An aerial photograph of the Lake Superior Basin, showing the lake and its surrounding land. The land is covered in green vegetation. Numerous small white dots are scattered across the land, representing sampling locations. The lake is dark blue/black. The title text is overlaid on the top half of the image.

Lake Superior Basin Floristic Quality Assessment, Phase 1: Setting Condition Benchmarks

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March 2014**

Citation

Hlina, P., N.P. Danz, K. Beaster, S. Hagedorn, and D. Anderson. 2014. Lake Superior Basin Floristic Quality Assessment, Phase 1: Setting Condition Benchmarks. Technical Report 2014-2, Lake Superior Research Institute, University of Wisconsin-Superior, Superior, WI.

INTRODUCTION

Inland non-forested and forested wetlands in Wisconsin's Lake Superior Basin are numerous and have critical ecological functions. In 1997, Epstein *et al.* identified more than 30 coastal and interior basin wetland areas as priorities for protection partly based on plant community diversity and the presence of rare plant populations. Some of these wetlands have suffered extensive degradation and loss over the last two centuries and continue to be under threat from human activities (Frayser *et al.* 1983, Dahl 1990, Dahl and Johnson 1991, Dahl 2000). Wetland functions under threat include temporary storage of surface water, stream flow maintenance, nutrient transformation, sediment retention, shoreline stabilization, and provision of fish and wildlife habitat (Tiner 2005).

While there are current large-scale projects underway to monitor the status and trends of coastal wetlands in Wisconsin's Lake Superior basin, there is scarce information and few assessments for inland wetlands of the region (Johnston *et al.* 2007, Johnston *et al.* 2010).

For inland wetlands of southern Wisconsin, where wetland degradation due to human activity has been more extensive, wetland floristic quality is judged using the Wisconsin Floristic Quality Assessment developed by Bernthal (2003). This approach is based on Swink and Wilhelm's (1994) development of Coefficient of Conservatism (C), a numerical score 0-10 assigned to plant species of a region by botanical experts based on species fidelity to specific habitat integrity and to varying degrees of disturbance. With a list of species from a site in-hand, indices of floristic quality are calculated by simple arithmetic methods including mean C and mean C weighted by species richness (Rooney and Rogers 2002, Bourdaghs *et al.* 2006). These measures are known to be sensitive to human disturbance across a wide range of wetland systems in Wisconsin and the Midwest (Hermann 2001, Bernthal *et al.* 2007, Mack 2004, Bourdaghs *et al.* 2006, Bourdaghs *et al.* 2011).

An open question is whether floristic quality approaches can be successfully applied to inland wetlands of northern Wisconsin, where wetlands occur in a generally more forested landscape matrix and are generally less-disturbed. Without information on wetland plant occurrence and benchmarks of overall floristic quality for this region, future vegetation changes in response to human activity or climate change cannot be properly placed in context. The objective of this study is to establish benchmarks of wetland condition for the inland wetlands of northern Wisconsin by evaluating floristic quality indices along a gradient of anthropogenic stress from least-impacted to most-impacted wetlands.

METHODS

Site Selection

Our study was limited to the five ecological landscapes comprising the Wisconsin portion of the Lake Superior drainage basin. Based on the occurrence and prominence of wetland plant communities in this region, we selected nine wetland plant communities for the development of condition tier benchmarks: Northern Sedge Meadow (NSM), Shallow Water Marsh (SWM), Shrub Carr (SC), Alder Thicket (AT), Open Bog (OB), Black Spruce Swamp (BSS), White Cedar Swamp (CS), Muskeg (MK), and Black Ash Swamp (BAS). A complete description of these nine types is listed in Appendix I.

Many of these community types are most prominent north of the tension zone in Wisconsin and represent rare wetlands over the northern landscape of woods, lakes, and wetlands. Collectively, these represent

about 40% of the total inland wetland resources acreage of the basin. Other wetland types not surveyed included aquatic submerged plant communities, deep water marshes, and some lowland hardwood forest types.

Using data from the Wisconsin Wetland Inventory (WWI, WI DNR 1984 - 2013), we identified 110,058 mapped inland wetland units in the Lake Superior Basin in a geographic information system (GIS). Lake Superior coastal wetlands in the basin were not considered for this study. Mapped wetland units were polygons assigned a code identifier for the type of wetland plant community present. About 44,023 (40%) of the mapped units had classifications from WWI that belonged to the plant communities of interest. However, some of the plant communities were not easily identified by WWI information. For example, Alder Thicket and Shrub Carr were two communities of interest listed by one community type code; sites of each type were verified with field visits (see below). Black Ash Swamp sites were pooled into the broader category known as Lowland Deciduous Forest and were also verified with site visits. The communities Shallow Water Marsh and Northern Sedge Meadow had two codes in the WWI database, but the boundaries of mapped polygons were much more clearly defined in GIS than in the field, where they often blended together along a vegetative gradient controlled by water depth.

For the purpose of site selection, we used GIS to characterize human activity in a 300-m buffer around the mapped wetland units in the plant communities. We quantified two anthropogenic variables: 1) road density divided by wetland buffer area including roads and railroads from the TIGER dataset (US Census Bureau 2012), and 2) percent of the wetland buffer in natural land cover types summarized from the 2006 National Land Cover Dataset (NLCD, Fry *et al.* 2011). Wetlands were separated into those likely having high levels and low levels of human disturbance by ranking along these two anthropogenic variables. The goal of sampling was to survey sites at the high and low end of these gradients.

Our site selection process involved selecting an oversample of sites with the goal of approximately 20 wetlands with high and 20 wetlands with low amounts of human disturbance for each of the wetland plant community types. The oversample of wetlands allowed for field rejections of sites due to accessibility or cases when the digital database of the community type did not match the actual plant community in the field.

For 2012, our site selection was limited to four plant community types: Alder Thicket, Northern Sedge Meadow, Open Bog, and Shrub Carr. Prior to the 2012 field season, wetland sites in these communities at the high end of the human disturbance gradient were ranked in decreasing order by their density of surrounding roads. Sites having >1.5 km roads per hectare within a 300-m buffer were tentatively classified as having high levels of disturbance. We chose the value 1.5 km per hectare as the cutoff because it represented the 90th percentile of road density values among all wetland buffers. Sites at the upper end of this gradient were primarily located in or near cities of Superior, Ashland, Iron River, and Hurley, Wisconsin. Wetlands were reviewed in decreasing order along this road density gradient for site accessibility and having public ownership or private land ownership that had given permission for sampling. The process continued until a list of about 20 accessible wetland sites was created for each of the four plant community types. Especially for Open Bog, accessible wetlands with high amounts of adjacent road density were not available in the dataset. There are low numbers of heavily disturbed sites in these classes in our region, making it difficult to define the disturbed end of the gradient. In these

cases, we purposely selected wetlands with the highest amount of surrounding road density that was available.

A similar process was used for sites at the low end of the human disturbance gradient, whereby wetlands were ranked in decreasing order by their road density. Maps of wetlands were reviewed in decreasing order along this gradient for site accessibility as above, resulting in a pool of 20 accessible wetlands sites for each of the four community types. Sites with low amounts of human disturbance were much more plentiful in the database, and it was therefore easier to get a sufficient number of wetlands minimally affected by human disturbance.

Following the 2012 field season, preliminary data analysis suggested road density was not strongly correlated with floristic quality at our wetland sites in the four plant communities sampled, whereas the amount of natural land cover in a 300-m buffer around the wetland polygon was more tightly linked with floristic quality. Thus, prior to the 2013 season, we used land cover instead of road density as the human disturbance variable to rank sites during selection of sites for 2013.

For the 2013 field season, sites were selected in Black Spruce Swamp, Muskeg, and White Cedar Swamp by ranking along high- and low-levels of surrounding natural land cover and evaluating for accessibility and ownership as described for road density in 2012 above. To add better coverage at the ends of human disturbance gradients, 19 additional Open Bog sites were added in 2013, as well as 13 Alder Thicket, and 8 Shrub Carr.

Shrub Carr, Alder Thicket, Black Ash Swamp, and Shallow Water Marsh were four plant communities not easily identified from the WWI digital inventory. Rather than use a site selection process based on GIS analysis of surrounding disturbance, we purposely selected sites in these communities in 2012 and 2013 as they were encountered in the field, for example when they were adjacent to surveyed sites with a different plant community. Alder Thicket was well represented at high and low levels of human disturbance, while Shrub Carr was underrepresented at the low-disturbance end of the gradient. Black Ash Swamp and Shallow Water Marsh were difficult to identify on our digital wetland inventory, yet to generate preliminary floristic data we surveyed a small number of these sites during the summer of 2013. Hence they have fewer replicates than the other community types.

Field Sampling

Three hundred twenty-two wetland sites were visited during June-Aug of 2012 and 2013. Upon arrival at a site, it was confirmed or rejected for sampling based on being ≥ 0.5 ha, having a homogeneous plant community belonging to one of the nine types of interest, and being accessible within 300 m of a railroad, road, navigable stream, or trail by foot. There were a few occasions that sites were chosen that exceeded the 300 meter access buffer to capture a wetland type at either end of the disturbance gradient. Eighty-eight (24%) of 322 site visits resulted in rejections, with the confirmation and survey of 272 wetlands overall.

A timed-meander survey method was used for vegetation sampling at each site (Goff 1982). Although timed-meander surveys do not result in density estimates of vegetation, recent research by Hlina *et al.* (2011), Bourdaghs *et al.* (2011), and Bourdaghs (2012), indicate that they are more cost-effective and

yield more complete species lists per wetland than traditional quadrat-based surveys. Floristic quality metrics based on the Coefficient of Conservatism, including the Wisconsin Floristic Quality Assessment (WFQA) approach (Bernthal *et.al* 2007) are known to perform better with complete species lists.

Full details of our timed-meander approach of vegetative sampling are documented in the Standard Operating Procedure (LSRI - FS/27 SOP, Hlina *et.al.* 2012). Briefly, the timed-meander consisted of two trained botanists searching a wetland site for a minimum of 45 minutes. In cases when human disturbances were not evident, the starting point of the survey was a conveniently chosen location at least 20 m from the border of an adjacent plant community. In cases when human disturbances were evident, the starting point was directly adjacent to a neighboring community (i.e. edge of a roadside). During the timed survey period, the botanists walked through the site and recorded all species present. Plants that were not identified to species in the field were collected and later identified in the laboratory. Special effort was made to record undergrowth species that are easily overlooked. If >3 species were recorded during the last 10 minutes of the 45-minute interval, an additional 15 minutes was added to the survey. If > 3 species were observed during these 15 minutes, an additional 15 minutes were added. This process continued until fewer than three species were added in the final 15-minute interval up to a maximum of 75 minutes.

