluejoint grass, and occasionally big bluestem, while southern sedge meadows have a higher prevalence of sedges. Similarly, calcareous fens (sometimes called prairie fens due to their prairie flora) are also usually located on organic soils (peat and/or marl) rather than mineral soils. While fens impacted by past land use such as plowing or hydrologic alteration can have vegetation very similar to a wet prairie (including prairie cord grass and tall sunflower), examination of the soil with a soil probe (at least 36-40" deep) will almost always reveal peat (sometimes oxidizing to mucky mineral) and marl rather than a shallow clay layer that typifies wet prairies.

Wet prairies have some forbs in common with emergent marshes but lack the dominance of cattails and bulrushes that typify marshes, although aggressive non-native cattails (e.g., *Typha angustifolia, T.* X *glauca*) may invade and take over wet prairies, blurring this distinction.

Wet prairies also sometimes occur in wetland complexes with shrub-carr, and can become invaded by shrubs if the hydrology and fire regime is disrupted. The dividing line between shrub-carr and prairie is generally the degree of shrub cover, with shrub-carr having greater than 50% cover but the length of time shrubs have been dominant and the presence of prairie indicators can help distinguish a shrub-invaded but restorable wet prairie from a shrub-carr with a long presence on the landscape.

Appendix E: Updated Key to Wisconsin Wetland Natural Communities

Key to Wetland Natural Communities of Wisconsin





Wisconsin's Natural Heritage Inventory Program
Bureau of Natural Heritage Conservation
Department of Natural Resources
P.O. Box 7921, Madison, WI 53707

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Acknowledgments

This resource is the product of decades of data collection and analysis. Numerous individuals have played a significant role in its development, not least Eric Epstein, former ecologist with the Wisconsin DNR and John Curtis, author of Vegetation of Wisconsin (1959) and grandfather of the natural community classification for Wisconsin. Special thanks also to Melissa Gibson, Aaron Marti, Tom Bernthal, Sally Jarosz, Chris Noll, Amy Staffen, Kevin Doyle, Zach Kron, and John Zaborsky for their assistance with field data collection and feedback on the key. Countless additional past ecologists and botanists have also contributed to the composition, distribution, and general knowledge of Wisconsin's wetland natural communities. Funding for the initial development of this resource was provided by an EPA Wetland Program Development Grant.

Primary Author: Ryan O'Connor

Cover Photos: Clockwise from top left: Kakagon Sloughs and Long Island (photo by Christina Isenring), floodplain forest on Wisconsin River at flood stage (photo by Ryan O'Connor), prairie cordgrass in wet prairie at Princeton Prairie State Natural Area (photo by Ryan O'Connor), poison sumac at edge of bog relict at Lulu Lake State Natural Area (photo by Ryan O'Connor), black spruce swamp at Scott Lake and Shelp Lake State Natural Area (photo by Ryan O'Connor).

Suggested citation:
O'Connor, R.P. 2023. Key to Wetland Natural Communities of Wisconsin, version 1.4. Wisconsin Department of Natural Resources, Bureau of Natural Heritage Conservation. Madison, WI.

Introduction

This key is for the Wisconsin DNR Bureau of Natural Heritage Conservation natural community classification. The key is based on communities with minimal anthropogenic disturbance, although ruderal communities based in part on the U.S. National Vegetation Classification have been included for completeness. Semi-disturbed sites as well as sites undergoing ecological restoration may fall somewhere between a weedy, ruderal type and a least-disturbed natural community and may be difficult to classify. If utilizing this key in the field, avoid transition areas and ecotones. In addition, key users must recognize that sites change over time through succession and disturbance. For example, tree or shrub encroachment or disturbances such as catastrophic fire, pest and disease outbreaks, windthrow, or beaver flooding may leave a site in an intermediate state as it recovers from disturbance or transitions from one community type to another. As with any key, users are encouraged to choose the statement in the couplet that best fits the community observed in the field, even if it does not match all aspects of the couplet.

This key is not intended to be used alone to definitively classify natural communities. Once you have worked a through the key, users are encouraged to read the additional descriptions provided on the WDNR Natural Heritage Inventory natural community webpages available online at dnr.wi.gov, keyword "protecting Wisconsin's biodiversity". Links to the community webpages are included in the key below. For each natural community type, online information includes a general overview, photos, associated rare plants and animals, and a print-ready 2- to 4-page detailed description featuring the distribution, abundance, environmental setting, ecological processes, community composition and structure, and conservation and management considerations excepted from Chapter 7 of the Ecological Landscapes of Wisconsin (dnr.wi.gov, keyword "ecological landscapes").

