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Testing The Floristic Quality Assessment Index In Natural And Created Wetlands In Mississippi, Usa

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TESTING THE FLORISTIC QUALITY ASSESSMENT INDEX IN NATURAL AND CREATED WETLANDS IN MISSISSIPPI, USA

By

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The U.S. Environmental Protection Agency has mandated that states must include the use of biological assessments in their water quality laws to assess the biological integrity of aquatic systems. The Floristic Quality Assessment Index (FQAI), which uses wetland vegetation to assess the biological integrity of an ecosystem, has not been tested in Mississippi. The purpose of this study was to test the efficiency of the FQAI in wetlands along a gradient of human influence. Coefficients of conservatism (CC) were assigned to plant species based on their tolerance to disturbance and fidelity to habitat. A negative correlation was found between the FQAI and level of human disturbance for 53 sites surveyed in the summer of 2004. Based on the results of this study, the FQAI and the average CC could be effective tools for monitoring wetland management and restoration and for identifying areas of high conservation value in Mississippi.

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INTRODUCTION

Maintaining and restoring the biological integrity of surface waters is a component of the Clean Water Act of 1977. Karr (1991) defined biological integrity as “the ability to maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.” The foundation on which to assess changes to natural systems caused by humans is based on an understanding of baseline, or average, conditions that are determined by the interaction of biogeographic and evolutionary events (Karr and Chu 1999). Figure 1 illustrates the influence of multiple intrinsic and extrinsic factors on the biological integrity of an ecosystem, specifically wetlands.

Although the concept of “integrity” is included in the Clean Water Act, there is dissent within the scientific community as to whether this term should be used in the realm of ecology. Holland (2000) states that “integrity” is a normative concept. While science is based on how things are or are not, normative concepts (e.g., integrity, health) carry suggestions of how things should be or should not be. Sagoff (1997) objects to the use of “integrity” because it is construed as a property of ecosystems that suggests the ecosystem has structure, order and design. Because of this attribute, although not typically recognized by many ecologists, Sagoff (1997) also suggests that ecosystem old, no longer acknowledged paradigm of equilibrium ecology. Sutter (1993) suggests that ecosystem health is a metaphor, not an observable property, and that this term implies that ecosystems are "superorganisms." No matter whether the concept of integrity has some aspects in common with older ecological theory, the fact remains that there are patterns, structure, and predictability in nature (Holland 2000). Holland also points out that integrity need not be just a historical characterization (condition of minimum human influence), but can be functional and thereby quantifiable, such as describing and measuring soil composition, functional guilds, mineral and nutrient cycling, trophic exchange, nature and rates of decomposition, etc., which are affected by human activities. Also, using the term "integrity" implies there is intrinsic value to the element being described (Karr and Chu 1999). Biological integrity, when described as a service or commodity, can be used to engage society, since wetlands do indeed support human viability indirectly in numerous and irreplaceable ways.

Bioassessments

The Environmental Protection Agency (EPA), in cooperation with state agencies, has been given the responsibility of monitoring and managing aquatic systems to comply with the Clean Water Act. Criteria for chemical assessments, have been employed by many states to monitor aquatic systems, namely streams and lakes. Unfortunately, chemical criteria use a single-source-single-effect approach that does not take into account the complex interactions of multiple stressors to which ecological systems are subjected (Karr and Chu 1997). Karr and Chu (1999) argue that living organisms are more informative because their presence represents the integration of surrounding conditions and their evaluation can diagnose chemical, physical and biological impacts and their cumulative influences. The EPA and several states have developed systems of bioassessment, using biotic assemblages (e.g., vegetation, insects) as bioindicators. Bioindicators can be described as using the responses of living organisms to environmental stressors to determine and track the health of a particular system (Johnson et. al. 1993). Few states track the water quality of wetlands or have incorporated wetlands into their water resource quality programs in their jurisdictions. Wetland bioassessments can be used to refine water quality standards and help to develop numeric and narrative biological criteria (biocriteria). Other uses of bioassessments of wetlands include their incorporation into Clean Water Act Section 305(b) water quality reports and into decision making processes for approving development activity (e.g., dredge and fill permits). A more critical role bioassessments can play is in designating the type and condition mitigated wetlands have to achieve to replace those destroyed (Cronk and Fennessy, 2001). A more quantifiable approach based on bioassessments, such as indices of biological integrity, would improve our understanding of environmental stressors on biological integrity. Overall, bioassessments may increase our knowledge of the global role of wetland ecosystems and their value to humanity, in addition to serving as an important regulatory tool.

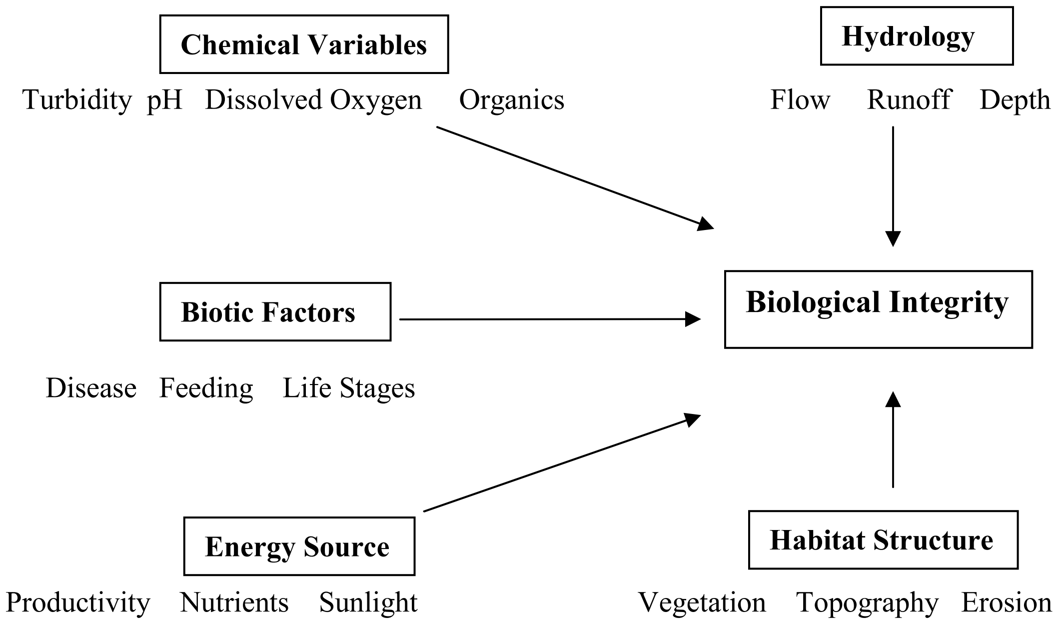

Figure 1. Ecosystem influences on Biological Integrity (adapted from EPA, 2002).

A stress on any one of the different factors influencing the biological integrity of a wetland can decrease the 'health' of the wetland.

Indices of Biological Integrity

In light of the progress made by the use of bioassessments, the next logical step was to develop a more scientifically testable assessment method. Certain attributes of biotic assemblages change systematically and predictably across a gradient of human disturbance. Based on that premise, biotic indices have been developed that assign a numeric score to reliable attributes, such as taxa richness, according to the level of disturbance indicated by comparison to a reference site. Biotic attributes that are given a score are referred to as metrics and the scores are then combined into a multimetric or an overall index. An Index of Biological Integrity (IBI) can be described as a reflection of the condition of the biological components of an ecosystem, summarized by a single number calculated from multiple metrics (EPA, 2002) (Figure 2). Indices of Biological Integrity can help states and the EPA to identify areas that need management action or evaluation of progress toward a set of environmental goals (Weisberg et al., 1997). Also, the summary score provided by the IBI can be used to communicate easily the results of the ecological evaluation to the public and policy makers. In ecosystem management, the use of biotic indices for monitoring biological assemblages can assess conditions prior to the initiation of new management practices, determine the impact of established practices, or track the impact of abiotic stressors (Rader et al., 2001).

Problems exist in developing IBIs, one of which was described by a project to develop an IBI for wetlands along the Great Lakes using a variety of community based metrics (e.g., plants, fish and invertebrates) (Wilcox, et al., 2002). Results from that study suggested that one weakness of the IBI is accurately quantifying or describing the amount of disturbance per site. Even though single metrics are predicted *a priori*, they are tested and assigned based on the subjective *a posteriori* assignment of amount of disturbance per site. Large scale activity can be evaluated by the use of aerial maps and GIS software within the watershed (e.g., percentage of impervious surfaces or agricultural use), but local disturbances, which can be more degrading to a wetland, usually are not taken into account in the ranking of sites. For example, if a set of wetlands is assigned levels of human disturbance based on a single surrogate of human influence, such as amount of urban area in watershed and then plotted against the amount of invasive species present per wetland, this may not reveal a classic dose response (linear) relationship. In fact, the response may be a non-linear, and may or may not be statistically testable. However, Karr and Chu (1999) express their concern that weak statistical correlations may miss important biological patterns. So the question remains: how does one accurately and objectively measure macro and micro disturbances and their overall impacts to a wetland, which then can be used to test the effectiveness of IBIs? Additionally, there are complications in choosing the appropriate set of wetlands and the temporal scale at which to compare them. In the previously described study, Wilcox, et al. (2002), felt the variation in ecological integrity among their study sites was confounded by the natural variability among the lakes and the temporal variability produced by yearly changing lake levels.