During the meander survey, hand-held Garmin GPS units were used to record the survey track. At the end of the survey, the botanists estimated to the nearest percent the average total cover of each species along their meander track. Percent cover estimation was calibrated and practiced in sample wetlands prior to surveys. The botanists also completed the Wisconsin Disturbance Factors Field Checklist (Bernthal, *et.al.* 2007) at the end of the survey (Appendix II). This checklist is a rapid method to qualitatively depict hydrological and habitat alterations and percent coverage of invasive plants observed in the wetland. From the checklist, *habitat quality code* is a single index that summarizes the overall level of disturbance and invasive species encroachment on a site, with values of this index ranging from 1-6.

Floristic Quality Metrics

We calculated four metrics of wetland floristic quality using the approach of the Wisconsin Floristic Quality Analysis (Bernthal *et al.* 2007). In all calculations, non-native species were included in the calculations, receiving a C-value of zero. Calculations were made for all surveyed wetlands. The four metrics included:

- 1) *Mean C* is the arithmetic average of the *C* values across the total number of plant species (*n*) observed in a wetland

$$\bar{C} = (C_1 + C_2 + C_3 + \dots + C_n) \div n$$

- 2) *Weighted mean C* is an arithmetic mean where the *C*-value for each species (*i*) is multiplied by its proportional abundance (*p*) and divided by the sum of the proportional abundances:

$$w\bar{C} = \frac{\sum p_i C_i}{\sum p_i}$$

- 3) *Floristic Quality Index* is calculated by multiplying *mean C* by the square root of the total number of species (*n*).

$$FQI = \bar{C}\sqrt{n}$$

4) *Weighted Floristic Quality Index* is weighted *mean C* divided by the square root of the total number of species (*n*).

$$FQI = w\bar{C}\sqrt{n}$$

Analysis

To evaluate the distinctiveness of the nine wetland plant communities, we ran a non-metric multidimensional scaling (NMDS) analysis in PC-ORD (McCune and Mefford 2011). We used 272 sites and 590 species that were present on at least one site.

To verify whether the floristic quality metrics were able to discriminate site quality along a gradient of human disturbance, we created scatter plots and calculated simple linear regressions using the metrics as *y*-variables and site habitat quality code and amount of surrounding natural land cover as two independent *x*-variables. We considered only regressions significant at $\alpha = 0.05$ for condition tier benchmark development.

For the purpose of setting benchmarks, surveyed wetlands were placed into two categories based on field results of the disturbance factor checklist. *Least-disturbed* wetlands were defined as wetlands with habitat quality code scores (from the field disturbance factor checklist) of 1 or 2. *Most-disturbed* wetlands were defined as having habitat quality scores between 4 and 6. In this context, *disturbance* refers to human disturbance and not ecological disturbances including fire or wind that occur naturally in wetland ecosystems. Our goal was to have a minimum of 10 sites in each category, although this was not possible for all of the communities (Table 1).

Table 1. Number of sites in disturbance classes used for setting condition tier benchmarks.

Plant Community	Total Number of Surveyed Wetlands	Disturbance Classes Based on Disturbance Factor Field Checklist		Disturbance Classes Based on % Natural Surrounding Land Cover	
		Least Disturbed	Most Disturbed	Least Disturbed	Most Disturbed
Alder Thicket	42	14	8	16	14
Black Ash Swamp	16	12	1	9	3
Black Spruce Swamp	31	27	2	22	1
Muskeg	34	31	1	22	2
Northern Sedge Meadow	32	19	8	17	12
Open Bog	46	40	1	37	1
Shallow Water Marsh	15	12	3	12	1
Shrub Carr	31	8	15	5	16
White Cedar Swamp	25	20	2	18	2

For each of the nine plant community types, a series of condition tier benchmarks (up to 5) were set in the least-disturbed and most-disturbed categories using percentile scores along the mean C and weighted C metrics (Bourdaghs 2012). We did not develop condition tier benchmarks using FQI and weighted FQI

based on weak relationships between these metrics and wetland disturbance (see Results below). Benchmarks for Condition Tiers 1 and 2 were defined as the 75th and 25th percentiles, respectively, of metric scores in the least disturbed group of wetlands. Thus, future wetland surveys in a particular community type receiving scores at or above these percentiles would be considered in the least-disturbed condition, with Condition Tier 1 reflecting the highest quality wetland. Similarly, in the most-disturbed class, the benchmarks for Condition Tiers 4 and 5 were defined as the 75th and 25th percentiles, respectively, of metric scores among wetlands in this category. Future wetlands that score at or below these values would be considered in the most-disturbed or degraded condition, with Condition Tier 5 representing a very poor quality wetland. Future wetlands receiving scores between the benchmarks for least- and most-disturbed wetlands would be represented in Condition Tier 3 or *intermediate* condition.

There were several plant community types in which the least-disturbed or most-disturbed categories had low sample size, Black Spruce Swamp, Open Bog, Muskeg, White Cedar Swamp, and Shrub Carr. For these communities, the benchmarks should be considered preliminary until the sample size is expanded in Phase II – Northern Forests and Lakes Ecoregion – Setting Condition Benchmarks to be conducted in the summer of 2014.

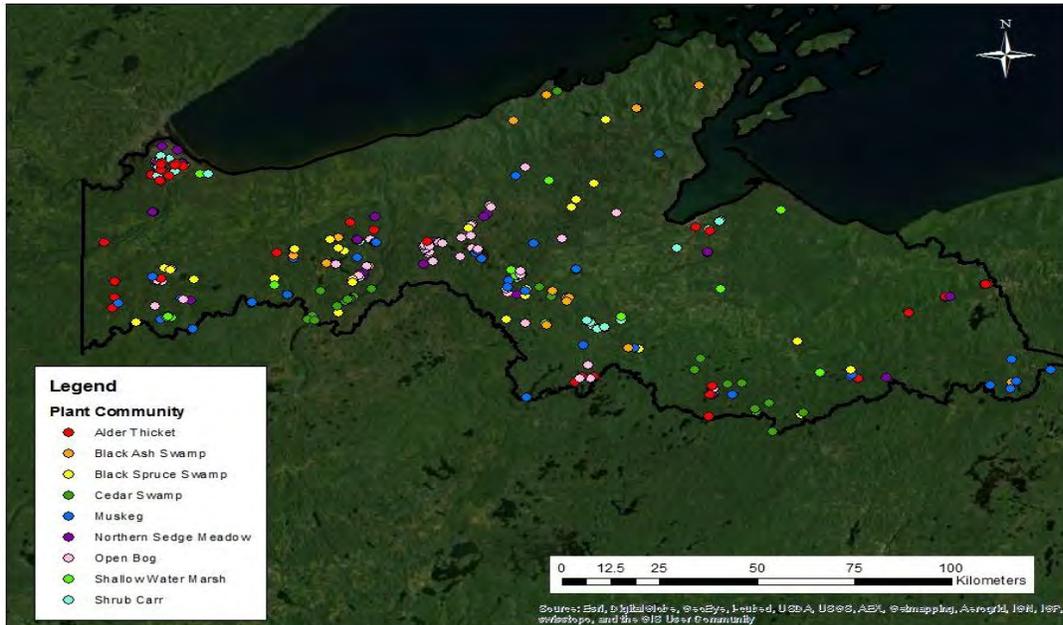
For the purpose of comparison and verification, the same process described above to set benchmarks was repeated by using a different variable to define the wetland condition tiers. In this second benchmark analysis, we used the amount of surrounding natural land cover in a 300-m buffer around the wetland meander track for each survey. A similar land use intensity scale has been used by others in establishing and creating condition benchmarks for wetland quality (Bourdaughs 2012, Bernthal *et. al* 2007, Bourdaughs 2006, Wilcox *et.al* 2002, Cohen *et. al.* 2004, Lopez and Fennesey 2002). In our analysis we defined *least-disturbed* wetlands having natural land cover >90%, while *most-disturbed* wetlands were defined as having <75% surrounding natural land cover. The five condition tier benchmarks were defined using the same percentile scores along the four metrics as described above.

RESULTS and DISCUSSION

Site Selection

Eighty-eight (24%) of 322 site visits resulted in rejections, with the confirmation and survey of 272 wetlands overall (Figure 1). Most rejections were due to inaccurate map delineations or to site inaccessibility. Among the surveyed sites, 182 (67%) occurred on public lands including city, county, or National Forest, whereas 60 (22%) occurred on private lands representing five different corporate landowners in Superior, Ashland, and Hurley. An additional 30 (11%) sites were surveyed on private lands of individual property owners in the region. Although many wetlands occur on private lands throughout the region, it is difficult to survey these sites because landowners often do not grant permission, plus it takes a large effort to identify and contact landowners. This will likely continue to be a problem with monitoring studies into the future.

Figure 1. Wetland study sites of nine plant community types

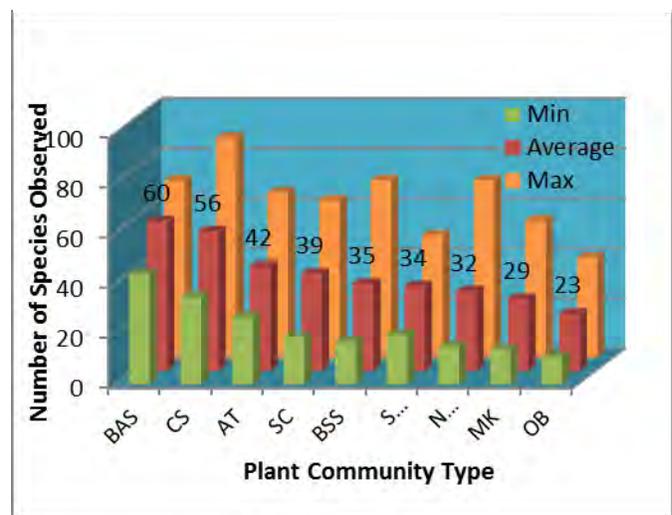


Forested swamp and bog communities exhibiting high levels of surrounding human disturbance were difficult to find throughout the Lake Superior basin. Among Black Ash Swamp, Black Spruce Swamp, Muskeg, Open Bog, and White Cedar Swamp, only 1 of 143 surveyed sites had surrounding natural land cover below 60%. Apparently, substantial plant compositional changes occur when these sites are subject to human disturbance, resulting in species replacement towards wetland plant communities not meeting the community type definitions. We hypothesize that when these wetlands are degraded by hydrological or pH changes, these community types may experience declines of *Sphagnum* abundance accompanied by encroachment of *Alnus* and other shrubs, eventually developing not into a degraded coniferous forest or open bog, but instead to an Alder Thicket community. Based on our personal observations, the absence of Open Bog, Muskeg, Black Spruce Swamp, and White Cedar Swamp with high levels of surrounding human disturbance was due to degradation of these communities into different plant communities entirely, including Alder Thicket, Shrub Carr, Northern Sedge Meadow, and Shallow Water Marsh.