1a. Wetland dominated by > 75% non-native cover or cover of non-native species is less but native species are indicative of disturbance (ruderal communities).
  2a. Wetlands with at least 30% cover of trees or shrubs (ruderal forested and shrub wetlands).
    3a. Forested with at least 30% canopy of trees, usually dominated by non-native tree willows [e.g., crack willow (*Salix* X *fragilis*), etc.] or weedy natives such as boxelder. Shrub layer strongly dominated by non-native species such as non-native bush honeysuckles (*Lonicera* spp.), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Frangula alnus*), and multiflora rose (*Rosa multiflora*); herbaceous layer also usually dominated by non-natives such as reed canary grass (*Phalaris arundinacea*), garlic mustard (*Alliaria petiolata*), creeping Charlie (*Glechoma hederacea)*, dame's rocket (*Hesperis matronalis*), and moneywort (*Lysimachia nummularia*). Generalist native tree species may be co-dominant in the canopy, especially green ash or red maple ..... **Ruderal Flooded and Swamp Forest**
    3b. Dominated by non-native shrubs (<30% tree cover) such as non-native bush honeysuckles, common buckthorn, or glossy buckthorn, sometimes co-dominated by aggressive native shrubs such as dogwoods (*Cornus* spp.), sandbar willow (*Salix interior*), etc. Ground layer typically strongly dominated by reed canary grass, or occasionally bare ground where shrubs are very dense..... **Ruderal Shrub Swamp**
  2b. Wetlands with trees and tall shrubs (>5 feet tall) less than 30% cover (ruderal marshes and meadows).
    4a. Dominated by non-native reeds and cattails such as common reed (*Phragmites australis* ssp. *australis*), invasive or hybrid cattail species (e.g., *Typha angustifolia*, *T.* X *glauca*), or reed manna grass (*Glyceria maxima*). Non-native forbs may also be dominant, such as purple loosestrife (*Lythrum salicaria*). ..... **Ruderal Marsh**
    4b. Dominated by non-native grasses such as reed canary grass (*Phalaris arundinacea*) and redtop (*Agrostis gigantea*), or by weedy native forbs such as giant ragweed (*Ambrosia trifida*), stinging nettle (*Urtica dioica*), Canada goldenrod (*Solidago canadensis*), blunt spike-rush (*Eleocharis obtusa*), etc. ..... **Ruderal Wet Meadow**

1b. Wetland dominated by native vegetation (Wisconsin Natural Heritage Conservation natural communities).
  5a. Very small (usually one acre or less) kettle depressions in forested landscapes on moraines or interlobate regions, with standing water in spring, usually drying by late summer..... **Ephemeral Pond**
  5b. Larger wetlands, or if small, occurring in a variety of other landscapes and hydrologic setting combinations.

6a. Forested or tall shrub-dominated wetlands. Mature trees contributing greater than 30% overall canopy cover or tall shrubs (> 5 feet) contributing more than 50% canopy cover.

7a. FORESTED WETLANDS. Dominated by trees contributing greater than 30% overall canopy cover.

8a. Community occurring adjacent to Great Lakes shorelines on alternating series of narrow, sandy, upland ridges and low swales. Ridges may be open or shrub-dominated closest to the shoreline, and further from the shore are forested with pines, oaks, white spruce, balsam fir, and paper birch. Swales may contain open water, sedge meadow, alder, or be forested with black ash, tamarack, or northern white-cedar ... **Great Lakes Ridge and Swale**

8b. Community occurring adjacent to Great Lakes shorelines or not, but landforms and topography otherwise.

9a. Conifers common to dominant throughout canopy layer.

10a. Canopy dominated by northern white-cedar or white pine. Tamarack and black spruce may be present but are minor canopy components and are not dominant across large areas.

11a. Canopy dominated by white pine, subcanopy dominated by red maple. Groundlayer often dominated by cinnamon fern (*Osmunda cinnamomea*), bristly dewberry (*Rubus hispidus*), and long sedge (*Carex folliculata*). Located mainly in Central Sand Plains ecological landscape on an ancient glacial lakebed. Soils peat over acidic sand..... **White Pine-Red Maple Swamp**

11b. Canopy dominated by northern white-cedar, sometimes co-dominant with black ash, balsam fir, tamarack, or black spruce. Groundlayer often contains sedges (such as *Carex disperma* and *C. trisperma*) and forbs such as fringed polygala (*Polygala pauciflora*), naked miterwort (*Mitella nuda*), twinflower (*Linnaea borealis*), creeping snowberry (*Gaultheria hispidula*), and Sphagnum and other mosses. Located mainly in northern (occasionally in southeastern) Wisconsin in areas with mineral-enriched groundwater, often on outwash plains and ground moraines. Soils usually muck to mucky peat, minerotrophic, weakly acidic to moderately alkaline .....**Northern Wet-mesic Forest**

10b. Canopy dominated by black spruce or tamarack. Cedar and white pine absent to sparse.