Biological communities not only reflect the cumulative effects of multiple stressors, they also exhibit effects from short-term and intermittent stressors such as pollution events and chemicals that break down shortly after entering the water column

(EPA, 2002). Indices of biological integrity were developed to gain a better understanding of how human induced changes to the environment were affecting the health or integrity of freshwater systems. The first IBI was developed by Karr (1981) for assessment of fish assemblages in freshwater streams in Illinois. The Ohio EPA (1987) developed an invertebrate community index (ICI) using macroinvertebrates to assess streams. Davis and Lubin (1989) independently tested and validated the ICI for use in evaluating the biological condition of Ohio streams. The Ohio EPA found that the use of older methods, such as measuring the chemistry of the water and physical characteristics of a stream, failed to identify a percentage of impaired streams that the IBI detected. Stream bioassessments also are less expensive then many frequent chemical measurements (Karr and Chu 1999). Having proven to be successful in streams, the original form of the IBI has been modified to assess many other ecosystems: rivers, (Kearns and Karr, 1994), lake coastal wetlands (Wilcox, et al., 2002, Simon, et al., 2001, Burton, et al., 1999), terrestrial areas (Kimberling et al., 2001) and marine ecosystems (Smith, et al., 2001). A variety of biological assemblages have been used to develop IBIs, such as zooplankton (Lougheed and Chow-Fraser, 2002), terrestrial invertebrates (Kimberling and Karr, 2001), diatoms (Apfelbeck, 1999), birds (EPA, 2002 and Bryce, et al., 2002) and amphibians (Micacchion, 2002).

One of the steps in developing an IBI for use in any natural system is to choose an assemblage of fauna or flora that consistently and reliably reflects the health of a system across a gradient of human disturbance. For the present work, vegetation was chosen as the indicator assemblage. There are many advantages to using plants as biological indicators (Cronk and Fennessy, 2001). Plants are of prime use because they complete their life cycle in the wetland and are in fixed positions. They have high species diversity and are a constant element of all wetlands worldwide. Taxonomy of wetland plant species is well known, and sampling techniques have been well developed. Many plant species have reliable sensitivity levels and respond predictably to changes in the temporal, spatial, chemical, physical and biological dynamics of the wetland and surrounding landscape. Although wetland plant species have many attributes compatible with use in biological assessments, they do have some disadvantages. Examples of disadvantages in the use of vegetation include: lag time in response exhibited by some species, such as trees, a limited seasonal sampling window for some herbaceous species, and the amount of training on the part of the investigator, which may influence the resolution of the identification of more difficult species (Cronk and Fennessy, 2001). However, by continued rigorous testing of their respective metrics, such as the response of certain functional groups to human induced stress, plant communities show promise as reliable indicators of wetland integrity.

Floristic Quality Assessment Index

Perhaps because they recognized the utility of vegetation for ecological assessments, Swink and Wilhem (1979, 1994) developed a floristic ranking system for the Chicago region, based on the fundamental principle that native plant taxa display a range of tolerances to disturbances and varying degrees of fidelity to a set of environmental parameters. This ranking system was based on what they called ‘species conservatism’.

Each species was assigned a numerical score, called a coefficient of conservatism (CC), reflecting the species' level of conservatism relative to other species present in the region. Descriptions of the categories used to assign the CC scores to each species, which range from 0-10, are listed in Table 1. For this study a modified version of CC categorical descriptions from Lopez and Fennessy (2002) was used.

Because species are assigned scores in relation to other elements in the local flora (Wilhelm and Ladd, 1988), these scores become less accurate as distance increases from the region of origin. Thus, CC scores need to be developed for defined areas were they will be applied. Once CC scores are developed for a regional flora, they can be used directly in assessing the quality of vegetation in target ecosystems by calculating a mean CC for all species present (Swink and Wilhelm, 1979), or by incorporation into one of the various floristic quality indices that have been developed for assessing terrestrial (Wilhelm and Ladd, 1988, Ladd, 1992 and Taft, et al., 1997) or wetland (Matthews, 2003, and Lopez and Fennessy, 2002) ecosystems. Although this system has been used primarily in the Midwest, it presently is being developed and evaluated in other parts of North America (e.g., California, Connecticut, and Florida). There is subjectivity inherent in using one's personal familiarity of a regional flora, but once the assignments have been made during the development phase, further bias would only occur during the application of these scores. Relative comparisons between sites (site 1 to site 2 to site 3), using CC, should not be distorted because any personal bias would be uniform across all sites. Andreas, et al. (2004) suggested that although there is subjectivity associated with the development of the CC values, the significance of any bias is a one time occurrence in the development phase and the actual application of these scores can be used objectively.

After the CC scores for a region are developed, species occurring in a defined area can be used to calculate a Floristic Quality Assessment Index (FQAI) for that area. The method for calculation of the FQAI is shown below (Andreas and Lichvar, 1995):

CC = Σ of coefficients of conservatism of native spp.

N = Number of Native spp.

$$\text{FQAI} = \overline{CC} * \sqrt{N} = \frac{\sum CC}{N} * \sqrt{N} = \frac{\sum CC}{\sqrt{N}}$$

Significance of Project

Despite calls for more regulation and stricter enforcement of environmental laws designed to protect the natural diversity of our nation's waters, the loss of wetlands and impairment of rivers and streams in the U.S. and across the globe continues at an alarming rate (McAllister, 1997). As the mitigation and restoration of wetlands continue, it is essential to ascertain whether a created or restored wetland resembles naturally occurring wetlands in terms of their ecological functions (Campbell et al., 2002). States, along with the EPA, can incorporate information from assessment indices such as the FQAI, into their water quality standards to improve water quality decisions. Under the Clean Water Act, states are required to develop water quality standards, such as designation of the use or uses of a waterbody, criteria to regulate and protect those uses, and measures to prevent impairment of the waterbody (EPA, 2002). Historically, states have relied on chemical and toxicity based criteria to determine the level of impairment of a wetland. However, states now are required to adopt biological criteria as part of their water quality standards for wetlands (EPA, 2002). Currently, Ohio, North and South Dakota, Wisconsin, Illinois, Florida, Indiana, Iowa, and Michigan have developed CC for their state's flora, Connecticut and California are in the development stages. With the development and integration of the FQAI and other biological assessments, states, such as Mississippi, could strengthen their wetland regulatory programs, improve wetland tracking, improve water quality decisions, improve monitoring, protection and restoration of biological integrity and improve the evaluation of the performance of regulatory activities (EPA, 2002).

Research Objectives

Because a need exists for wetland bioassessment, mandated by the Clean Water Act, which are currently undeveloped and/or untested for the state of Mississippi, the objectives of this research were to:

- Test the accuracy and utility of using the Floristic Quality Assessment Index and its modifications to summarize the vegetative quality, across a gradient of human disturbance, of created and natural wetlands in Mississippi.
- Develop a sensitive, objective method of indexing the level of human disturbance to wetland sites and identify relationships between human disturbance and floristic characteristics.

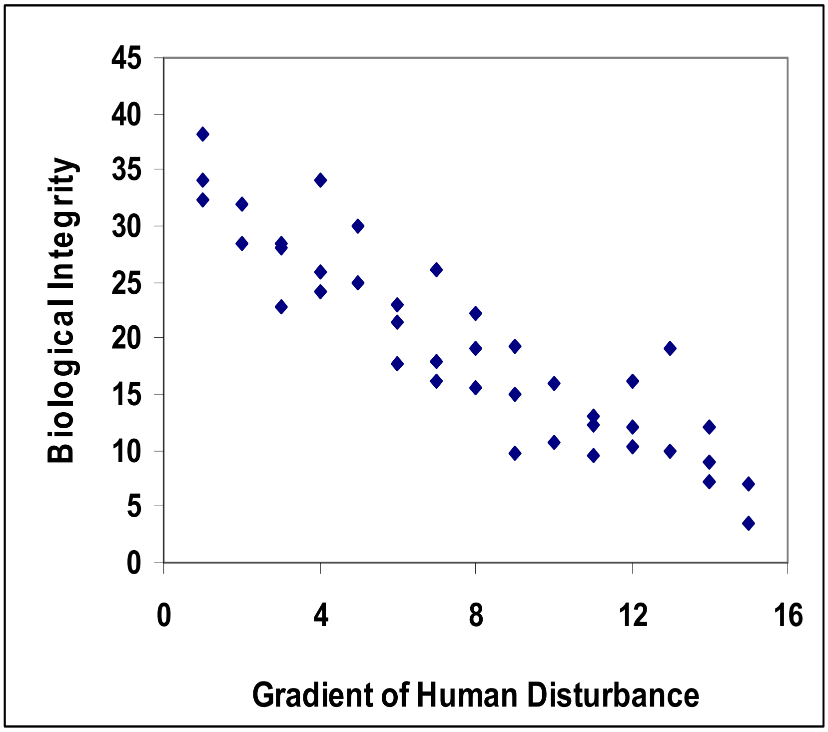

Figure 2. A hypothetical scenario illustrating the effects of human disturbance on a biological community.

The y-axis can be calculated by any index of biological integrity, such as the Floristic Quality Assessment Index or species richness. The biological integrity of an ecosystem decreases across the gradient of human disturbance.

Table 1. Description of categories used to assign Coefficients of Conservatism. Modified version from Lopez and Fennessy (2002)

Score	Description
0	All non-native taxa
1-3	Native taxa that are found in disturbed sites
4-6	Native taxa that are typically associated with a specific plant community, but tolerate moderate disturbance to that community
7-8	Native taxa in plant communities in an advanced successional stage that have undergone minor disturbance
9-10	Native species with high degrees of fidelity to a narrow range of synecological parameters

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CHAPTERII:

METHODS

Description of Study Area

Sample sites were situated across north and central Mississippi, including one Alabama, just east of MS-AL state line. Human activities within this region are predominately agricultural (31%, unpublished data, Ervin et al., 2005) (e.g., cotton, soybeans, corn, and domestic cattle), including a proportion managed actively for commercial timber production (15%). The smallest proportion of the landscape is urban or residential (1%). This area of the southeast has two predominant types of naturally-occurring emergent heraceous wetlands: beaver impoundments and oxbows (formed when a river channel changes course). All other emergent wetlands surveyed during this research were constructed by humans; examples include moist soil wetlands managed for waterfowl, farm ponds, city park ponds, sewage lagoons, and borrow pits. Wetland sites were located using a variety of methods including aerial photograph observation (Terra Server-USA 2004), collaboration with local landowners and natural resource managers, and topographic map reconnaissance.