Compositional Patterns

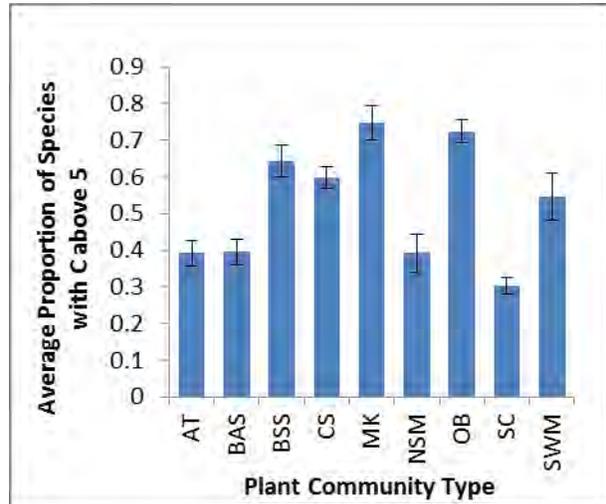
Across all 272 wetland site surveys, 590 species were identified. This represents about 20% of the flora of Wisconsin. Minimum, maximum, and average species count for each wetland site by community type are depicted in Figure 2. These values represent native and non-native species combined. Black Ash Swamp (60) and White Cedar Swamp (56) had the greatest average species richness, while Muskeg (29) and Open

Figure 2. Minimum, average, and maximum number of species observed per wetland site for nine plant community types.



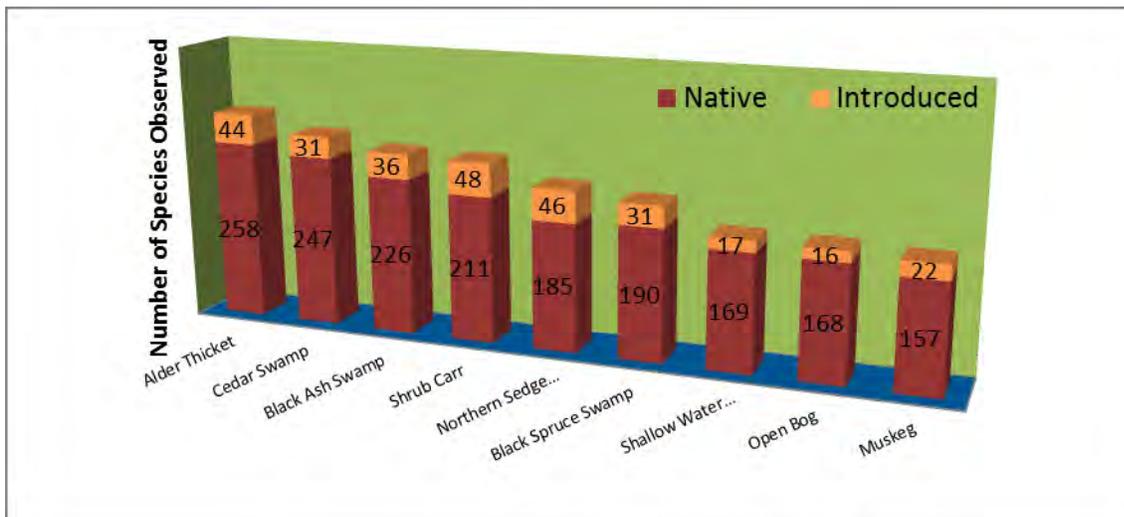
Bog (23) had the lowest average richness. Muskeg, Open Bog, and White Cedar Swamp had the highest numbers of species with C values ≥ 5 (Figure 3) indicating these communities tend to harbor a greater proportion of species that are habitat specialists. These species are among the first to disappear from sites following degradation of these swamp and bog communities as they change compositionally into shrub or emergent meadow communities. These latter communities are comprised by a greater proportion of species with C values ≤ 5 , indicating a greater tendency towards habitat generalist and higher tolerance for anthropogenic disturbance.

Figure 3. Average proportion of species per site with C value above 5. Error bars indicate 95% confidence interval.



Total species richness values across all sites for each community type were highest for Alder Thicket (302) and White Cedar Swamp (278) (Figure 4). Northern Sedge meadows had a higher percentage of introduced species (20%) while the Open bogs had the lowest amount (9%). Muskeg (179), Open Bogs (184), and Shallow Water Marsh (186) had the lowest species richness and all had low numbers of introduced species.

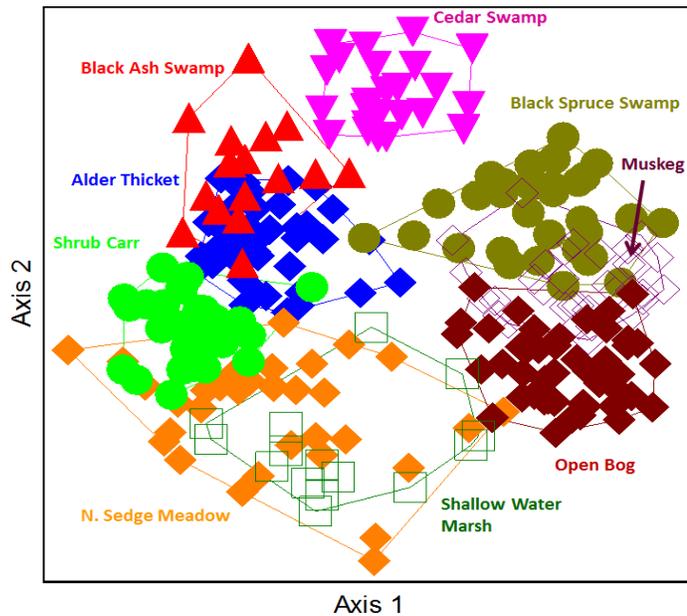
Figure 4. Total number of native and invasive species recorded across all survey sites for nine plant community types.



In the NMDS, a 2-dimensional solution was preferred (Figure 5). The first axis was interpreted as primarily a gradient in soil pH and *Sphagnum*-dominated wetlands, whereas the second axis was interpreted as primarily a gradient in tree cover. Some plant communities (i.e. Shrub Carr, Open Bog, Black Spruce Swamp, and White Cedar Swamp) had sharply distinctive community composition as judged by discrete clouds of points in the ordination. Other communities were less distinct. Muskeg was

intermediate between Black Spruce Swamp and Open Bog; this result is perhaps unsurprising because the defining feature of Muskeg is intermediate tree density. Northern Sedge Meadow and Shallow Water Marsh had a fair amount of overlap in community composition, likely due to high shared abundance levels of some open water emergent and floating leaf species (esp. *Sparganium* spp., *Nuphar variegata*, *Brasenia schreberi*, among others) in these communities. Black Ash Swamp and Alder Thicket shared many of the same understory species, resulting in a fair amount of overlap in these communities. We used the generally distinctive patterns of community separation in ordination space as justification for calculating separate benchmarks for each wetland community type. However, there may be justification for combining some of the overlapping communities in future work.

Figure 5. NMDS ordination of 272 wetland sites and 590 species.



Relationships between Floristic Quality Metrics and Human Disturbances

Metrics based on mean C were more tightly linked to human disturbance than FQI metrics (Appendix III). In regressions of mean C and weighted mean C versus the habitat quality code score as a measure of human disturbance, 8 of 9 plant communities showed statistically significantly decreasing floristic quality with increasing disturbance. Using FQI and weighted FQI, only 4 of 9 plant communities showed significantly decreasing floristic quality. These results indicate the metrics based on C values have more power to discriminate sites along this disturbance gradient.

When the amount of natural land cover in a surrounding 300-m buffer was used as a measure of human disturbance, there were fewer strong relationships with floristic quality (Appendix III), likely due to the extreme shortness of the disturbance gradient for Black Ash Swamp, Black Spruce Swamp, Muskeg, Open Bog, Shallow Water Marsh, and White Cedar Swamp, where 1 of a combined 168 sites in these wetlands had natural land cover less than 60% (Appendix II).

Based on the results of the regression analysis with the data collected here, we recommend using mean C and weighted mean C as the most appropriate measures of floristic quality that can discriminate sites along a gradient of human disturbance. For the disturbance gradient, we recommend using the habitat quality code from the disturbance factor checklist. Future refinements of land cover data that better reflect on-the-ground wetland disturbances may make this GIS-based approach more appealing.

Open Bog and Muskeg sites at the low end of the disturbance gradient had the highest mean C values (approximately 7-8), followed by Black Spruce Swamps (approximately 7). There were similar results

for weighted mean C, except that White Cedar Swamp sites also had average values in the 7-8 range. Degraded sites with habitat quality code of 5-6 had the lowest mean C scores, typically about 2-3 in Alder Thicket, Northern Sedge Meadow, and Shrub Carr. These three plant community types also had the best distribution of sites across the entire disturbance gradient. In particular, Shrub Carr had the most uniformly low mean C values across this gradient. For the eight plant community types with significantly negative relationships between mean C and habitat quality code, the slope coefficient ranged between -0.17 (Shrub Carr) and -0.64 (Northern Sedge Meadow), indicating that for every increase of 1 in the habitat quality code score, mean C experienced an average drop between -0.17 and -0.64. Using this line of reasoning, we can say floristic quality in Northern Sedge Meadow dropped 4 times more sharply with increasing disturbance gradients than it did for Shrub Carr.

Condition Tier Benchmarks

Benchmarks of mean C and weighted mean C for the condition tiers are presented in Tables 2-5. Here, we provide a brief overview and interpretation of some of the main patterns of benchmark values.

The coniferous swamps and bogs, which comprise the largest percent (36%) of wetland area in the Lake Superior basin are represented in only condition Tiers 1, 2, and 3 at the least-disturbed end of the gradient. Based on our analysis, Open Bog and Muskeg have the highest benchmark values among wetland communities in the region.

Conversely, the scrub shrub communities of Alder Thicket and Shrub Carr had representation across most condition tiers, being especially well represented in Tier 3 – Tier 5 along the most-disturbed end of the gradient. These plant communities tended to have lower benchmark scores in the upper condition tiers than bogs and swamps. Alder Thicket, Shrub Carr, Northern Sedge Meadow were commonly found in disturbed areas, while representing the second largest percentage (27%) of wetland area in the Lake Superior basin. Among all plant communities, Northern Sedge Meadows

Table 2. Mean C benchmarks for condition tiers defined by values of disturbance factor checklist. *Preliminary Benchmarks.