12a. Located south of Wisconsin's climatic tension zone.

13a. Dominated by tamarack, may be co-dominated by American elm, black ash, red maple, or yellow birch. Poison sumac or winterberry often common in tall shrub layer. Sphagnum usually sparse and discontinuous (<40% cover, usually much lower), or if higher, ericaceous shrubs (especially leatherleaf) sparse. Soil substrate usually muck to mucky peat, weakly to moderately acidic (pH >5.5). ..... **Southern Tamarack Swamp**

13b. Dominated by tamarack or rarely by black spruce. (More commonly, tree layer absent to sparse, but included here in key for convenience for sites with locally higher canopy. See also couple 28 under non-forested wetlands). Tall shrub layer variable. Leatherleaf (*Chamaedaphne calyculata*) and/or huckleberry (*Gaylussacia baccata*) usually abundant in low shrub layer. Sphagnum usually continuous (>40% cover, often much higher, approaching 90% cover). Soils substrate peat, usually very strongly to ultra acidic (3.0 – 5.0). ..... **Bog Relict**

12b. Located mainly north of Wisconsin's climatic tension zone or in the Central Sand Plains Ecological Landscape. Canopy dominated by black spruce or tamarack; most associates above (American elm, red maple, yellow birch) absent or sparse, though black ash may be present. Note: Formerly, all northern coniferous wetlands dominated by tamarack or black spruce in Wisconsin were termed Northern Wet Forest. While occasional records of this type remain in legacy data, it has been effectively retired and is now split into the following communities.

14a. Canopy dominated by black spruce or co-dominant with tamarack. Tall shrub layer (> 5 feet) usually sparse (< 5% total cover, usually much less), shrubs listed in 14b absent to sparse. Sphagnum moss abundant, often forming a nearly continuous carpet. Soils extremely acidic (<4.5).. **Black Spruce Swamp**

14b. Canopy dominated by tamarack; black ash may be locally co-dominant. Tall shrubs common (> 5% total cover, usually much greater) dominated by species such as speckled alder (*Alnus incana*), mountain holly (*Ilex mucronata*), winterberry (*Ilex verticillata*), black chokeberry (*Aronia melanocarpa*), and bog birch (*Betula pumila*). Sphagnum moss occasional on hummocks, usually discontinuous. Soils strongly to moderately acidic (pH 4.5 – 5.5) ..... **Northern Tamarack Swamp**

9b. Conifers absent, or, if present, less dominant than hardwoods (may be locally co-dominant in hardwood swamps).

15a. Occurring in floodplains of 3rd order or greater streams and rivers. Dominant overstory species include silver maple, green ash, black willow, cottonwood, river birch, basswood, swamp white oak, bur oak, bitternut hickory, and hackberry (boxelder may be dominant in disturbed stands). Where organic soil accumulates in areas such as groundwater seepages, backswamps, and meander scars, tree species may include black ash, yellow birch, red maple, and conifers (tamarack, northern white-cedar, white pine, and hemlock), especially in northern Wisconsin..... **Floodplain Forest**

15b. Occurring along headwater streams (1st and 2nd orders), seeps, and on poorly drained glacial outwash, lakeplain, and/or depressions in moraines or ice-contact topography.

16a. Occurring along sloping seepage areas with active spring discharges in hardwood forests, usually at the head of ravines or at the base of steep bluffs. Found in moraines, river valleys along the margins of sandy outwash plains and escarpments below glacial lakeplains, and in small steep-sided valleys in the Driftless Area. ..... **Forested Seep**

16b. Occurring on mostly level terrain along headwater streams, outwash plains, lakeplains, or depressions in moraines and ice-contact topography.