Selection and Characterization of Wetland Sites and Human Disturbance Gradient

According to the framework proposed for the development of an IBI, a specific category of wetland must be chosen *a priori*. One must strive to avoid comparing wetlands of dissimilar classes to lessen the effects of natural variability among ecosystems on statistical evaluation of index effectiveness, which may obscure a biological signal produced by human disturbance (EPA, 2002). For this study, emergent palustrine wetlands (Cowardin, et al., 1979) that had a hydrologic regime consisting of at least some year-round standing water were selected. Only beaver impoundments were chosen to represent reference conditions, because of their frequency of occurrence in the study area and ease of access. The recommended number of reference wetlands is at least three (EPA, 2002). However, Karr and Chu (1999) and Karr (personal communication) proposed using only one reference site of the highest overall quality when conditions of the study region are dominated by very high levels of activity and all other sites that represent the lowest amount of human disturbance are still considered to be moderately impaired. We included seven beaver ponds in our set of study wetlands, other wetland sites were then selected, spanning the gradient of human influences available within the study region as per suggestions of EPA (2002).

Initially, sites were selected based on current knowledge of watershed- and landscape-level characteristics in order to ensure sampling across a gradient of potential human impacts. Once the set of study sites was selected, local-scale wetland characteristics were investigated further and recorded, such as buffer condition (100 m surrounding wetland boundary) and hydrologic and immediate habitat alterations. These measures of human disturbance were used to rank each wetland site according to the level of anthropogenic disturbance within the surrounding landscape and within the wetland proper.

Two methods were used to rank the level of human disturbance at each site. The first method, the Disturbance Index (DI) (Appendix A), originally was developed in Ohio (Lopez and Fennessy, 2002) and is a three-tiered hierarchical flow chart. The first level of the chart represents the dominant landscape use within the surrounding area of the site, followed by the type of buffer surrounding the wetland, and then finally by a dichotomous measure of hydrologic alteration. Sites were ranked from 1, representing the least impairment, to 24, representing the highest level of impairment. An example of a least impaired site is a naturally occurring beaver impoundment in a forested landscape with forested buffer and hydrology unaltered by humans. A ditch, surrounding a shopping mall, is an example of a highly impaired site, situated in an urban area, with no buffer and human altered hydrology. The second method of quantifying human disturbance to the wetlands, the Anthropogenic Activity Index (AAI) (Appendix B), was developed to rank each level of disturbance separately, rather than coupled as in the DI flowchart. Also, the development of the AAI strove to include other types of disturbances and measures of habitat heterogeneity not included in the DI. The AAI is a modification of the index developed by Minnesota Department of Environmental Quality (Gernes and Helgen, 2002) and includes sections from the Ohio disturbance ranking system (Mack, 2001). Sites were evaluated by five different metrics. Those metrics are divided into four categories, each of which is scored 0 to 3. The metrics are summed for a total index score. Sites that score a 0 are considered to have very low levels of impairment, as expected for reference sites. At the opposite end of the gradient, sites that scored a 15 represent the highest levels of impairment.

Plant Surveys

Ten wetland sites were surveyed in the summer of 2003 and revisited in 2004. Eight of those ten sites, along with one new wetland (9 sites total), were surveyed in the spring of 2004. An additional 43 wetlands were surveyed in the summer of 2004 (53 sites total in 2004). Site information and data summary for all 53 sites sampled in the summer of 2004 are listed in Appendix C.

In 2003, wetland plant species were surveyed for sites HSBP, HSM1 and HSM2 (location of sites listed in Appendix C), along a single transect with random starting points. The transect was placed approximately in the middle of the vegetated zone running parallel to open water at time of the sampling, 20 to 26 0.25 m^2 circular plots were placed along the transect. Sites NFP, N11B, N10, N8, HSFP, MP4 and MP2, were surveyed using a modified version of the plant sampling protocol described by Lopez and Fennessy (2002). At each wetland, ten transects were placed perpendicular to and evenly (~ 10 – 40 m apart) around the edge of the wetland boundary extending toward the center. At every 10 meters along transects, two 0.25 m^2 square plots were placed on either side and all vascular plant species within or overhanging plots were recorded. This was repeated along transects until reaching the approximate center or open water (no vegetation).

All other species encountered, but not present in the plots, were recorded. As a result, larger wetlands had a higher number of plots, and thus larger area, sampled than in smaller wetlands.

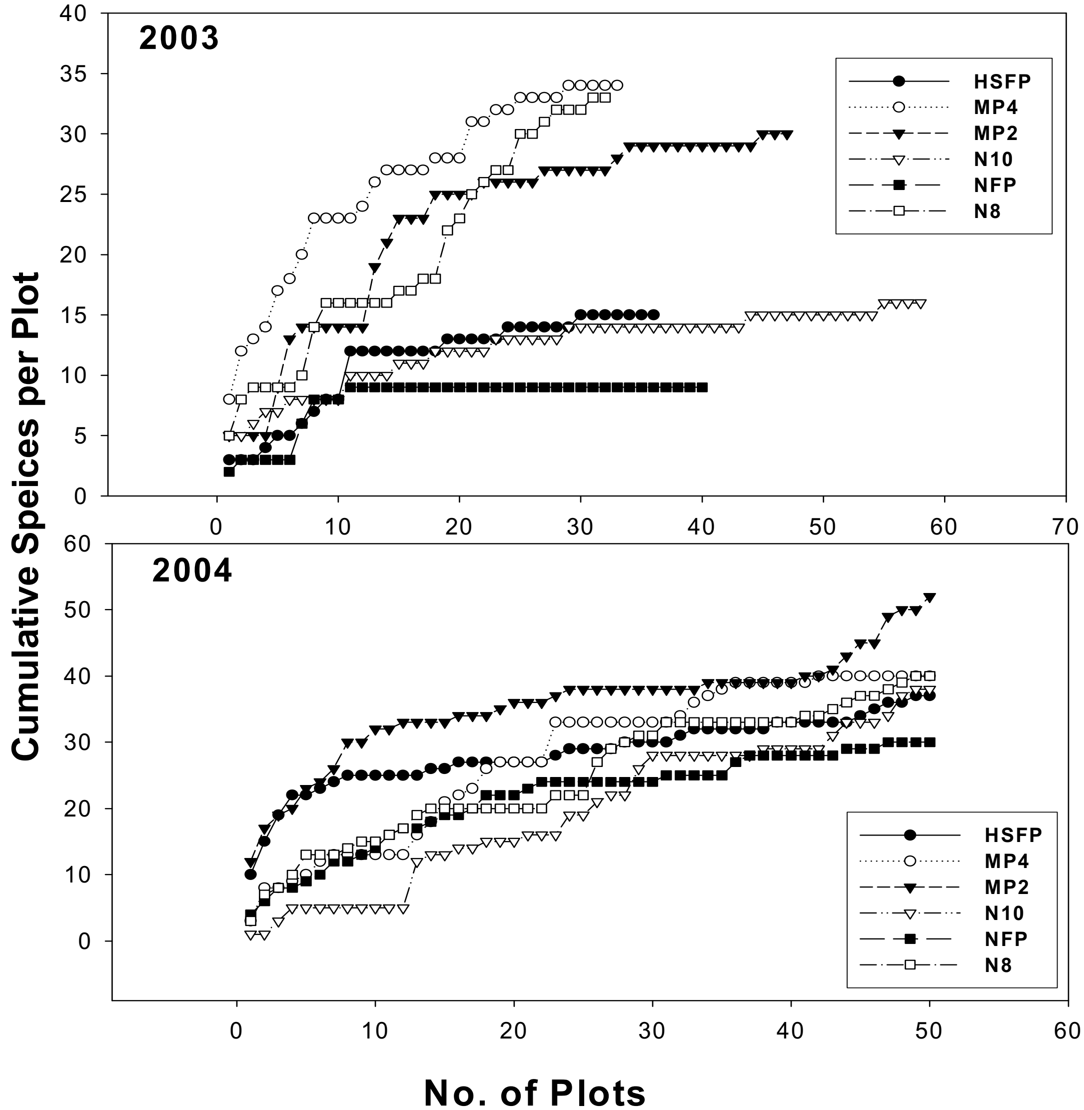

Figure 3. Species area curves for six wetland sites sampled with two different methods.

The first method used to sampled plants in 2003 and the second in 2004.

Also, the species-area curves generated from the 2003 data showed a lack of saturation for many wetlands, regardless of size, indicating that area (number of plots) sampled needed to be increased to include more species information (Figure 3).

In 2004, the wetland vegetation survey method was modified to standardize the absolute area sampled per wetland. Wetland plant species were surveyed at each site, by placing 0.5 m^2 circular plots, which improve accuracy of assigning of perimeter species as in or out of the plot (Krebs, 1999), every 5 to 20 meters along transects for a total of 50 plots. Transects were placed 10-40 m apart, perpendicular to the edge of the upland/wetland boundary extending through the vegetation zone towards the center of the wetland. The transects were placed using a stratified random sampling design. This was to ensure that data were collected from all habitat zones within the wetland. Daubenmire (1959) suggested that after 40 plots are surveyed by such procedures, no additional significant information is gained by further sampling. Species accumulation curves from the 2004 data suggested that the effort was sufficient enough not to warrant continued sampling after 50 plots (Figure 3). This method was repeated at all sites except in extreme topographic situations, in which the accessible vegetation was arranged in a band encircling water too deep to transverse. In those cases, transects bisected the available vegetation, running parallel to the open water. All vascular plants that occurred in the plots, or were overhanging the plots, were identified to species if possible. Voucher specimens of all species identified were preserved and deposited in the Mississippi State University Herbarium. For quality control purposes, trained botanists confirmed many species identifications. Also, species that did not occur in the plots but were observed within the wetland proper were recorded. Even though the vast majority of species were identifiable to species level, the number of unknown species per site was recorded, to ensure accurate calculation of species-area curves. For the most up to date nomenclature, the PLANTS Database (USDA) was followed, with a few exceptions: *Carex* spp. followed the Flora of North America vol. 23 (Cyperaceae) (1993) and *Solidago* spp. followed Radford, et al. (1968). Species identifications were made first with Godfrey and Wooten (1979, 1981) for most obligate wetland species, Cyperaceae and Poaceae. Most upland species (forbs and graminoids) were first identified with Radford, et al. (1968) and Hitchcock (1971). Determination of species origin and wetland indicator status was a compilation of personal communication with professionals and numerous sources, including botanical key descriptions and the PLANTS Database (USDA). It should be noted that the PLANTS Database should not be the only source when determining origin, because of unresolved inconsistencies in their database; the Flora of North America was considered the definitive source for this information where possible.