Plant Community	Condition Tiers Defined by Disturbance Factor Checklist				
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
*Shallow Water Marsh	>6.1	5.5-6.1	<5.5		
N. Sedge Meadow	>5.9	5.1-5.9	3.0-5.1	2.5-3.0	<2.5
Alder Thicket	>5.7	4.8-5.7	3.9-4.8	3.7-3.9	<3.7
Shrub Carr		>4.8	3.8-4.8	3.3-3.8	<3.3
Open Bog	>8.0	7.1-8.0	<7.1		
Muskeg	>7.8	6.7-7.8	<6.7		
Black Spruce Swamp	>7.2	6.3-7.2	<6.3		
Cedar Swamp	>6.4	5.5-6.4	<5.5		
*Black Ash Swamp	<4.8	4.6-4.8	<4.6		

Table 3. Mean C benchmarks for condition tiers defined by values of surrounding natural land cover. *Preliminary Benchmarks

Plant Community	Condition Tiers Defined by Surrounding Land Cover				
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
*Shallow Water Marsh	>6.1	5.5-6.1	<5.5		
N. Sedge Meadow	>5.9	4.8-5.9	3.8-4.8		
Alder Thicket	>5.7	4.9-5.7	4.3-4.9	3.8-4.3	<3.8
Shrub Carr		>4.9	4.2-4.9	3.3-4.2	<4.2
Open Bog	>8.0	7.0-8.0	<7.0		
Muskeg	>8.3	6.4-8.3	<6.4		
Black Spruce Swamp	>7.2	6.4-7.2	<6.4		
Cedar Swamp	>6.3	5.7-6.3	<5.7		
*Black Ash Swamp	>4.8	4.6-4.8	<4.6		

had the steepest decrease of mean C with increasing human disturbance, which led to the greatest difference in benchmark scores between upper and lower condition tiers. Northern Sedge Meadow communities were commonly degraded with frequent mowing, hydrological alterations, and invasive plant species encroachment; more so than any other community. Black Ash Swamp and Shallow Water Marsh condition benchmarks are preliminary as most-disturbed sites were infrequently visited.

There are minor differences of benchmark values in the condition tiers when the least- and most-disturbed wetland classes were defined using surrounding land cover instead of the field disturbance factor checklist. Comparing the values in Table 2 with Table 3 shows that the two methods yielded benchmarks within 0.10 of each other in most cases. The largest appreciable difference in benchmark values occurred for Muskeg with differences of about 0.5 in Condition Tier 1 and about 0.30 in Condition Tier 3. Small differences in benchmark values between the two methods suggests that either approach may be valid, although we recommend using the disturbance factor checklist because it yields sites more widely spanning the disturbance gradient, as discussed earlier.

We provided benchmark values of mean C and weighted mean C for comparison within this study and across other earlier studies that have primarily used mean C. In practice, we recommend benchmarks developed with weighted mean C because this approach incorporates proportional abundance. This may be especially important for wetlands that have become dominated by invasive species yet still have a fair number of native species at lower abundances. In these cases, weighted mean C will yield a score that gives greater weight to the proportional abundance of the invasive and will therefore be lower than mean C.

In practice, using weighted mean C yielded benchmarks within about 0.5 units of benchmarks from mean C. For Condition Tier 1, across all plant community types benchmarks of weighted mean C were higher

Table 4. Weighted mean C benchmarks for condition tiers defined by values of disturbance factor checklist. *Preliminary benchmarks

Plant Community	Condition Tiers Defined by Disturbance Factor Checklist				
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
*Shallow Water Marsh	>7.4	5.3-7.4	<5.3		
N. Sedge Meadow	>6.2	5.3-6.2	2.4-5.3	1.1-2.4	<1.1
Alder Thicket	>5.2	4.5-5.2	4.1-4.5	3.5-4.1	<3.5
Shrub Carr		>5.3	4.5-5.3	3.8-5.3	<3.8
Open Bog	>8.8	8.1-8.8	<8.1		
Muskeg	>8.4	7.8-8.4	<7.8		
Black Spruce Swamp	>7.9	7.3-7.9	<7.3		
Cedar Swamp	>7.6	7.0-7.6	<7.0		
*Black Ash Swamp	>6.3	5.8-6.3	<5.8		

Table 5. Weighted mean C benchmarks for condition tiers defined by values of surrounding natural land cover *Preliminary Benchmarks

Plant Community	Condition Tiers Defined by Surrounding Land Cover				
	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
*Shallow Water Marsh	>7.4	5.2-7.4	<5.2		
N. Meadow	>6.1	5.1-6.1	4.6-5.1	<4.6	
Alder Thicket	>5.0	4.5-5.0	4.4-4.5	4.0-4.4	<4.0
Shrub Carr		>5.3	4.7-5.3	4.2-4.7	<4.2
Open Bog	>8.8	8.1-8.8	<8.1		
Muskeg	>8.4	7.8-8.4	<7.8		
Black Spruce Swamp	>7.9	7.1-7.9	<7.1		
Cedar Swamp	>7.6	7.0-7.6	<7.0		
*Black Ash Swamp	>6.2	5.8-6.2	<5.8		

for 5 of 6 communities (average difference + 0.4). At other condition tiers, the results were more variable, with no consistent upward or downward differences.

The benchmarks developed herein should be used only for the Lake Superior basin region in Wisconsin monitoring and on-going wetland assessment projects. For statewide benchmarks, future efforts and research should include a wider set of wetlands that encompass more urban and agricultural activities in northern Wisconsin. This will provide an opportunity to locate higher levels of anthropogenic disturbance thereby strengthening the condition tier benchmarks stated in this report.

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Appendix I. Nine wetland plant communities for which benchmarks were developed.

Forested wetland communities

Black Ash Swamp (BAS): These are northern deciduous forested wetlands that occur along lakes or streams, or in insular basins in poorly drained morainal landscapes. The dominant tree species is black ash (*Fraxinus nigra*). The tall shrub speckled alder (*Alnus incana*) may be locally common. The herbaceous flora is often diverse and may include many of the same species found in Alder Thickets. Typical species are marsh-marigold (*Caltha palustris*), swamp raspberry (*Rubus pubescens*), skullcap (*Scutellaria galericulata*), orange jewelweed (*Impatiens capensis*), and the greatest diversity of sedges (*Carex spp.*) of all wetland types. Soils may be mucks or mucky sands.

Black Spruce Swamp (BSS): An acidic conifer swamp forest characterized by a relatively closed canopy (i.e., larger than 20' tall and greater than 30% cover) of black spruce (*Picea mariana*) and tamarack (*Larix laricina*) with an understory in which Labrador-tea (*Ledum groenlandicum*) and sphagnum mosses (*Sphagnum spp.*) are often prominent, along with three-leaved false Solomon's-seal (*Maianthemum trifolium*), creeping snowberry (*Gaultheria hispidula*), and three-seeded sedge (*Carex trisperma*). The herbaceous understory is otherwise relatively depauperate. This community is closely related to Open Bogs and Muskegs, and sometimes referred to as Forested Bogs outside of Wisconsin.

White Cedar Swamp (CS): This forested minerotrophic wetland is dominated by white cedar (*Thuja occidentalis*) and occurs on rich, neutral to alkaline substrates. Balsam fir (*Abies balsamea*), black ash (*Fraxinus nigra*), and spruces (*Picea glauca* and *P. mariana*) are among the many potential canopy associates. The understory is rich in sedges (i.e., *Carex disperma* and *C. trisperma*), orchids (e.g., *Platanthera obtusata* and *Listera cordata*), and wildflowers such as gold thread (*Coptis trifolia*), fringed polygala (*Polygala pauciflora*), and naked miterwort (*Mitella nuda*), and trailing sub-shrubs such as twinflower (*Linnaea borealis*) and creeping snowberry (*Gaultheria hispidula*). A number of rare plants occur more frequently in the cedar swamps than in any other habitat.

Wetland plant communities dominated by woody shrubs

Scrub Shrub: Alder Thicket (AT): Deciduous shrub community excluding bog birch; sphagnum moss mat layer absent. *Alnus incana* is dominant (greater than 50% shrub canopy layer). **Shrub Carr (SC):** Deciduous shrub community excluding bog birch; sphagnum moss mat layer absent. Willow species dominant (i.e., *Salix petiolaris*, *S. discolor*, *S. pyrifolia*), with *Cornus stolonifera* and *Spiraea alba* often present. The forb layer is very similar to the northern sedge meadow.

Muskeg (MK): These weakly minerotrophic conifer swamps are dominated by black spruce (*Picea mariana*) and tamarack (*Larix laricina*) representing more than 30% of the cover and less than 20' tall. Jack pine (*Pinus banksiana*) may be a significant canopy component in certain parts of the range of this community complex. Understories are composed mostly of sphagnum mosses (*Sphagnum spp.*) and ericaceous shrubs such as leatherleaf (*Chamaedaphne calyculata*), Labrador-tea (*Ledum groenlandicum*), and small cranberry (*Vaccinium oxycoccos*) and sedges such as (*Carex trisperma* and *C. magellanica*).

Appendix I cont... Nine wetland plant communities for which benchmarks were developed.

Open Bog (OB): Low ericaceous shrubs leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*) or graminoid dominated community on a mat of Sphagnum moss/acidic deep peat. Specialized acid tolerant (indicator) species dominant (i.e., *Carex lasiocarpa*, *C. oligosperma*, *C. magellanica*). We lumped the open bog and northern poor fen as one type as species composition closely corresponds to one another. **Northern Poor Fen:** This acidic, weakly minerotrophic peatland type is similar to the Open Bog, but can be differentiated by higher Ph, nutrient availability, and floristics. Sphagnum (*Sphagnum* spp.) mosses are common but don't typically occur in deep layers with pronounced hummocks. Floristic diversity is higher than in the Open Bog and may include white beak-rush (*Rhynchospora alba*), pitcher-plant (*Sarracenia purpurea*), sundews (*Drosera* spp.), pod grass (*Scheuchzeria palustris*), and the pink-flowered orchids (*Calopogon tuberosus*, *Pogonia ophioglossoides* and *Arethusa bulbosa*). Common sedges are (*Carex oligosperma*, *C. limosa*, *C. lasiocarpa*, *C. chordorrhiza*), and cotton-grasses (*Eriophorum* spp.)

Wetland plant communities dominated by herbaceous plants

Northern Sedge Meadow (NSM): Sphagnum moss mat absent; dominant vegetation consists of graminoids. Soils are usually neutral to alkaline, poorly-drained mineral soils and mucks. Over 50% of the cover dominance contributed by sedges or grasses, especially *Carex lacustris*, *Carex stricta* and/or *Calamagrostis canadensis*. Emergent plants growing on saturated soils to areas inundated by standing water up to 6 inches in depth throughout most of the growing season. Characteristic forbs include *Eupatorium maculatum*, *Aster umbellatus*, *Solidago gigantea*, *Impatiens capensis*, etc.