17a. Canopy dominated by black ash, often with red maple, yellow birch, or American elm. Conifers such as balsam fir and northern white-cedar may be locally common. Green ash and silver maple absent to sparse. Specked alder common. Groundlayer dominated by marsh marigold (*Caltha palustris*), swamp raspberry (*Rubus pubescens*), orange jewelweed (*Impatiens capensis*), purple-stemmed aster (*Symphyotrichum puniceum*), lake sedge (*Carex lacustris*), blue-joint grass (*Calamagrostis canadensis*); many also include groundwater-loving species like bristle-stalked sedge (*Carex leptalea*), American golden saxifrage (*Chrysosplenium americanum*), and swamp saxifrage (*Micranthes pensylvanica*). Soils mucks or mucky sands, usually constantly saturated with a relatively stable water table. Occurring along lakes, streams, or in poorly drained basins. ..... **Northern Hardwood Swamp**

17b. Canopy dominated by silver maple, red maple (or the hybrid *Acer* X *freemanii*), and green ash. Associate species may include swamp white oak, bur oak, basswood, and American elm, which may be dominant in stands impacted by emerald ash borer. Black ash local but not dominant. Speckled alder uncommon or absent. Groundlayer dominated by species typical of floodplain forests such as Virginia wild-rye (*Elymus virginicus*), white grass (*Leersia virginica*), common wood-reed (*Cinna arundinacea*), wood nettle (*Laportea canadensis*), false nettle (*Boehmeria cylindrica*), and Ontario aster (*Symphyotrichum ontarionis*). Soils predominantly mineral, water table fluctuating seasonally (wet in the spring, drying below the soil surface by late summer). Occurring in insular basins on low-lying portions of till plains and on lakeplains. Not restricted to southern Wisconsin; the name rather refers to swamps more commonly found in the southern Midwest. ..... **Southern Hardwood Swamp**

7b. SHRUB-DOMINATED WETLANDS. Trees contributing 30% or less to overall canopy cover. Tall shrubs (> 5 feet) dominant, contributing greater than 50% overall canopy cover.

18a. Shrub layer dominated by speckled alder, with alder contributing to half or more of the shrub canopy cover relative to all other shrubs combined. Occurring mainly in central and northern Wisconsin, rare in southern Wisconsin and Driftless Region. ..... **Alder Thicket**

18b. Shrub layer dominated by a greater diversity of shrubs, often at least 4 or 5 species that are co-dominant. Alder usually present, even common, but contributes less than half of the relative shrub cover. Other common shrub species may include willows (*Salix* spp.), dogwoods (*Cornus* spp.), meadowsweet (*Spiraea alba*), bog birch (*Betula pumila*), nannyberry (*Viburnum lentago*), winterberry (*Ilex verticillata*), poison sumac (*Toxicodendron vernix*), etc. Occurring statewide..... **Shrub-carr**

6b. OPEN (NON-FORESTED) WETLANDS. Mature trees absent or contributing 30% or less overall canopy cover. Tall shrubs (> 5 feet) contributing to 50% or less canopy cover.

19a. Standing water greater than 6 inches deep usually present in normal (non-drought) growing season (most marshes).

20a. Vegetation dominated by submergent or floating-leaved aquatic vegetation, or, if emersed, dominated by American lotus-lily (*Nelumbo lutea*).

21a. Vegetation dominated by near-continuous (>50%) cover of rooted floating leaved vegetation (i.e., not counting free-floating duckweeds) or American lotus-lily (*Nelumbo lutea*).

22a. Vegetation dominated by American lotus-lily. Occurring along margins of large rivers, especially the Mississippi, Lower Wolf and Winnebago Pool lakes. .....**American Lotus-lily Marsh**

22b. Vegetation dominated by other species, usually with large round leaves such as white water-lily (*Nymphaea variegata*), bull-head pond-lily (*Nuphar variegata*), or water-shield (*Brasenia schreberi*). Other aquatic macrophytes with long, narrow floating leaves may also be present such as long-leaf pondweed (*Potamogeton nodosus*) and floating-leaf bur-reed (*Sparganium fluctuans*). Occurring in lakes, ponds, or occasionally margins of rivers. .....**Floating-leaved Marsh**

21b. Vegetation dominated by submergent aquatics. Rooted aquatic macrophytes with floating leaves (i.e., not counting free-floating duckweeds) less than 50% cover.