Assigning Coefficients of Conservatism

A total of eight professionals, with different areas of expertise in wetland vegetation, separately were asked to assign coefficients of conservatism (CC) to the list of plant species surveyed. Although there were many species which not all eight botanists could decisively grant a preliminary score, an average of the available scores was taken for each species, and that mean value was assigned as the CC. A list of species and their CC values are in Appendix D. In many other regions, a special meeting was convened, and a group of regional botanists came to a consensus regarding each species separately (Ohio, North and South Dakota, and Wisconsin). However, the present method was similar to that employed in Florida, wherein Cohen, et al. (2004) tested the Floristic Quality Assessment Index calculated by their CC values. Their method of assigning CC values was proven to be an effective alternative method to convening a committee. Also, in a study conducted in North Dakota (Mushet et al., 2002), it was shown that changing the CC of some species to better reflect the best professional judgment of one particular surveyor would not appreciably change the outcome of the assessment.

Data Analysis

The original method of calculating the FQAI excludes non-native species, thereby desensitizing the index to a sometimes considerable proportion of species that would reflect a more complete picture of the true quality of a site. For the purposes of assessing the impact of the exclusion of non-native species, a few modifications of the FQAI were calculated (FQAI 3) and included in my analyses. These modifications (FQAI 2 and 3) to the FQAI 1 are detailed below:

cc = Σ coefficients of conservatism of native spp. occurring in plots

CC = Σ coefficients of conservatism of native spp.

n = Number of native spp. occurring in plots

N = Number of native spp.

T = Number of all spp.

$$1.\text{FQAI } 1 = \frac{\sum CC}{\sqrt{N}} \qquad 2.\text{FQAI } 2 = \frac{\sum cc}{\sqrt{n}} \qquad 3.\text{FQAI } 3 = \frac{\sum CC}{\sqrt{T}}$$

The second modification (FQAI 2) was an attempt to measure the effects of not including all species that occur at a site when calculating the FQAI, but instead including only native species which were present in the sample plots. An example of how the FQAI, its modifications, and the average CC scores were calculated for two sites are illustrated in Table 2.

Data were analyzed using linear regression techniques, performed on SYSTAT version 9.0. All FQAI (1-3) values were regressed against the two different disturbance indices, total species, invasive species and native species. Data for seasons (spring and summer), years (2003 and 2004) and methods to calculate the FQAI (FQAI 2 and 3) were separately regressed against both the DI and AAI. To compare the relationship between seasons, years and methods, analyses of covariance (ANCOVA) were performed. To test for normality, probability plots were generated and the straightness of line did not change appreciably when data were transformed and replotted, therefore data were not transformed for the previously described analyses.

Table 2. Calculation of Floristic Quality Assessment Indices for two wetland sites in Mississippi.

Holly Springs Beaver Pond (HSBP) and Dahomey National Wildlife Refuge (Dahomey NWR). Authorship of species is given in Appendix C.

HSBP	CC	Dahomey NWR	CC
Aster dumosus	3	*Ammania coccinea*	5
Bidens discoidea	3	*Ampelopsis arborea*	2
Boehmeria cylindrica	3	*Brunnichia ovata*	3
Brasenia schreberi	5	*Campsis radicans*	3
Campsis radicans	3	*Carex albolutescens*	2
Carex albolutescens	1	*Carex frankii*	4
Carex squarrosa	5	*Cephalanthus occidentalis*	5
Cephalanthus occidentalis	5	*Cyperus pseudovegetus*	2
Ceratophyllum demersen	2	*Desmanthus illinoense*	2
Cinna arundinacea	6	*Diospyros virginiana*	2
Cyperus erythrorhizos	2	*Eleocharis obtusa*	4
Cyperus strigosus	2	*Hibiscus moschoetus*	3
Dicanthelium dichotomum	6	*Hydrolea uniflora*	3
Echinochloa crusgali	0	*Iva annua*	1
Echinochloa walteri	4	*Juncus diffusissimus*	2
Eclipta alba	3	*Juncus effusus*	3
Eleocharis obtusa	4	*Leersia oryzoides*	3
Erechtites hieracifolia	1	*Ludwigia decurrens*	4
Eupatorium perfoliatum	3	*Ludwigia peploides*	1
Eupatorium serotinum	2	*Ludwigia repens*	3
Galium tinctorium	1	*Lythrum lineare*	3
Heteranthera reniformis	5	*Penthorum sedoides*	3
Hydrocotyle ranunculoides	2	*Pluchea camphorata*	5
Impatiens capensis	6	*Polygonum hydropiperiodes*	5
Ipomoea hederacea	1	*Rhynchospora corniculata*	3
Juncus effusus	3	*Rubus argutus*	4
Leersia oryzoides	3	*Rubus trivialis*	4
Lemna minor	3	*Rumex crispus*	3
Liquidumbar styraciflua	3	*Setaria geniculata*	0
Lonicera japonica	0	*Sorghum halepense*	3
Ludwigia decurrens	4	*Taxodium distichum*	5
Ludwigia leptocarpa	2	*Typha latifolia*	4
Ludwigia peploides	1	*Veronica altissima*	1
Lycopus virginicus	4		
Microstegium vimineum	0		

Table 2. (Concluded)

HSBP	CC	Dahomey NWR	CC
Mikania scandens	3		
Nuphar luteum	3		
Panicum dichotomiflorum	2		
Panicum rigidulum	3		
Platanus occidentalis	2		
Pluchea camphorata	5		
Polygonum caespitosum	0		
Polygonum densiflorum	5		
Polygonum hydropiperoides	3		
Polygonum lapathifolium	0		
Polygonum sagittatum	7		
Potamogeton nodosus	2		
Rhexia mariana	3		
Rosa multiflora	0		
Rotala ramosoir	3		
Rubus argutus	4		
Salix nigra	3		
Scirpus cyprinus	4		
Smilax glauca	3		
Sparganium americanum	7		
Spirodela punctata	0		
Toxicodendron radicans	1		
Triadenum walteri	4		
Typha latifolia	4		
Utricularia biflora	5		
Vitis cinerea	4		

HSBP		Dahomey NWR	
Σ CC	**181**	**Σ CC**	**100**
No. of native spp.	**54**	**No. of natives spp.**	**32**
No. of non-native spp.	**7**	**No. of non-natives spp.**	**1**
Total spp.	**61**	**Total spp.**	**33**
FQAI 1	**24.6**	**FQAI 1**	**17.7**
FQAI 3	**23.2**	**FQAI 3**	**17.4**
Average CC	**2.97**	**Average CC**	**3.03**

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CHAPTER III:

RESULTS

Species Surveyed and Coefficients of Conservatism

Wetlands were assessed in 24 counties across central and north MS and one in AL on the MS-AL border, with 411 vascular plant species identified (Appendix C). Of the 411 plant species identified, non-native species accounted for 14% (59 species). The majority of plant species (82.5%) were assigned a CC of 4 or less, and only 7 species received a CC value of 8. There were no species assigned a CC of 9 or higher. The average CC value for the 411 plant species was 2.8.

The frequency distribution of CC values (Figure 4) for wetland species sampled in Mississippi was skewed toward less conservative species. The majority of the 411 plant species surveyed were assigned a CC score of 5 or less and 14 % of species were non-native. When species were grouped by their growth forms and life history traits (Figure 5), perennial forbs (113 spp.) were the largest group of species, and along with perennial *Carex* spp. and perennial graminoids (19 and 66, respectably, a total of 85 spp.) perennial species accounted for 58.2% of total species recorded. The second largest physiognomic group was annual forbs, with 76 spp.

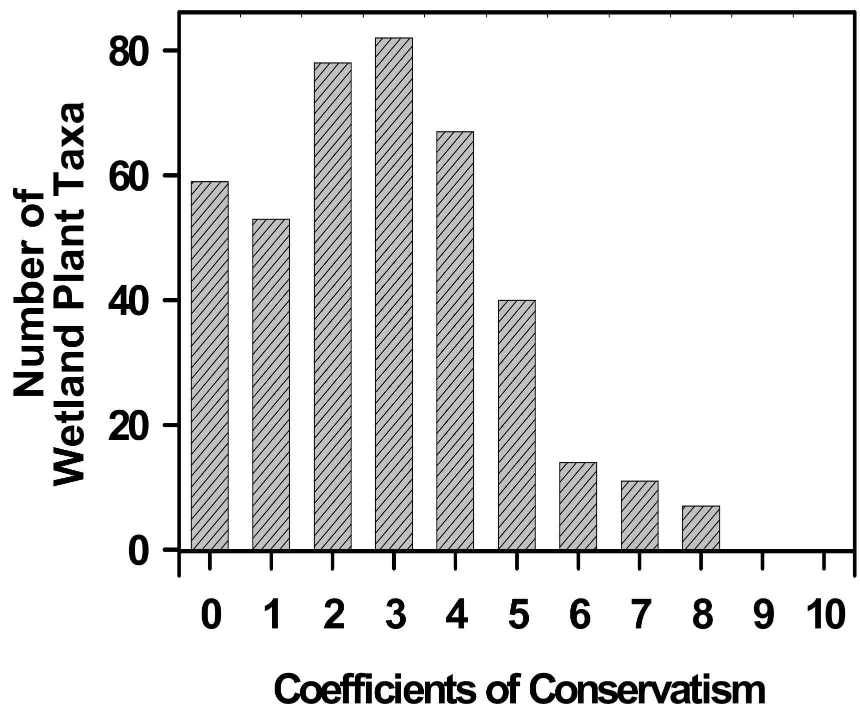

Figure 4. Distribution of coefficients of conservatism for wetland plant species surveyed in 2003 and 2004.