Shallow Water Marsh (SWM): These open, marsh, lake, riverine and estuarine communities with permanent standing water are dominated by robust emergent macrophytes, in pure stands of single species or in various mixtures. Dominants include cattails (*Typha* spp.), bulrushes (particularly *Schoenoplectus tabermontani*, *S. acutus*, and *Bolboschoenus fluviatilis*), bur-reeds (*Sparganium* spp.), giant reed (*Phragmites australis* subsp. *americanus*), pickerel-weed (*Pontederia cordata*), water-plantains (*Alisma* spp.), arrowheads (*Sagittaria* spp.), and the larger species of spikerush such as (*Eleocharis palustris*)

Appendix II. Disturbance Factors Field Checklist (page 1).



Wisconsin Floristic Quality Assessment for Wetlands
Bureau of Integrated Science Services
Northwest Region, Lake Superior Basin

Disturbance Factors Field Checklist Form – wfoaf06

Site Location Information			
Site Name:		County:	PLSS: T__N R__E/W Sec__ __1/4__1/4
Date:	Observer:	X, Y Coordinates:	Coordinate System:
Hydro & Habitat Alteration:	Feature	Presence	Alteration Intensity
<i>Is there hydrological or habitat alteration present at the site? Check the box if present. Circle low, medium or high to indicate the intensity of alteration. Circle only one.</i>	Ditch	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Tile	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Dike	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Weir	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	StormH2O input	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Filling/grading	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Road/RR	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Dredging	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Mowing/Grazing	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Clear cut	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Selective cut	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Herb removal	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Sedimentation	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Plowing/Other Ag.	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
	Eutrophication	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High
Motor vehicle use	<input type="checkbox"/> Present <input type="checkbox"/> None	Low Medium High	
	Other:		
Overall Disturbance:	<input type="checkbox"/> (1) Non-disturbed <input type="checkbox"/> (2) Minimal <input type="checkbox"/> (3) Moderate <input type="checkbox"/> (4) Major <input type="checkbox"/> (5) Severe		
Tree Age Class:	<input type="checkbox"/> Not applicable <input type="checkbox"/> (1) Seedlings: < 2.5 cm <input type="checkbox"/> (2) Saplings: 2.5-10cm <input type="checkbox"/> (3) Middle-Age: 10-25 cm <input type="checkbox"/> (4) Mature: >25 cm		

Appendix II. Disturbance Factors Field Checklist (page 2).



Wisconsin Floristic Quality Assessment for Wetlands
Bureau of Integrated Science Services
Northwest Region, Lake Superior Basin

Disturbance Factors Field Checklist Form – WFAQF06

<p>% Coverage Invasive Plants¹:</p> <p><i>Consider the entire site. List the invasive plants present at the site. What percent of the site is covered with invasive plants? Select only one coverage class for each plant listed.</i></p>	<p>Invasive Plant 1:</p>	<input type="checkbox"/> (1) Absent: 0% aerial cover of invasive plants. <input type="checkbox"/> (2) Present: 1-5% aerial cover of invasive plants. <input type="checkbox"/> (3) Sparse: 5-25% aerial cover of invasive plants. <input type="checkbox"/> (4) Medium: 25-50% aerial cover of invasive plants. <input type="checkbox"/> (5) Extensive: >50% aerial cover of invasive plants.
	<p>Invasive Plant 2:</p>	<input type="checkbox"/> (1) Absent: 0% aerial cover of invasive plants. <input type="checkbox"/> (2) Present: 1-5% aerial cover of invasive plants. <input type="checkbox"/> (3) Sparse: 5-25% aerial cover of invasive plants. <input type="checkbox"/> (4) Medium: 25-50% aerial cover of invasive plants. <input type="checkbox"/> (5) Extensive: >50% aerial cover of invasive plants.
	<p>Invasive Plant 3:</p>	<input type="checkbox"/> (1) Absent: 0% aerial cover of invasive plants. <input type="checkbox"/> (2) Present: 1-5% aerial cover of invasive plants. <input type="checkbox"/> (3) Sparse: 5-25% aerial cover of invasive plants. <input type="checkbox"/> (4) Medium: 25-50% aerial cover of invasive plants. <input type="checkbox"/> (5) Extensive: >50% aerial cover of invasive plants.

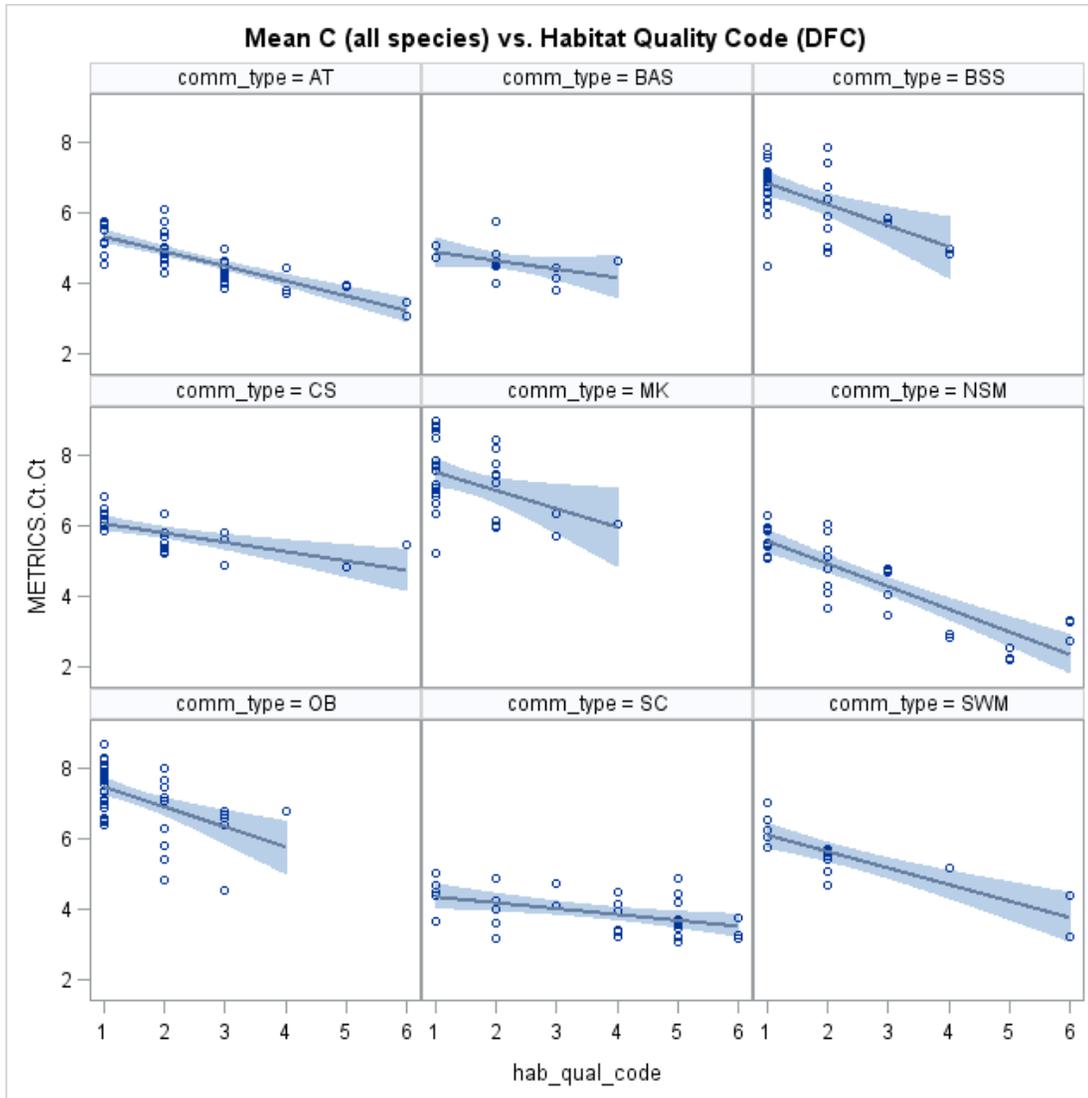
¹See the Wisconsin State Herbarium website for detailed information on invasive species:
<http://www.botany.wisc.edu/wisflora/>

<p>Habitat Quality Assessment:</p> <p><i>Based on all the above selections, what is your Best Professional Judgment of site quality? Select only one.</i></p>	<input type="checkbox"/> (1) Natural structure & function of biotic community maintained. <input type="checkbox"/> (2) Minimal changes in structure & function. <input type="checkbox"/> (3) Evident changes in structure & minimal changes in function. <input type="checkbox"/> (4) Moderate changes in structure & minimal changes in function. <input type="checkbox"/> (5) Major changes in structure & moderate changes in function. <input type="checkbox"/> (6) Severe changes in structure & function.
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General Comments:

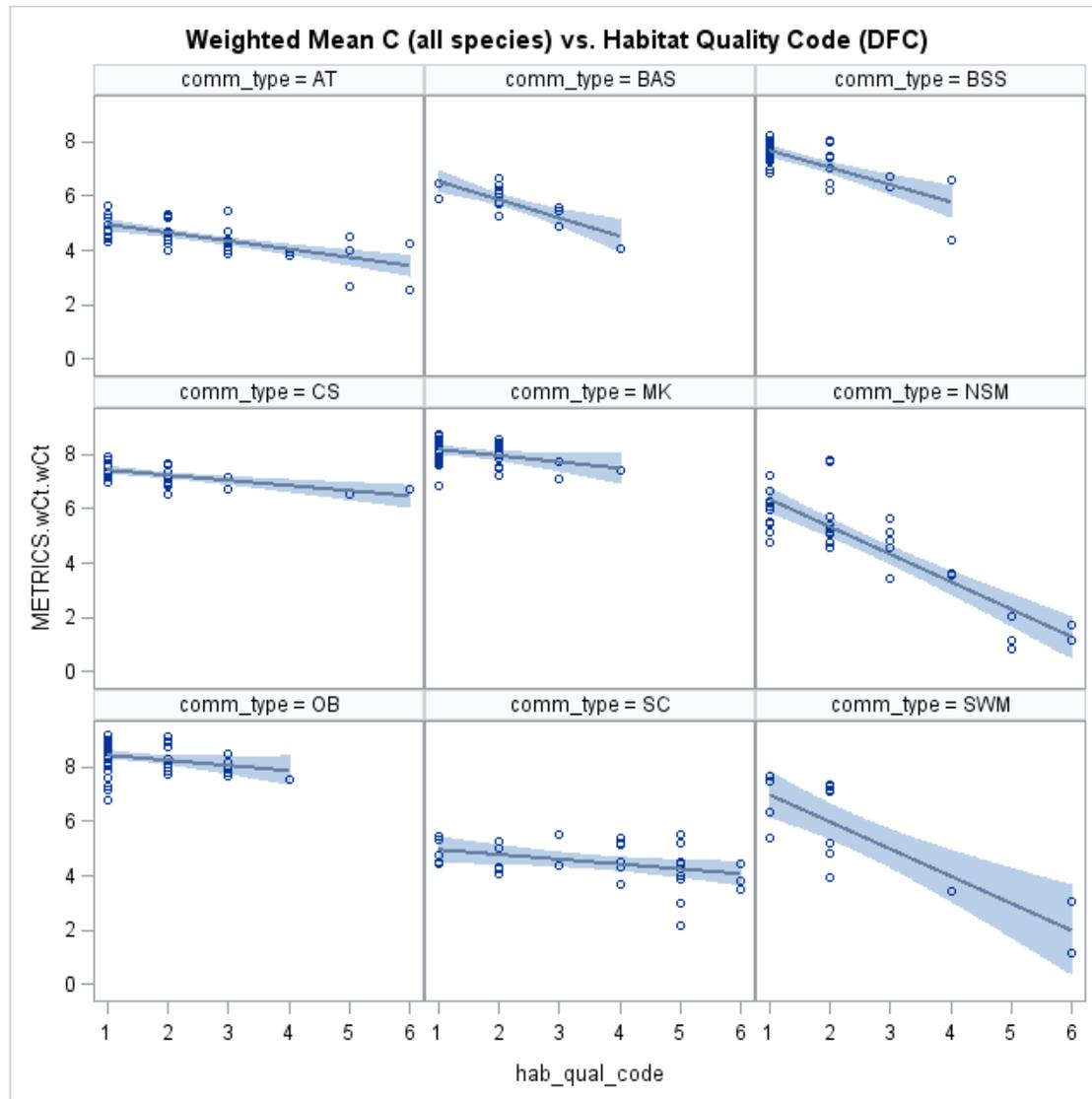
Lake Superior Inland Wetland Floristic Quality Assessment
 University of Wisconsin – Lake Superior Research Institute