23a. Vegetation dominated by rosette-forming aquatic macrophytes such as seven-angled pipe-wort (*Eriocaulon aquaticum*), yellow hedge-hyssop (*Gratiola aurea*), aquatic lobelia (*Lobelia dortmanna*), dwarf water-milfoil (*Myriophyllum tenellum*), brown-fruited rush (*Juncus pelocarpus*), and quillworts (*Isoetes* spp). Occurring in clear, deep, circumneutral lakes with extremely soft water in northern Wisconsin. Bottom materials usually sand or occasionally gravel. .....**Oligotrophic Marsh**

23b. Vegetation dominated by a wide variety of common aquatic macrophytes, including pondweeds (*Potamogeton* spp.), waterweeds (*Elodea* spp.), coon's-tails (*Ceratophyllum* spp.), slender naiad (*Najas flexilis*), eel-grass (*Vallisneria americana*), water-milfoils (*Myriophyllum* spp.) and bladderworts (*Utricularia* spp.). Occurring in a wide variety of lake types and water chemistries. Bottom materials usually muck or silt but may also include sand and gravel. .....**Submergent Marsh**

20b. Vegetation dominated by emergent vegetation, usually 1.5 – 3+ feet above the surface by mid- to late summer.

24a. Occurring along the margins of sand-bottomed seepage lakes and ponds on glacial lakebeds (especially Glacial Lake Wisconsin) and outwash plains in south central Wisconsin. Vegetation exhibiting strong zonation with sedges (*Carex* spp.) and bulrush (*Scirpus* spp.) dominant in the emergent zone, aquatic macrophytes (e.g., water-shield, etc.), in deeper water, and with medium-statured grasses, sedges, and forbs disjunct from the Atlantic Coastal Plain in shallow water and along the shore, especially autumn or chestnut sedge (*Fimbristylis* spp.), dwarf umbrella-sedge (*Fuirena pumila*), half-chaff sedge (*Lipocarpha* spp.), beak-rush (*Rhynchospora* spp.), nut-sedge (*Scleria* spp.), brown-fruited rush (*Juncus pelocarpus*), milkworts (*Polygala cruciata* and *P. sanguinea*), tooth-cup (*Rotala ramosior*), meadow-beauty (*Rhexia virginica*), lance- leaved violet (*Viola lanceolata*), and yellow-eyed grass (*Xyris torta*). .....**Coastal Plain Marsh** (high water phase)

24b. Occurring in a wide variety of hydrologic settings including inland lakes, Great Lakes, and along rivers Vegetation dominated by cattail, wild rice, bulrushes, or other species, lacking Coastal Plain disjuncts.

21a. Vegetation dominated by northern wild rice (*Zizania palustris*) or southern wild rice (*Zizania aquatica*). .....**Wild Rice Marsh**

21b. Vegetation dominated by species such as cattails (*Typha latifolia*), giant reed (*Phragmites australis var. americana*), bulrushes (*Schoenoplectus* spp.), river bulrush (*Bolboschoenus fluviatilis*), lake sedge (*Carex lacustris*), bur-reeds (*Sparganium* spp.), water-plantains (*Alisma* spp.), common spike-rush (*Eleocharis palustris*) and occasionally cut grass (*Leersia oryzoides*); wild rice may also present locally but is not dominant across large areas. Non-native cattail (*Typha angustifolia*, *T.* X *glauca*) and giant reed (*Phragmites australis* var. *australis*) may be occasional to locally common; if dominant, go to Ruderal Marsh (couplet 4a). .....**Emergent Marsh**

19b. Standing water absent or less than 6 inches deep throughout community in growing season, though water may be deeper in local pools (peatlands, fens, wetland prairies, sedge meadows, and coastal plain marsh, in part).

26a. Community structure characterized by a repeated, alternating pattern of low peat rises (strings) and hollows (flarks), especially evident on aerial photos. Strings may support scattered and stunted black spruce, tamarack, northern white-cedar, low shrubs including bog birch, shrubby cinquefoil, bog rosemary (*Andromeda glaucophylla*), leatherleaf (*Chamaedaphne calyculata*), and sedges (*Carex oligosperma, C. limosa, C. lasiocarpa*). The alternating flarks are often inundated and may support many sedges of bogs and fens, along with ericads, sundews (*Drosera* spp.), orchids, arrow-grasses (*Triglochin* spp.), and shrubs such as bog birch and shrubby cinquefoil (*Dasiphora fruticosa*). Soils are deep peat and slightly acid to circumneutral. Extremely rare in Wisconsin, known from only a handful of sites. .....**Patterned Peatland**

26b. Community structure lacking repeating pattern of low peat rises and alternating hollows.

27a. Sphagnum mosses abundant or at least locally dominant on scattered low peat mounds, soils peat. Groundlayer dominated by ericaceous shrubs or sedges.