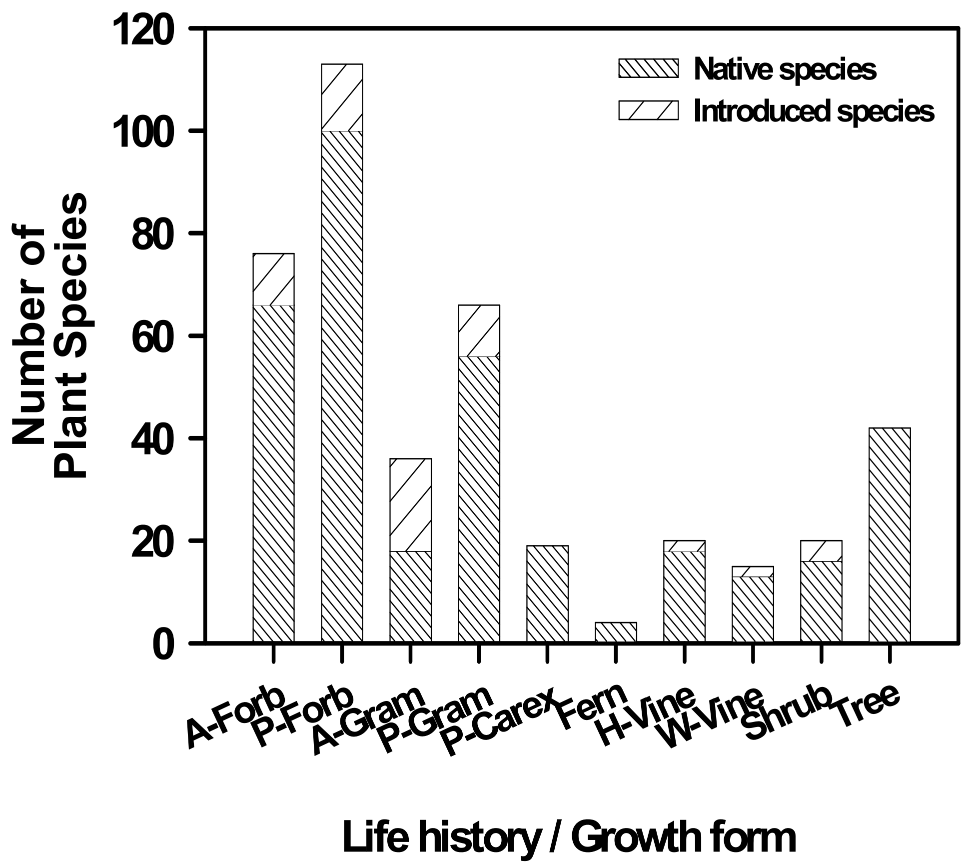

Figure 5. Distribution of wetland plant taxa by physiognomy.

Abbreviations as follows: (A) annual, (P) perennial, (H) herbaceous, (W) woody, and Gram = graminoid

Comparing 2003 and 2004 Vegetation Survey Methods

Vegetation was surveyed in ten wetland sites in 2003 and 2004 (Table 3). The method used to sample the plant communities differed between years as described in the methods section. Number of species sampled (natives and introduced) increased in nine out of the ten sites in 2004. An average of 18.5 species per site was added in 2004 across the ten sites. Most notably, in 2004, all sites increased in native species sampled. Nine sites had an increased FQAI 1 value. The average CC values for all sites did not change markedly.

Figure 3 depicts the species area curves for six of the ten sites sampled in 2003 (sites which were sampled in 2003 with ten total transects with two 0.25 m^2 square plots placed at every 10 m). The other four sites sampled in 2003 were not directly compared to the six sites because they were sampled with a slightly different method. In 2003, three of the six sites (MP2, MP4, and N8) did not display a saturation of species or an asymptote, suggesting that more sampling of those sites would have yielded a more adequate picture of species richness. Conversely, out of the same six sites surveyed with the second method in 2004, only one site (MP2) was not sampled with enough effectiveness to depict the characteristic plateau (species saturation). The five sites reached a plateau in cumulative number of species encountered between 40 and 50 plots. All sites sampled in 2004 had a total of 50 plots surveyed.

Wetland Site Disturbance Ranking

Wetland sites were qualitatively scored according to the amount of disturbance in and surrounding their boundaries by two different methods, the Disturbance Index and the Anthropogenic Activity Index (AAI). Disturbance Index scores ranged from 1 to 24, the largest number of sites were scored 1 to 4 (43%, Figure 6), with 5 sites receiving the lowest disturbed ranking of 1. On the other end of the gradient, three sites received a score of 24, representing the highest level of disturbance. For the second method, AAI, sites scores ranged from of 0 to 14. Seven sites were scored from 0 to 3 (13%, Figure 6), only one site was considered to have no measurable human influence (a beaver pond), and received a 0. No wetland sites were scored 15, which represent the highest level of human influence, however, two sites were scored 14.

Floristic Quality Assessment Indices Relationship to Human Disturbance

Data were assumed normally distributed when transformations did not appreciably change the distribution of values plotted by probability plots (all analyses performed with SYSTAT version 9). Linear regression analyses were performed to assess the relationship between the FQAIs (1 and 3; FQAI 2 is treated in a later section), and the human disturbance rankings (DI and AAI). All regression results are reported on Table 4 for 53 sites surveyed in 2004. Although both the FQAIs were significantly correlated with both DI and AAI (Figure 7), the modified FQAI 3 showed the stronger relationship to the two disturbance indices. Notably, between the two disturbance indices, the AAI exhibited a stronger negative correlation for all indices.

Table 3. Summary data for ten wetlands surveyed in 2003 and 2004

Native species (N), introduced species (I), total species (T). Sampling methods differed between years. The majority of the sites had an increase of N, I, T and FQAI 1, but not average CC.

	N		I		T		FQAI 1		Ave CC	
	‘03	’04	’03	’04	‘03	‘04	‘03	‘04	‘03	‘04
HSBP	33	54	0	7	33	61	21.2	24.6	3.7	3.0
HSFP	17	36	1	3	18	39	16.3	17.5	3.1	2.7
HSM1	15	37	3	3	18	40	11.6	17.8	2.5	2.7
HSM2	16	34	3	6	19	40	13.5	19.2	2.8	2.8
MP2	29	51	9	10	38	61	16.9	21.3	2.4	2.5
MP4	28	48	7	12	35	60	17.2	19.9	2.7	2.3
N8	50	44	7	8	57	52	21.8	20.1	2.7	2.6
N10	26	40	8	6	34	46	17.1	20.7	2.6	2.8
N11B	41	51	3	4	44	55	20.1	23.8	2.9	3.1
Average	28	44	5	7	33	50	17.3	20.5	2.8	2.7

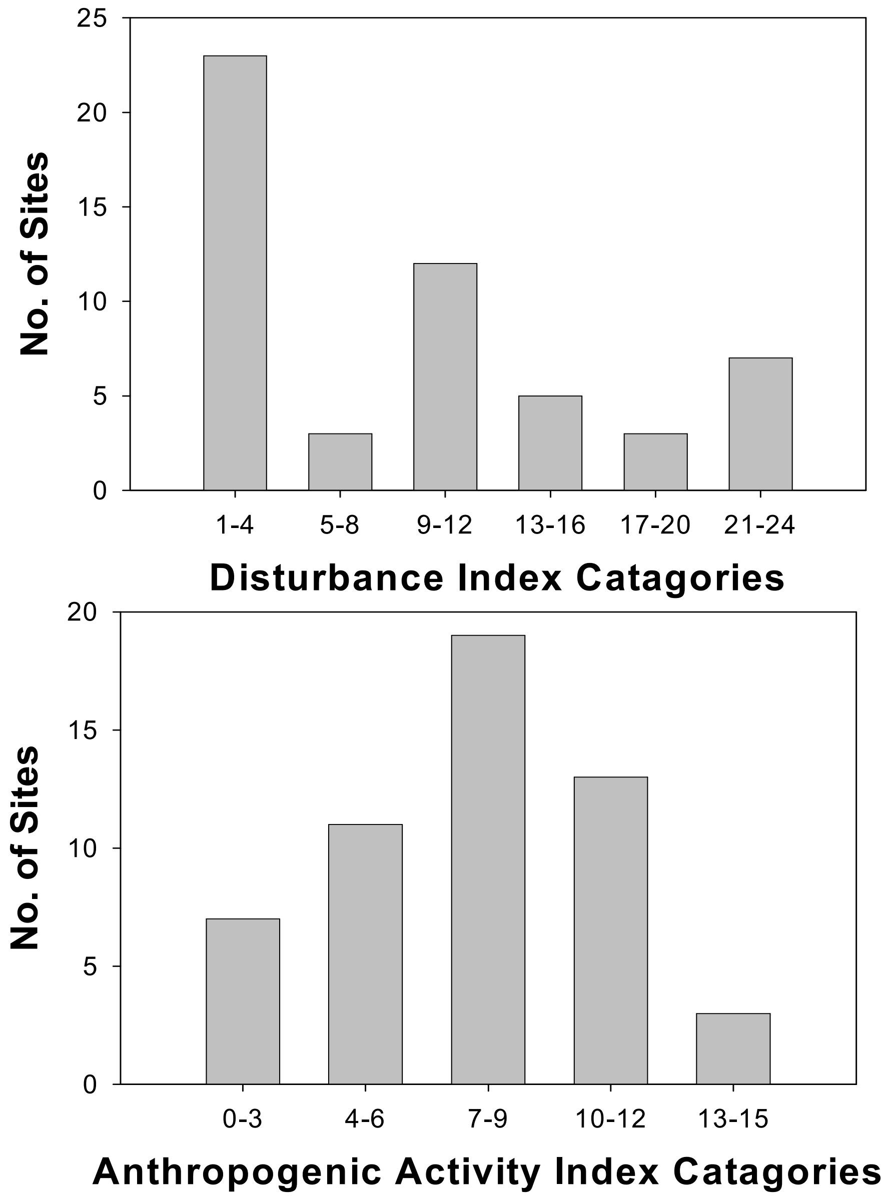

Figure 6. Distribution of site scores for 53 wetlands assigned by two different methods, Disturbance Index and Anthropogenic Activity Index.