Appendix III. Scatter plots of *mean C* versus habitat quality code for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



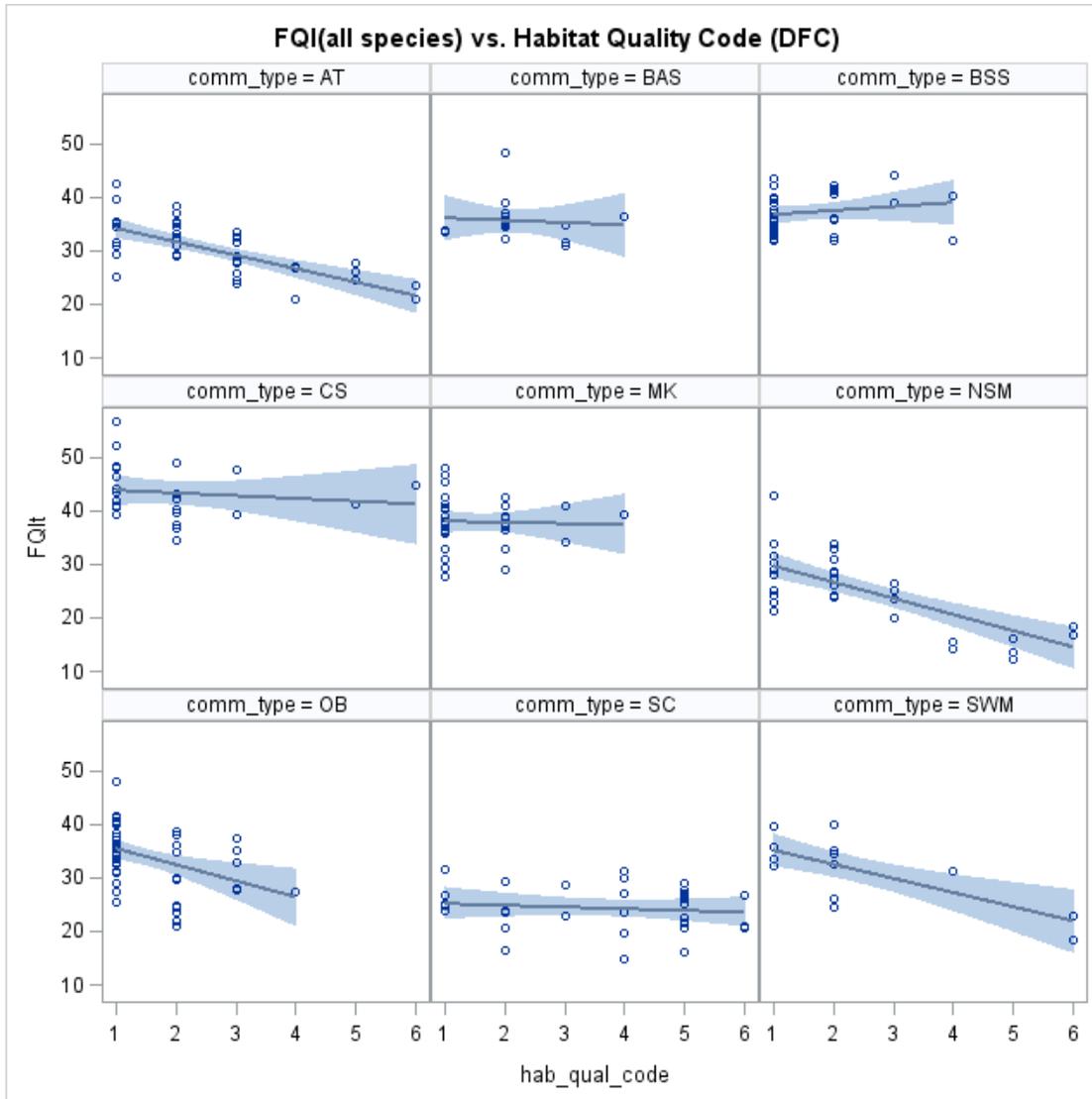
Floristic Quality Metric	Plant Community Type	Slope	r^2	p -value
\bar{C}	Alder Thicket (AT)	-0.42	0.66	0.0000
\bar{C}	Black Ash Swamp (BAS)	-0.23	0.16	0.1270
\bar{C}	Black Spruce Swamp (BSS)	-0.61	0.32	0.0012
\bar{C}	Muskeg (MK)	-0.52	0.15	0.0231
\bar{C}	Northern Sedge Meadow (NSM)	-0.64	0.72	0.0000
\bar{C}	Open Bog (OB)	-0.58	0.26	0.0002
\bar{C}	Shallow Water Marsh (SWM)	-0.46	0.71	0.0001
\bar{C}	Shrub Carr (SC)	-0.17	0.23	0.0066
\bar{C}	White Cedar Swamp (CS)	-0.27	0.40	0.0007

Appendix III cont... Scatter plots of *weighted mean C* versus habitat quality code for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



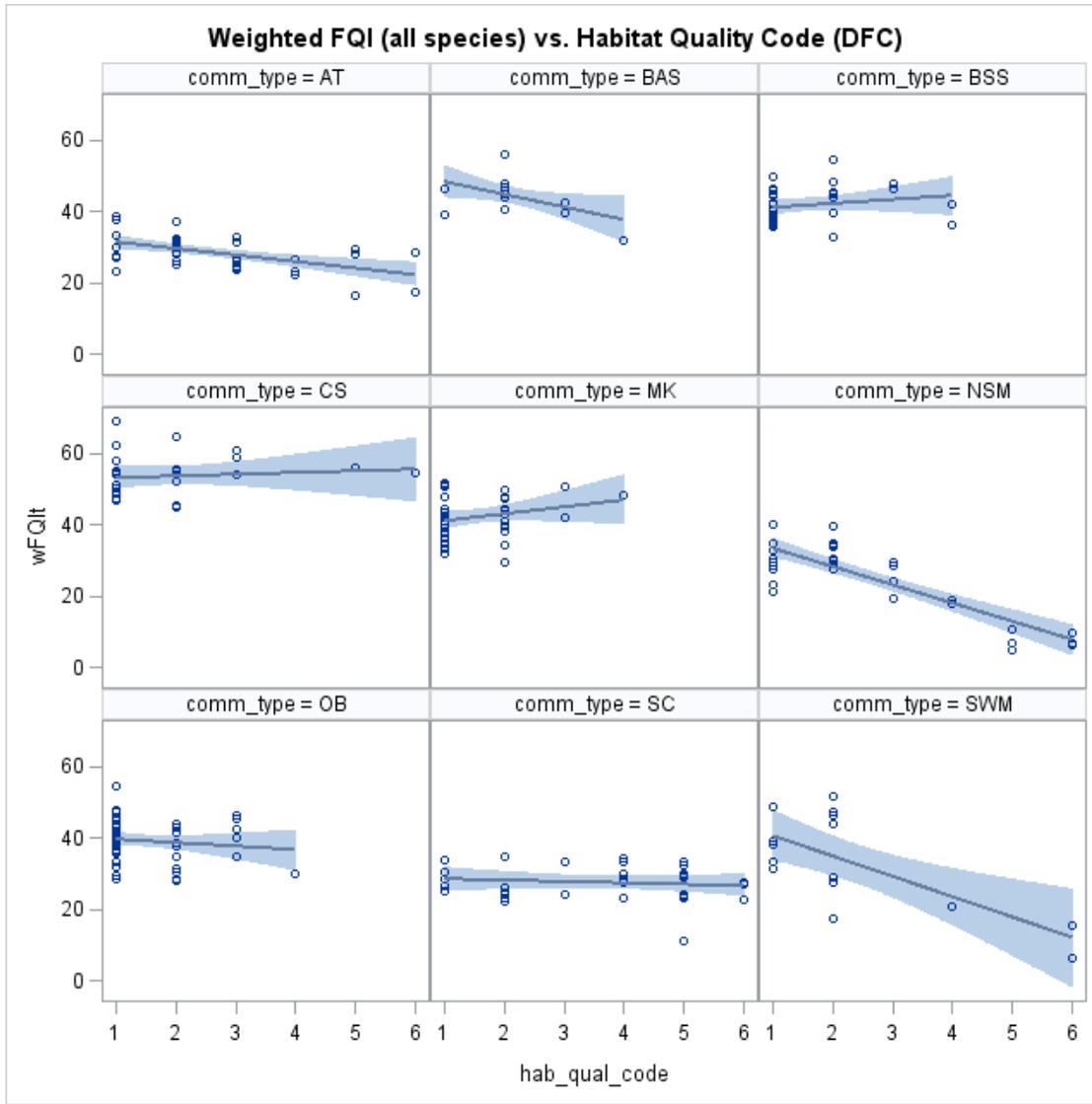
Floristic Quality Metric	Plant Community Type	Slope	r^2	p -value
w	Alder Thicket (AT)	-0.30	0.44	0.0000
$w\bar{C}$	Black Ash Swamp (BAS)	-0.67	0.60	0.0004
$w\bar{C}$	Black Spruce Swamp (BSS)	-0.62	0.51	0.0000
$w\bar{C}$	Muskeg (MK)	-0.23	0.12	0.0460
$w\bar{C}$	Northern Sedge Meadow (NSM)	-1.01	0.76	0.0000
$w\bar{C}$	Open Bog (OB)	-0.19	0.07	0.0681
$w\bar{C}$	Shallow Water Marsh (SWM)	-1.00	0.68	0.0002
$w\bar{C}$	Shrub Carr (SC)	-0.17	0.15	0.0335
$w\bar{C}$	White Cedar Swamp (CS)	-0.19	0.40	0.0007