28a. Occurring in kettle basins within glaciated areas in southern Wisconsin or rarely in the Driftless Region and dominated by leatherleaf, few-seeded sedge (*Carex oligosperma*), or wiregrass (*Carex lasiocarpa*). Poison sumac often present, especially near edge of upland and/or lake. “Bog” indicators more typical of northern Wisconsin often present including cranberries (*Vaccinium macrocarpon* and *Vaccinium oxycoccos*), sundews (*Drosera* spp.), pitcher plant (*Sarracenia purpurea*), and rose pogonia (*Pogonia ophioglossoides*) ....**Bog relict**

28b. Occurring in central or northern Wisconsin, within or north of the climactic tension zone.

29a. Tree canopy cover typically 10 to 30%, consisting of scattered and stunted black spruce and tamarack. Occurring in central and northern Wisconsin. Soils strongly acidic (pH <4.5) deep peat. ..... **Muskeg**

29b. Trees absent or occurring in localized areas with overall canopy cover typically less than 10%.

30a. Vegetation surface uneven and dominated by pronounced Sphagnum hummocks (often 18-24” or more in height) with intervening hollows; hummocks dominated by ericaceous shrubs such as leatherleaf, bog rosemary, Labrador tea, and bog laurel (*Kalmia polifolia*). Soil very strongly acidic, deep fibric peat. Occurring usually in the center of large peatland basins or occasionally on firm peat above a lake margin, always where the rooting zone is elevated above the influence of minerotrophic groundwater..... **Open Bog**

30b. Vegetation surface more even or with widely scattered low hummocks (usually less than 18-24” high). Soils strongly acidic to weakly minerotrophic. Occurring in broad depressions on lakeplains and outwash plains or along the margins of lakes, usually in contact with groundwater or surface water.

31a. Vegetation dominated by few-seed sedge (*Carex oligosperma*) and/or wiregrass sedge (*C. lasiocarpa*). Common shrubs are leatherleaf, bog rosemary and occasionally bog birch, plus stunted tamarack and black spruce. Other indicator species include mud sedge (*Carex limosa*), pitcher-plant (*Sarracenia purpurea*), round-leaved sundew (*Drosera rotundifolia*), pod grass (*Scheuchzeria palustris*), bogbean (*Menyanthes trifoliata*) and the pink-flowered orchids (*Calopogon tuberosus*, *Pogonia ophioglossoides* and *Arethusa bulbosa*). Usually occurring north of the climatic tension zone in kettle depressions and on level areas or shallow depressions of glacial outwash and lakeplains, often on the margins of "bog" lakes with a floating or grounded mat of peat and sedge rhizomes. .....**Poor Fen**

31b. Vegetation dominated by common yellow lake sedge (*Carex utriculata*), few-seed sedge (*Carex oligosperma*), wiregrass sedge (*C. lasiocarpa*), and bluejoint grass (*Calamagrostis canadensis*); wool grass (*Scirpus cyperinus*) occasional. Small tamarack and white pine scattered. Common shrubs are hardhack (*Spiraea tomentosa*), bristly dewberry (*Rubus hispidus*), leatherleaf, black chokeberry (*Aronia melanocarpa*), Kalm's St. John's-wort (*Hypericum kalmianum*) and sometimes bog birch (*Betula pumila*). Indicator forbs include swamp-candles (*Lysimachia terrestris*) and bog goldenrod (*Solidago uliginosa*). Minerotrophic herbaceous plants and orchids usually lacking. Occurring almost exclusively in the Central Sand Plains on the lakebed of Glacial Lake Wisconsin..... **Central Poor Fen**

27b. Sphagnum mosses absent or local. Soils various. Ground layer dominated by sedges, rushes, grasses, and/or forbs. Ericaceous shrubs absent to sparse.

32a. Prairie grasses or bluejoint grass common. Soils loam, silty clay loam, sandy clay loam, sandy clay, clay, or silty clay, sometimes overlain by a few inches of sand.

33a. Dominated by big bluestem, little bluestem, Indian grass, and prairie dropseed. Bluejoint grass, cordgrass, and tussock sedge may be present but are uncommon to rare. Forbs usually short (<2 to 3 feet), though may include some taller species such as prairie blazing-star (*Liatris pycnostachya*), prairie phlox (*Phlox pilosa*), prairie coneflower (*Ratibida pinnata*), prairie dock (*Silphium terebinthinaceum*), and Culver's-root (*Veronicastrum virginicum*). "Marsh forbs" (see 33b) absent to sparse ..... **Wet-mesic Prairie**