Table 4. Comparison of regression analyses for the Floristic Quality Assessment Index (FQAI 1) and modifications to index (FQAI 3) for 53 sites surveyed in 2004.

DI = Disturbance Index, AAI = Anthropogenic Activity Index, Total spp. = total species richness, Introduced spp. = number of introduced species, and Native spp. = number of native species. **P ≤ 0.01, ***P ≤ 0.001

Index	Slope	R^2	$F_{1, 51}$	P	
vs. DI					
FQAI 1	-0.18	0.13	7.5	0.008	**
FQAI 3	-0.23	0.18	11.1	0.002	**
vs. AAI					
FQAI 1	-0.55	0.24	16.2	0.0001	***
FQAI 3	-0.65	0.30	21.8	0.0001	***
vs. Total spp.					
FQAI 1	+0.18	0.37	30.4	0.0001	***
FQAI 3	+0.16	0.27	19.0	0.0001	***
vs. Introduced spp.					
FQAI 1	-0.28	0.07	3.8	0.055	
FQAI 3	-0.44	0.16	9.7	0.003	**
vs. Native spp.					
FQAI 1	+0.25	0.58	69.8	0.0001	***
FQAI 3	+0.24	0.49	49.7	0.0001	***

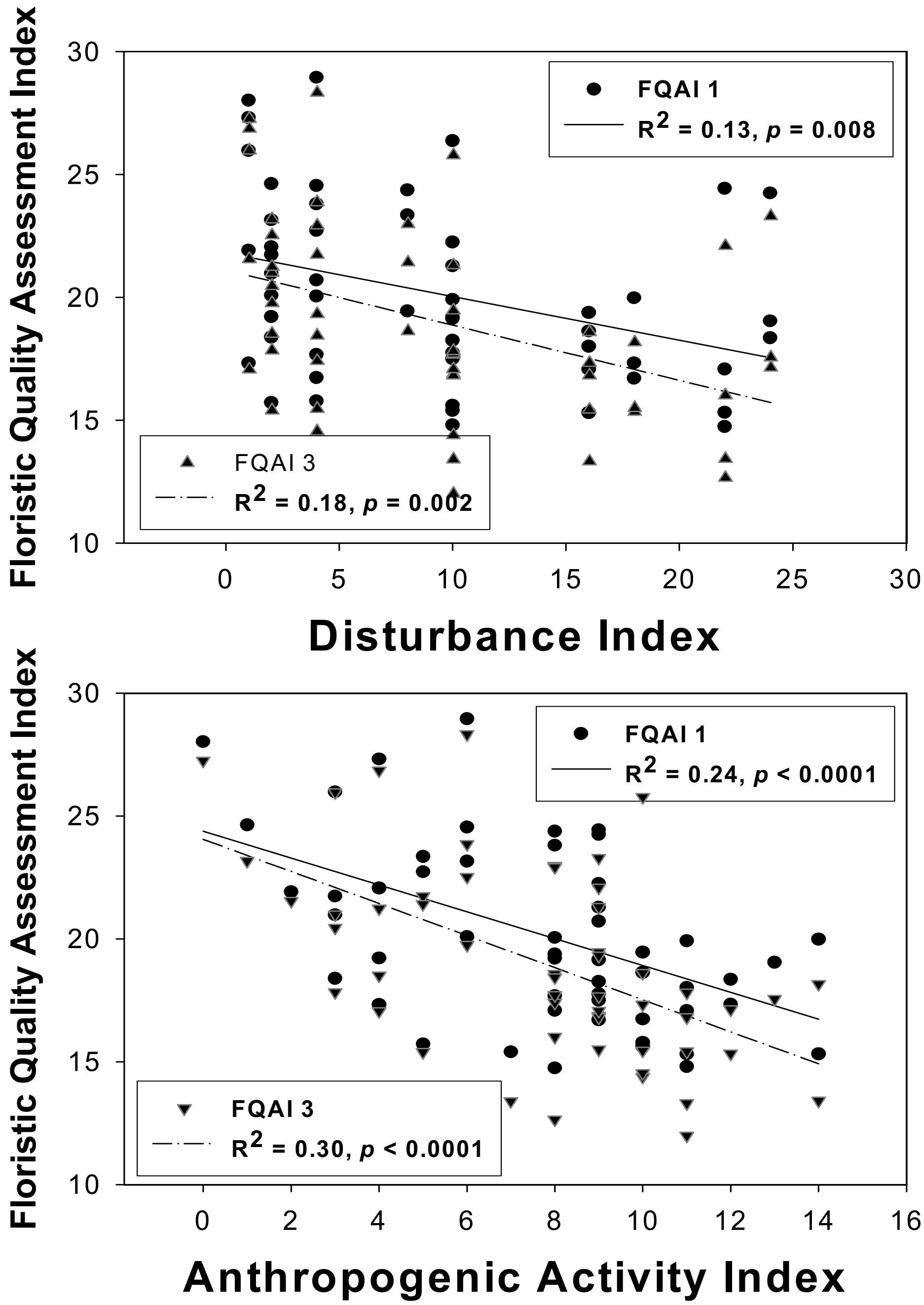

Figure 7. Relationship between FQAI 1 and 3 and the two disturbance indices, DI and AAI, for 53 wetland sites sampled in 2004.

Effect of Using a Subset of Species to Calculate Floristic Quality Assessment Indices

The FQAI 2, a modified version of the FQAI 1, was calculated by including only species which were present in sampled plots. The FQAI 2 used a smaller subset of species to calculate the quality of an area. This was performed for 44 sites sampled in 2004. Miscommunication among wetland vegetation surveyors led to nine sites not being sampled with the same protocol outlined in the methods, instead species present in plots were the only species recorded for those sites. Therefore those nine sites were not included in this analysis. Analysis of covariance (ANCOVA) was used to test for differences in the method used to calculate the FQAI 1 and FQAI 2 for each index of disturbance (DI and AAI). A significant interaction would indicate that the two methods of calculating the FQAI were responding to the amount of human disturbance in different ways. There was a significant interaction between FQAI 1 and FQAI 2 for both DI and AAI (df = 86, 1, F = 4.867, P = 0.030; df = 86, 1, F = 5.893, P = 0.017, respectively), thus the slopes were found to be non-homogeneous.

All indices were found to have a significant negative response to both DI and AAI (Table 5, Figure 8). As was found earlier, when comparing the two disturbance indices, the AAI demonstrated a stronger correlation with all indices than did the DI.

Average Coefficient of Conservatism Relationship to Human Disturbance

The average CC score for 53 sites sampled in 2004 was significantly correlated to both human disturbance rankings (Table 6). When compared with the FQAI 1, the average CC exhibited a stronger negative response to both DI and AAI (Figure 9).

Effect of Seasons on the Use of the Floristic Quality Assessment Indices

Nine sites were surveyed twice in 2004, once in spring and summer. The FQAI 1 scores for the spring-sampled sites ranged from 8.6 (site HSM1) to 17.8 (site HSBP) (Table 7), while summer scores ranged from 15.4 (site NFP) to 24.6 (site HSBP). The FQAI scores increased a mean value of 6.8 per site between the two seasons. Also, there was a mean increase of 23 new species recorded per site in the summer sampling period. Although there were changes in species richness between seasons, there was a negligible change in the average CC score per site.

To test for differences among seasons on the FQAI (spring and summer), an ANCOVA was used; disturbance indices were the covariates. There was a significant interaction between spring and summer against amount of disturbance for both disturbance indices (DI: df = 14, 1, F = 15.862, P = 0.001, AAI: df = 14, 1, F = 12.272, P = 0.003). Spring and summer FQAI scores were then analyzed separately against the disturbance indices. Regression results were mixed between seasons for the FQAI 1. The FQAI 1 of the summer-sampled sites were found to be negatively correlated with the DI, but not with AAI (Figure 10). Also, there was a broader range of scores between wetland sites indexed with the DI vs. the AAI. There was no correlation between FQAI 1 scores and both disturbance indices for spring-sampled sites.

While there was a negative trend, the average CC value per site for both seasons was not correlated with either disturbance index (Figure 11). However, there was an outlier (site Trimcane), and after removing the outlier from analysis, there was a significant negative relationship between the DI and both FQAI 1 and average CC.

Table 5. Comparing regression analyses for the FQAI calculated by species occurring only in plots (FQAI 2), for 44 of the 53sites surveyed in 2004.

All other abbreviations are the same from the previous Table 2.