Appendix III cont... Scatter plots of *FQI* versus habitat quality code for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



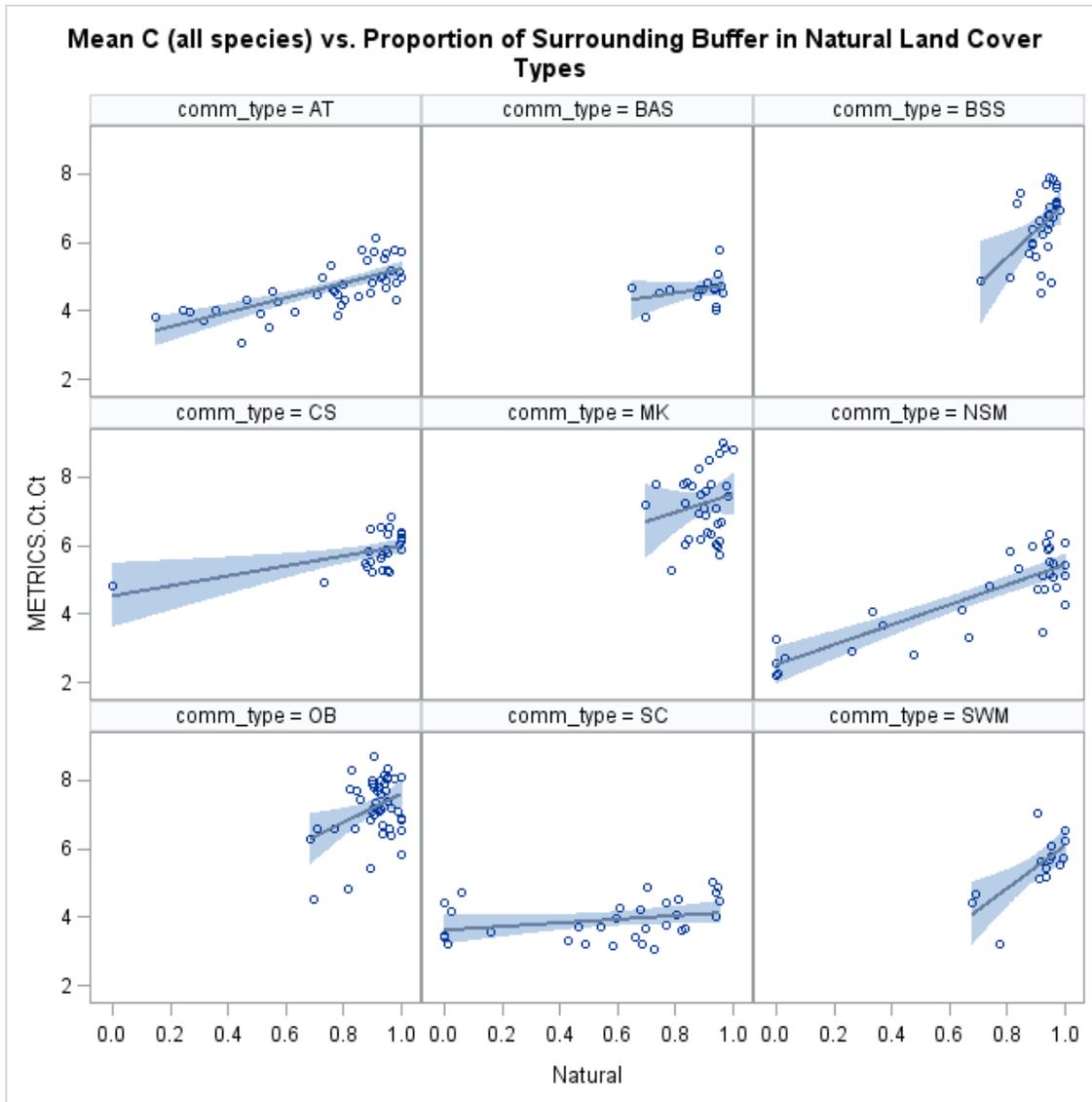
Floristic Quality Metric	Plant Community Type	Slope	r^2	p -value
<i>FQI</i>	Alder Thicket (AT)	-2.54	0.46	0.0000
<i>FQI</i>	Black Ash Swamp (BAS)	-0.45	0.01	0.7533
<i>FQI</i>	Black Spruce Swamp (BSS)	0.79	0.03	0.3286
<i>FQI</i>	Muskeg (MK)	-0.15	0.00	0.8918
<i>FQI</i>	Northern Sedge Meadow (NSM)	-3.07	0.54	0.0000
<i>FQI</i>	Open Bog (OB)	-2.99	0.16	0.0057
<i>FQI</i>	Shallow Water Marsh (SWM)	-2.66	0.54	0.0019
<i>FQI</i>	Shrub Carr (SC)	-0.33	0.02	0.4931
<i>FQI</i>	White Cedar Swamp (CS)	-0.53	0.02	0.5415

Appendix III cont... Scatter plots of *weighted FQI* versus habitat quality code for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



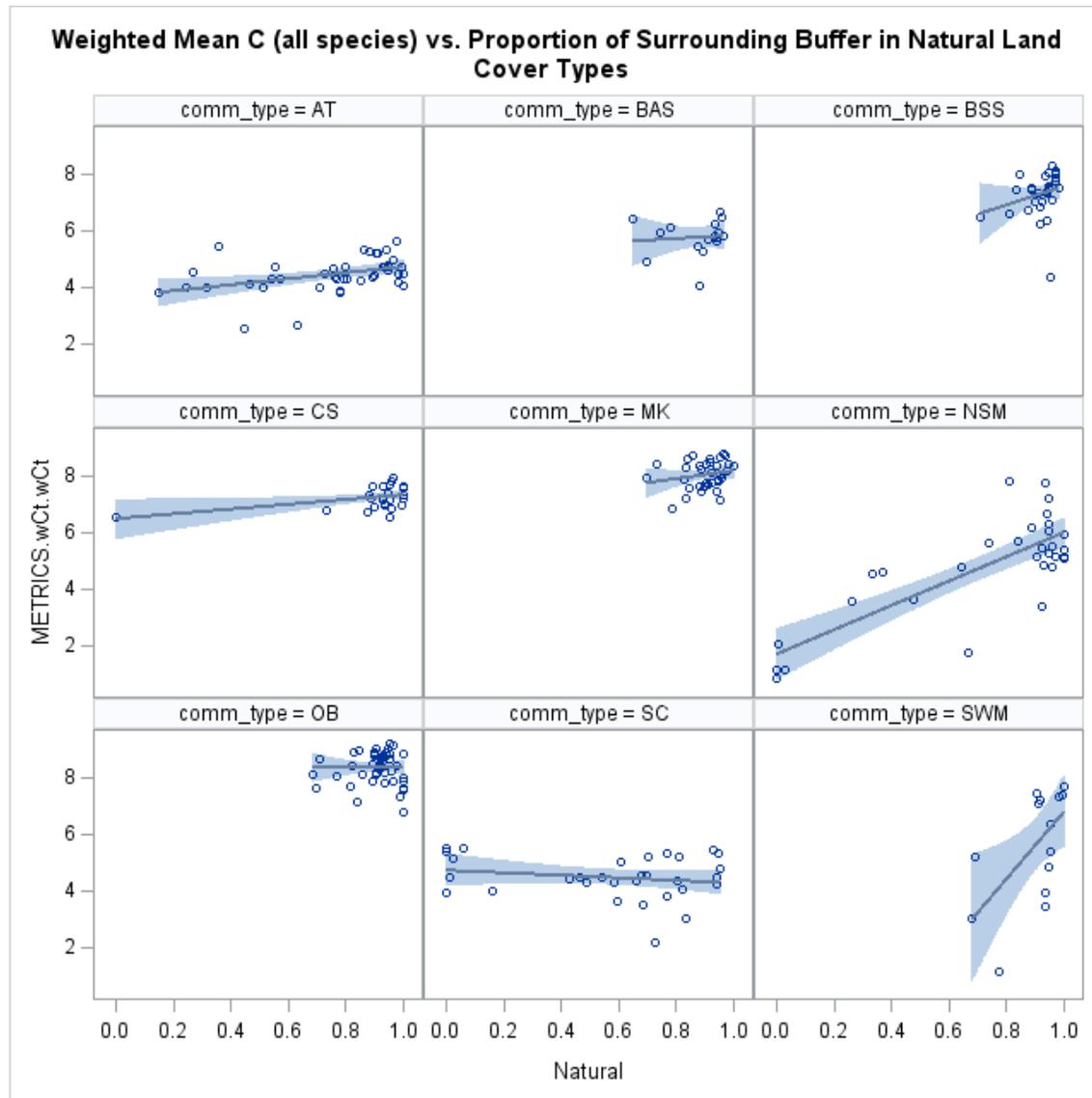
Floristic Quality Metric	Plant Community Type	Regression Slope	r^2	p -value
wFQI	Alder Thicket (AT)	-1.78	0.28	0.0004
wFQI	Black Ash Swamp (BAS)	-3.52	0.27	0.0395
wFQI	Black Spruce Swamp (BSS)	0.98	0.03	0.3579
wFQI	Muskeg (MK)	1.91	0.06	0.1687
wFQI	Northern Sedge Meadow (NSM)	-5.17	0.73	0.0000
wFQI	Open Bog (OB)	-1.04	0.02	0.3480
wFQI	Shallow Water Marsh (SWM)	-5.76	0.50	0.0032
wFQI	Shrub Carr (SC)	-0.32	0.01	0.5503
wFQI	White Cedar Swamp (CS)	0.40	0.01	0.7025

Appendix III cont... Scatter plots of *mean C* versus proportion of 300-m buffer in natural land cover types for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