33b. Dominated by cordgrass and bluejoint grass with tussock sedge or yellow-headed fox sedge (*Carex annectens*) with at least occasional wet prairie indicators such as winged loosestrife (*Lythrum alatum*) and cowbane (*Oxypolis rigidior*). Big bluestem may be present and rare, but little bluestem, Indian grass, and prairie dropseed absent. Vegetation (including forbs) usually tall (~3+ feet) and rank, may include forbs noted above (33a) as well as "marsh forbs" such as Joe-Pye-weed (*Eutrochium maculatum*), boneset (*Eupatorium perfoliatum*), common water hemlock (*Cicuta maculata*), swamp milkweed (*Asclepias incarnata*), and water smartweed (*Persicaria amphibia*)..... **Wet Prairie**

32b. Prairie grasses absent to uncommon. Soils sand or peat (occasionally mucky mineral, silty clay loam or clay loam). If heavier mineral soils at surface, soils saturated.

34a. Occurring along the shorelines of Lake Michigan and Superior, or in estuarine complexes near the Great Lakes, with hydrology influenced at least indirectly by Great Lakes water levels.

35a. Located in coastal embayments, often behind a barrier sandspit or near the mouth of estuarine rivers. Vegetation usually a floating mat dominated by wiregrass sedge (*Carex lasiocarpa*), twig-rush (*Cladium mariscoides*), sweet gale (*Myrica gale*), and buckbean (*Menyanthes trifoliata*)..... **Great Lakes Shore Fen**

35b. Located in depressions in open dunes or between dune ridges. Soils moist or submerged sand (sometimes covered by a thin layer of muck or marl). Water level sometimes deepening to several feet in center of depression. Species various, but often include Baltic rush (*Juncus balticus*), northern green rush (*Juncus alpinoarticulatus*), silverweed (*Potentilla anserina*), twig-rush (*Cladium mariscoides*), golden-seeded spike-rush (*Eleocharis elliptica*), hairy panic grass (*Dichanthelium acuminatum* var. *fasiculatum*), and sedges (e.g., *Carex aquatilis*, *C. aurea, C. lasiocarpa*, *C. oligosperma*, *C. viridula,* and in far northern Wisconsin, *C. michauxii*). ..... **Interdunal Wetland**

34b. Occurring elsewhere, or, if near the Great Lakes, hydrology not influenced by Great Lakes water levels.

36a. Occurring in shallow sandy depressions or on perimeters (or rarely entire shallow basins) of softwater seepage lakes with drying shores and other isolated depressions characterized by large water table fluctuations (both seasonally and from year to year). Soils sand or peaty sand.

37a. Occurring along the margins of sand-bottomed seepage lakes and ponds on glacial lakebeds (especially Glacial Lake Wisconsin in the Central Sand Plains) as well as on sandy outwash plains. Vegetation usually exhibiting strong zonation with an aquatic zone, shorted-statured emergent zone, and drier upland zone.

38a. Vegetation includes species disjunct from the Atlantic Coastal Plain, including dwarf umbrella-sedge (*Fuirena pumila*), half-chaff sedge (*Lipocarpha* spp.), beak-rush (*Rhynchospora* spp.), nut-sedge (*Scleria* spp.), brown-fruit rush (*Juncus pelocarpus*), milkworts (*Polygala cruciata* and *P. sanguinea*), tooth-cup (*Rotala ramosior*), meadow-beauty (*Rhexia virginica*), and yellow-eyed grass (*Xyris torta*); may also contain species listed below (see 38b)..... **Coastal Plain Marsh**

38b. Vegetation lacks Coastal Plain specialists (see 38a), dominated by graminoids such as Arctic rush (*Juncus arcticus*), narrow-panicle rush (*J. brevicaudatus*), Smith's bulrush (*Schoenoplectus smithii*), little green sedge (*Carex viridula*), yellow sedge (*C. flava*), broom sedge (*C. scoparia*), clustered beak-rush (*Rhynchospora capitellata*), and containing forbs such as silver-weed (*Argentina anserina*), brook lobelia (*Lobelia kalmii*), purple false foxglove (*Agalinis purpurea*), common false foxglove (*A. tenuifolia*), and northern St. John's-wort (*Hypericum boreale*)..... **Inland Beach**

37b. Occurring in moist sandy depressions with a high water table, but with little to no standing water; not associated with seepage lakes. Vegetation zonation weak, usually a mixture of species of coastal plain marsh as well as sedge meadow, oak barrens, and/or pine barrens..... **Moist Sandy Meadow**

36b. Occurring in depressions in glacial lakeplains and outwash plains, abandoned glacial lakebeds, stream corridors, and margins of lakes. Soils usually organic at surface or if mineral at or near surface, soil texture usually clay loam to sandy clay loam (silt loam on degraded sites), rarely sand.