Index	Slope	R^2	$F_{1, 42}$	P	
vs. DI					
FQAI 1	-0.231	0.14	6.6	0.014	**
FQAI 2	-0.176	0.15	7.1	0.011	**
vs. AAI					
FQAI 1	-0.76	0.26	14.9	0.0001	***
FQAI 2	-0.549	0.25	14.1	0.0001	***
vs. Total spp.					
FQAI 1	+0.328	0.37	24.1	0.0001	***
FQAI 2	+0.272	0.46	35.7	0.0001	***
vs. Introduced spp.					
FQAI 1	-0.613	0.14	6.7	0.013	**
FQAI 2	-0.507	0.17	8.8	0.005	**
vs. Native spp.					
FQAI 1	+0.409	0.55	50.5	0.0001	***
FQAI 2	+0.388	0.69	92.7	0.0001	***

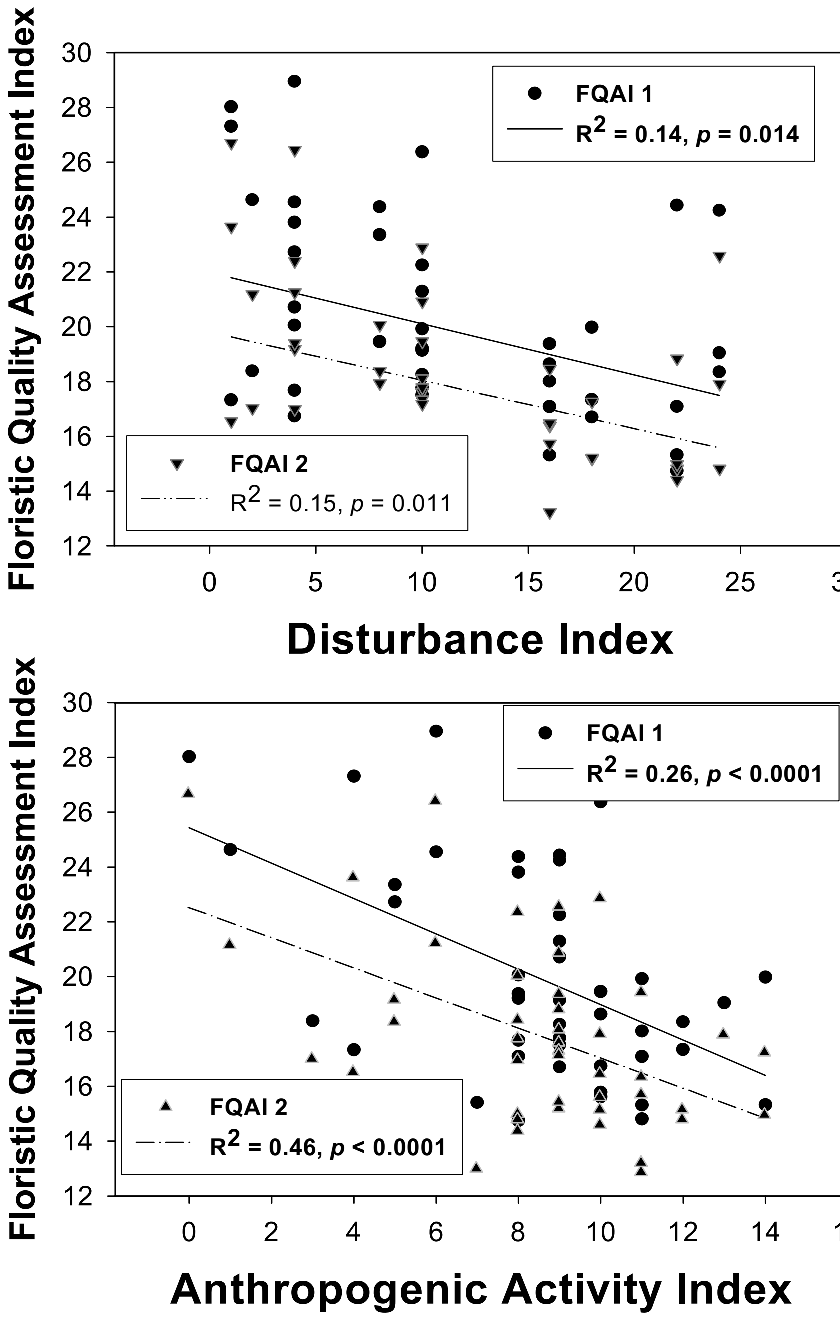

Figure 8. Relationship between FQAI 1 and 2 and two disturbance indices, DI and AAI, for 44 wetland sites sampled in 2004.

The sites that were sampled with species occurring in plots only recorded were excluded from analysis.

Table 6. Comparison of regression analyses for the average CC (Ave CC) and the Floristic Quality Assessment Index (FQAI 1) against the two disturbance indices (DI and AAI).

Total species richness (Total spp.), number of introduced species (Introduced spp.) and number of native species (Native spp.) for 53 sites surveyed in 2004.

Index	Slope	R^2	$F_{1,51}$	P	
vs. Ave CC					
DI	-0.04	0.36	29.05	0.0001	***
AAI	-0.12	0.55	63.44	0.0001	***
Total spp.	-0.01	0.02	1.01	0.32	
Introduced spp.	-0.12	0.63	87.29	0.0001	***
Native spp.	+0.004	0.01	0.44	0.511	
vs. FQAI 1					
DI	-0.18	0.13	7.50	0.008	***
AAI	-0.55	0.24	16.20	0.0001	***
Total spp.	+0.18	0.37	30.40	0.0001	***
Introduced spp.	+0.28	0.07	3.80	0.055	
Native spp.	+0.25	0.58	69.80	0.0001	***

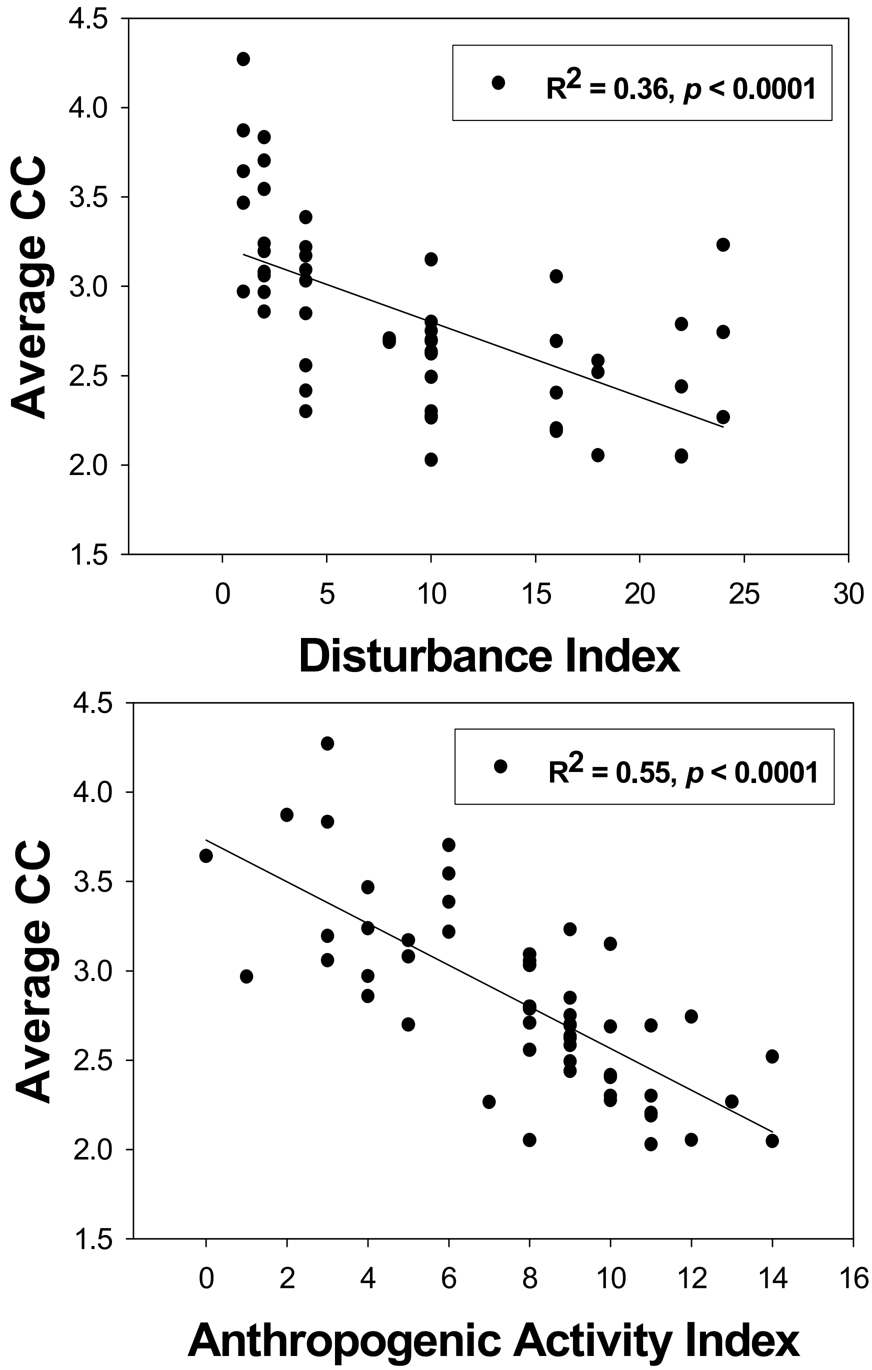

Figure 9. Relationship between the average CC and two disturbance indices, DI and AAI, for 53 wetland sites sampled in 2004.

Table 7. Comparison of nine sites surveyed twice in 2004 (spring = M, summer = S) for the Floristic Quality Assessment Index 1(FQAI 1), average CC (Ave CC).

TrimCane site was omitted from spring analyses when it was found to be an outlier. All other abbreviations are the same from previous Table 2.