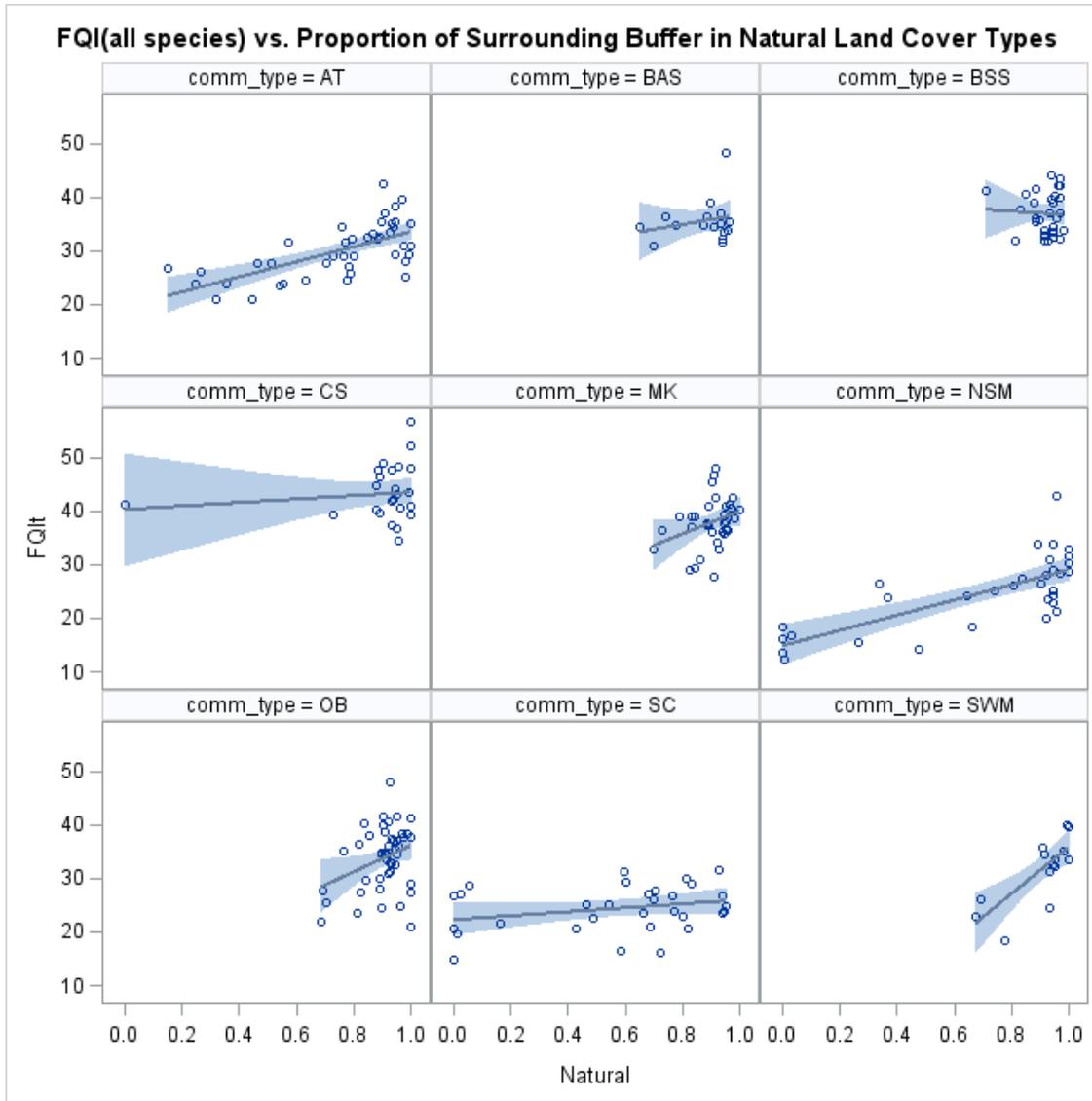
Floristic Quality Metric	Plant Community Type	Slope	r^2	p -value
\bar{C}	Alder Thicket (AT)	2.13	0.51	0.0000
\bar{C}	Black Ash Swamp (BAS)	1.36	0.10	0.2444
\bar{C}	Black Spruce Swamp (BSS)	7.99	0.23	0.0072
\bar{C}	Muskeg (MK)	2.59	0.03	0.3099
\bar{C}	Northern Sedge Meadow (NSM)	2.93	0.72	0.0000
\bar{C}	Open Bog (OB)	4.19	0.14	0.0109
\bar{C}	Shallow Water Marsh (SWM)	6.14	0.49	0.0034
\bar{C}	Shrub Carr (SC)	0.53	0.09	0.1063
\bar{C}	White Cedar Swamp (CS)	1.42	0.27	0.0083

Appendix III cont... Scatter plots of *weighted mean C* versus proportion of 300-m buffer in natural land cover types for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



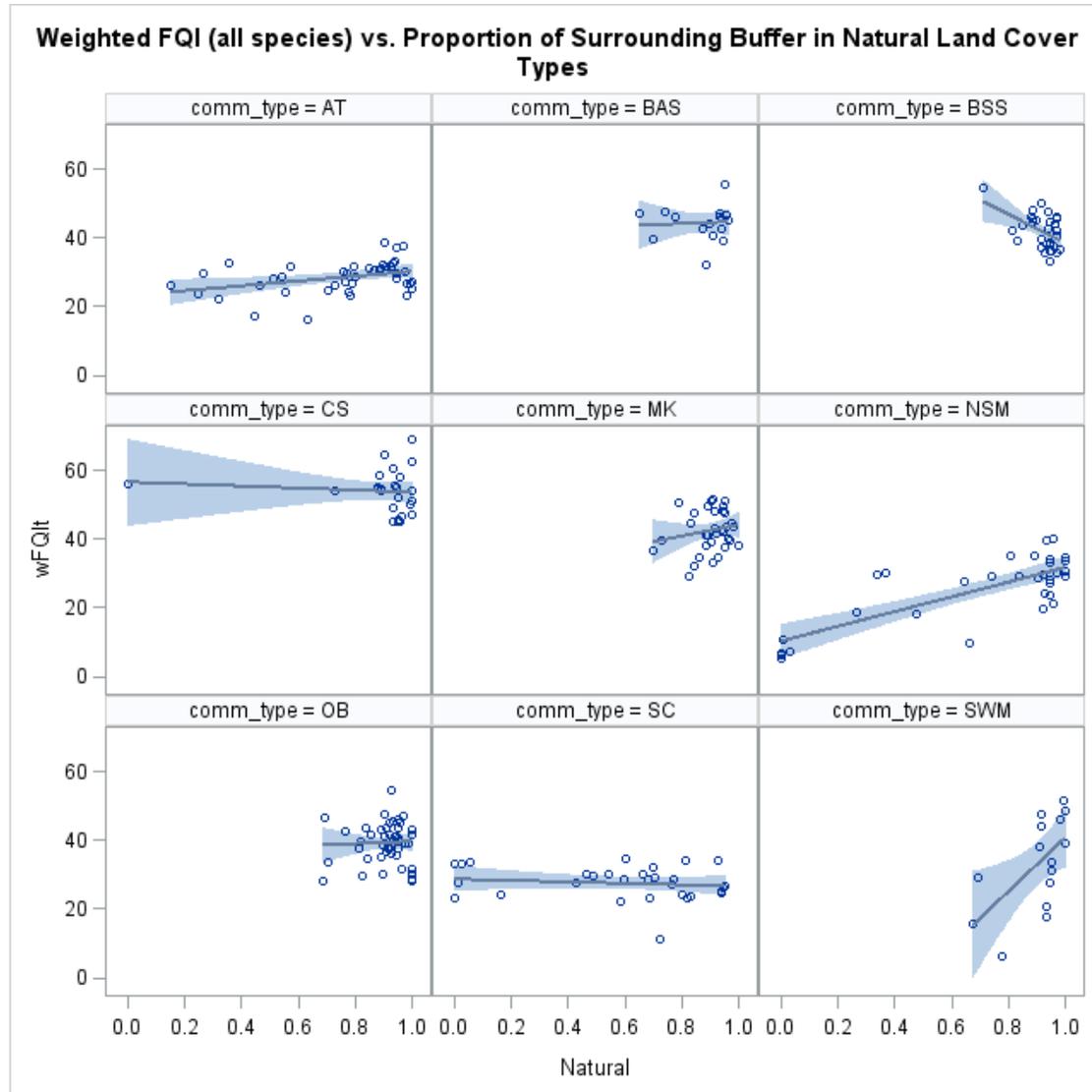
Floristic Quality Metric	Plant Community Type	Slope	r^2	p -value
$w\bar{C}$	Alder Thicket (AT)	1.08	0.17	0.0070
$w\bar{C}$	Black Ash Swamp (BAS)	0.56	0.01	0.7469
$w\bar{C}$	Black Spruce Swamp (BSS)	3.36	0.06	0.1791
$w\bar{C}$	Muskeg (MK)	1.52	0.05	0.2265
$w\bar{C}$	Northern Sedge Meadow (NSM)	4.30	0.65	0.0000
$w\bar{C}$	Open Bog (OB)	0.06	0.00	0.9553
$w\bar{C}$	Shallow Water Marsh (SWM)	11.84	0.37	0.0155
$w\bar{C}$	Shrub Carr (SC)	-0.46	0.04	0.2927
$w\bar{C}$	White Cedar Swamp (CS)	0.87	0.19	0.0295

AppendixIII cont... Scatter plots of *FQI* versus proportion of 300-m buffer in natural land cover types for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



Floristic Quality Metric	Plant Community Type	Slope	r^2	p -value
<i>FQI</i>	Alder Thicket (AT)	13.97	0.43	0.0000
<i>FQI</i>	Black Ash Swamp (BAS)	8.84	0.05	0.4076
<i>FQI</i>	Black Spruce Swamp (BSS)	-2.97	0.00	0.8123
<i>FQI</i>	Muskeg (MK)	20.79	0.10	0.0719
<i>FQI</i>	Northern Sedge Meadow (NSM)	13.99	0.54	0.0000
<i>FQI</i>	Open Bog (OB)	23.64	0.10	0.0315
<i>FQI</i>	Shallow Water Marsh (SWM)	43.86	0.57	0.0011
<i>FQI</i>	Shrub Carr (SC)	3.47	0.07	0.1532
<i>FQI</i>	White Cedar Swamp (CS)	3.50	0.02	0.5345

Appendix III cont... Scatter plots of *weighted FQI* versus proportion of 300-m buffer in natural land cover types for sites in nine wetland plant communities. The trend line is a simple linear regression, while the shading indicates the 95% confidence interval for the line. Regression statistics are included in the accompanying table.



Floristic Quality Metric	Plant Community Type	Regression Slope	r^2	p -value
<i>wFQI</i>	Alder Thicket (AT)	7.39	0.14	0.0133
<i>wFQI</i>	Black Ash Swamp (BAS)	2.38	0.00	0.8626
<i>wFQI</i>	Black Spruce Swamp (BSS)	-42.69	0.24	0.0055
<i>wFQI</i>	Muskeg (MK)	16.11	0.04	0.2810
<i>wFQI</i>	Northern Sedge Meadow (NSM)	21.73	0.61	0.0000
<i>wFQI</i>	Open Bog (OB)	3.15	0.00	0.7777
<i>wFQI</i>	Shallow Water Marsh (SWM)	77.72	0.36	0.0180
<i>wFQI</i>	Shrub Carr (SC)	-2.17	0.02	0.4385
<i>wFQI</i>	White Cedar Swamp (CS)	-2.90	0.01	0.6682