39a. Dominated by sedges, particularly tussock sedge (*Carex stricta*), wiregrass sedge (*C. lasiocarpa*), and/or lake sedge (*C. lacustris*), with bluejoint grass occasionally co-dominant. Sedge and bluejoint grass tussocks, if present, often tall (> 6 inches). Soils peat or muck, occasionally saturated clay loam to sandy clay loam, acid to neutral. Wet sedge meadow species such as water smartweed, great water dock (*Rumex britannica*), broad-leaved arrowhead (*Sagittaria latifolia*), marsh skullcap (*Scutellaria galericulata*), and wool grass (*Scirpus cyperinus*) more prevalent than fen specialists (see 39b), which are usually sparse.[1]

40a. Located in northern Wisconsin, mostly north of the climatic tension zone. Vegetation dominated by sedges (*Carex stricta*, *C. lacustris*, *C. lasiocarpa*, *C. oligosperma*, *C. utriculata*) and bluejoint grass. Species such as leatherleaf, marsh cinquefoil (*Comarum palustre*), northern blue flag (*Iris versicolor*), and bog willow (*Salix pedicellaris*) more prevalent than those listed below (see 40b). Soils neutral to strongly acidic, shallow to deep peat. Frequently invaded by speckled alder with tamarack and/or cedar on the margin ..... **Northern Sedge Meadow**

40b. Located in southern Wisconsin, mostly south of the climatic tension zone. Vegetation dominated by tussock sedge, lake sedge, and sometimes by wiregrass sedge. Species such as Joe-Pye-weed, jewelweed (*Impatiens capensis*), sensitive fern (*Onoclea sensibilis*), giant goldenrod (*Solidago gigantea*), glossy-leaved aster (*Symphyotrichum firmum*), and tall meadowrue (*Thalictrum dasycarpum*) more prevalent than species listed above (see 40a). Soils are typically neutral to mildly alkaline peat, occasionally saturated clay loam to sandy clay loam. Frequently invaded by dogwoods and willows (e.g., *Salix bebbiana*, *S. discolor*); alder absent to sparse. ..... **Southern Sedge Meadow**

39b. Dominance usually shared by sedges, grasses, rushes, bulrushes, and forbs (in boreal rich fens, Carex lasiocarpa may be dominant). Sedge tussocks, if present, usually short (< 6 inches). Soils neutral to moderately alkaline deep peat or marl. Vegetation strongly influenced by surface and subsurface groundwater seepage. Fen specialists such as sedges (*Carex buxbaumii*, C*. leptalea*, *C. limosa*, *C. livida*, *C. sterilis*), Kalm's lobelia (*Lobelia kalmii*), bog goldenrod (*Solidago uliginosa*), pitcher-plant (*Sarracenia purpurea*), beak-rushes (*Rhynchospora alba* and *R. capillacea*), bog arrowgrass (*Triglochin maritimum*), twig-rush (*Cladium mariscoides*), golden-seeded spike-rush (*Eleocharis elliptica*), shrubby cinquefoil (*Dasiphora fruticosa*), and alder-leaved buckthorn (*Rhamnus alnifolia*) more prevalent than sedge meadow/marsh specialists (see 39a), which are usually sparse.

41a. Located in northern Wisconsin, often adjacent to lakes or cedar swamps. Northern shrubs and stunted trees present such as bog rosemary, leatherleaf, sweet gale, northern white-cedar, tamarack, and black spruce. ..... **Boreal Rich Fen**

41b. Located in southern Wisconsin or occasionally in central Wisconsin, primarily in interlobate regions and occasionally in the Driftless Region. Species of prairies and calcareous southern wetlands present such as big bluestem, little bluestem, whorled loosestrife (*Lysimachia quadriflora*), cowbane (*Oxypolis rigidior*), swamp lousewort (*Pedicularis lanceolata*), Virginia mountain-mint (*Pycnanthemum virginianum*), Riddell's goldenrod (*Solidago riddellii*), and poison sumac (*Toxicodendron vernix*). ..... **Calcareous Fen**

[1] Some wetland restorations may key here, especially where conducted on former agricultural land, but may not match the descriptions of naturally-occurring sedge meadow communities. For an alternate categorization of these sites, please see the U.S. National Vegetation Classification description for Sedge species - Canada Bluejoint Midwest Wet Meadow Alliance.