	N		I		T		FQAI 1		average CC	
	M	S	M	S	M	S	M	S	M	S
TrimCane	18	34	1	5	19	39	15.1	18.0	3.4	2.7
HSBP	25	54	2	7	50	61	17.8	24.6	3.3	3.0
HSFP	26	36	3	3	29	39	12.6	17.5	2.6	2.7
HSM1	13	37	1	3	14	40	8.6	17.8	2.2	2.7
MP2	18	51	4	10	22	61	10.8	21.3	2.1	2.5
MP4	21	48	7	12	28	60	11.3	19.9	1.9	2.3
N10	16	40	4	6	20	46	14.8	20.7	2.9	2.8
N11B	20	51	0	4	20	55	15.0	23.8	3.3	3.1
NFP	14	25	9	8	23	33	11.5	15.4	1.8	2.3
Average	19	41.8	3.4	6.4	25	48.2	13.1	19.9	2.6	2.7

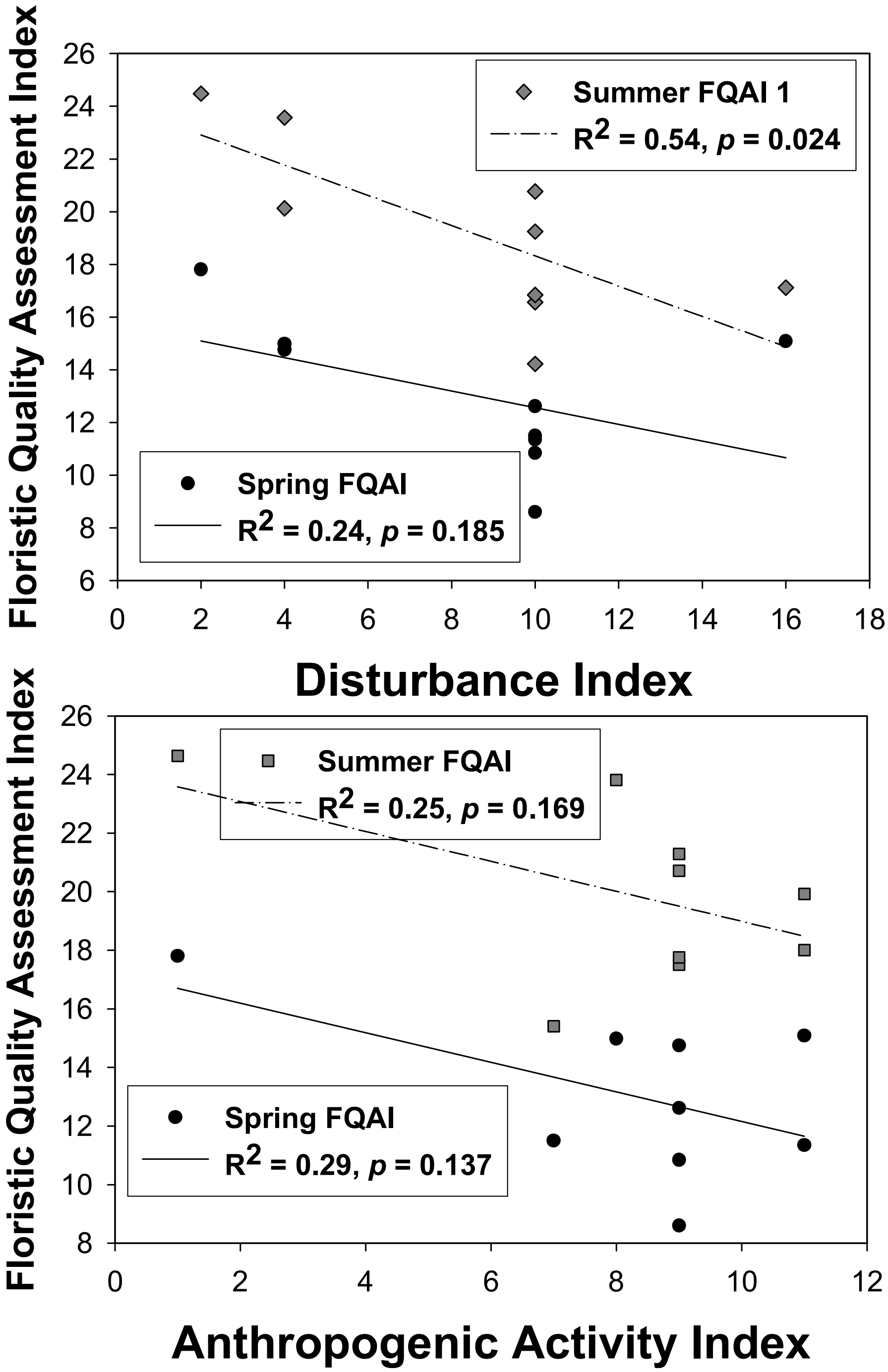

Figure 10. Relationship between FQAI 1 and two disturbance indices (DI and AAI), for nine wetland sites sampled in the spring and summer of 2004.

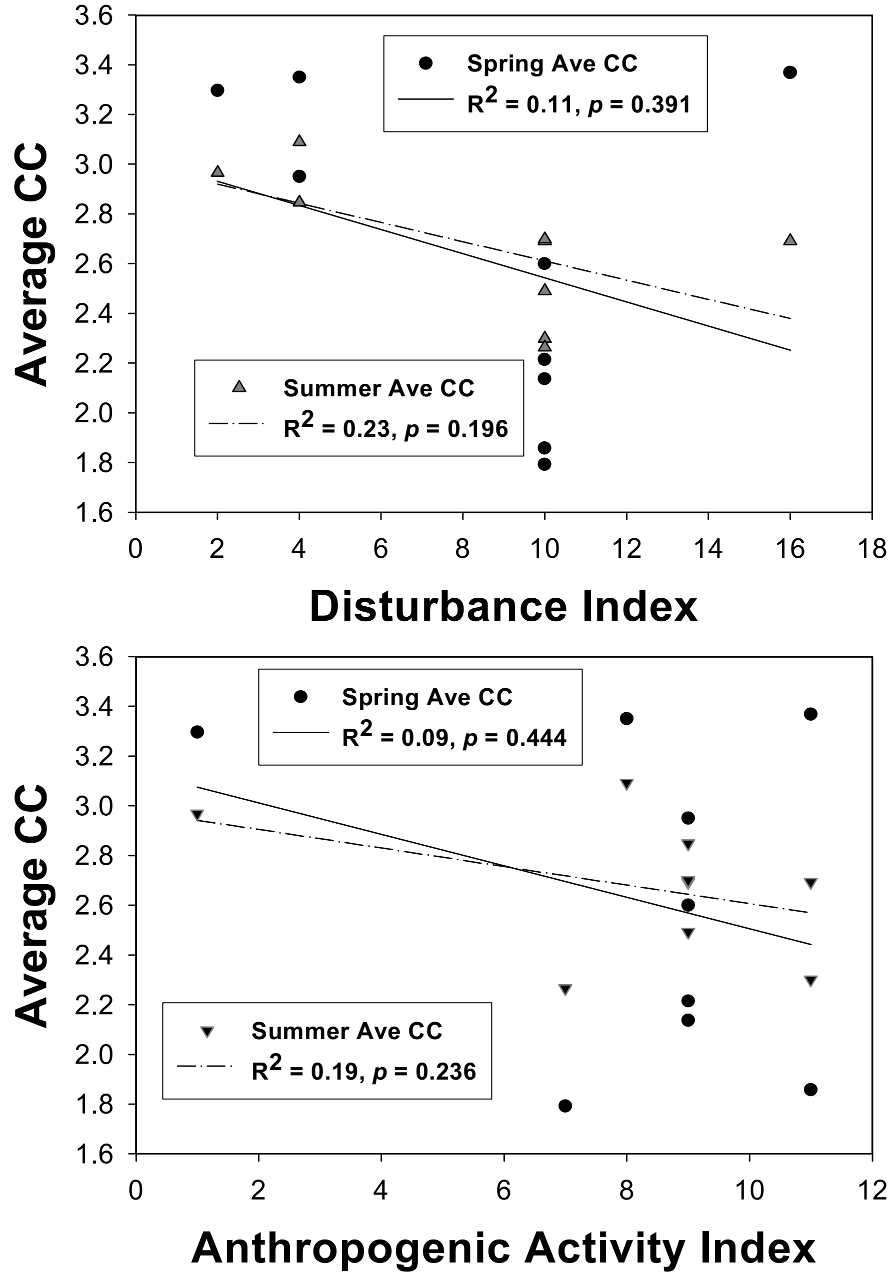

Figure 11. Relationship between the average CC and two disturbance indices (DI and AAI) for nine wetland sites sampled in the spring and summer of 2004.

Effect of Temporal Changes on the Floristic Quality Assessment Indices

Ten wetland sites were sampled in 2003 and 2004. As was described in an earlier section, there was an increase in species recorded for all ten sites sampled between years, as well as a 3.2 mean increase in the FQAI 1 scores, but only a minor change to average CC scores (Table 3). An ANCOVA was used to test for differences between years on the FQAI 1; the disturbance indices were the covariate. Although there was a significant interaction between years with DI as covariate (df = 18, 1, F = 4.945, P = 0.039), when AAI was used as a covariate, there was not a significant interaction between years (df = 18, 1, F = 2.573, P = 0.126). Thus, only when the AAI was regressed against FQAI 1 values for both years did the homogeneity of slope assumption hold. Interestingly, the FQAI 1 was significantly correlated with the DI, but not with AAI for both years (Figure 12). The average CC scores exhibited mixed results in their correlation between the two disturbance indices and years. The average CC was correlated with the DI in 2004, but not in 2003, although, the average CC was correlated with the AAI in 2003, but not in 2004 (Figure 13).

Total, Native and Introduced Species Response to Increasing Human Disturbance

As discussed in the introduction, the number of introduced species typically increases as human activity increases in the immediate and surrounding area. The number of introduced species found in 53 sites sampled in 2004 was positively correlated with the amount and intensity of human land usage surrounding and within the sites

(Figure 14). There was no effect on the number of total species or native species with amount of human disturbance (Figure 14).

Floristic Quality Assessment Indices Relationship to Species Richness and Introduced Species

Overall, with a few exceptions, there was a significant positive relationship between every modification of the FQAI and total species recorded per site (Tables 2 through 4). As a consequence, when a site was sampled twice in the proceeding season or year, the FQAI score would increase if there was an increase in species recorded for that site (Figure 14). Although it has been shown that the number of introduced species increased with increasing human activity, the FQAI 1 did not respond to increasing numbers of introduced species. Interestingly, when the FQAI was modified (FQAI 2 and 3), there was a significant response to number of introduced species (Table 4 and 5). In contrast, the average CC score was not affected by number of native species or total species present, but does respond significantly to number of introduced species per site (Figure 15).

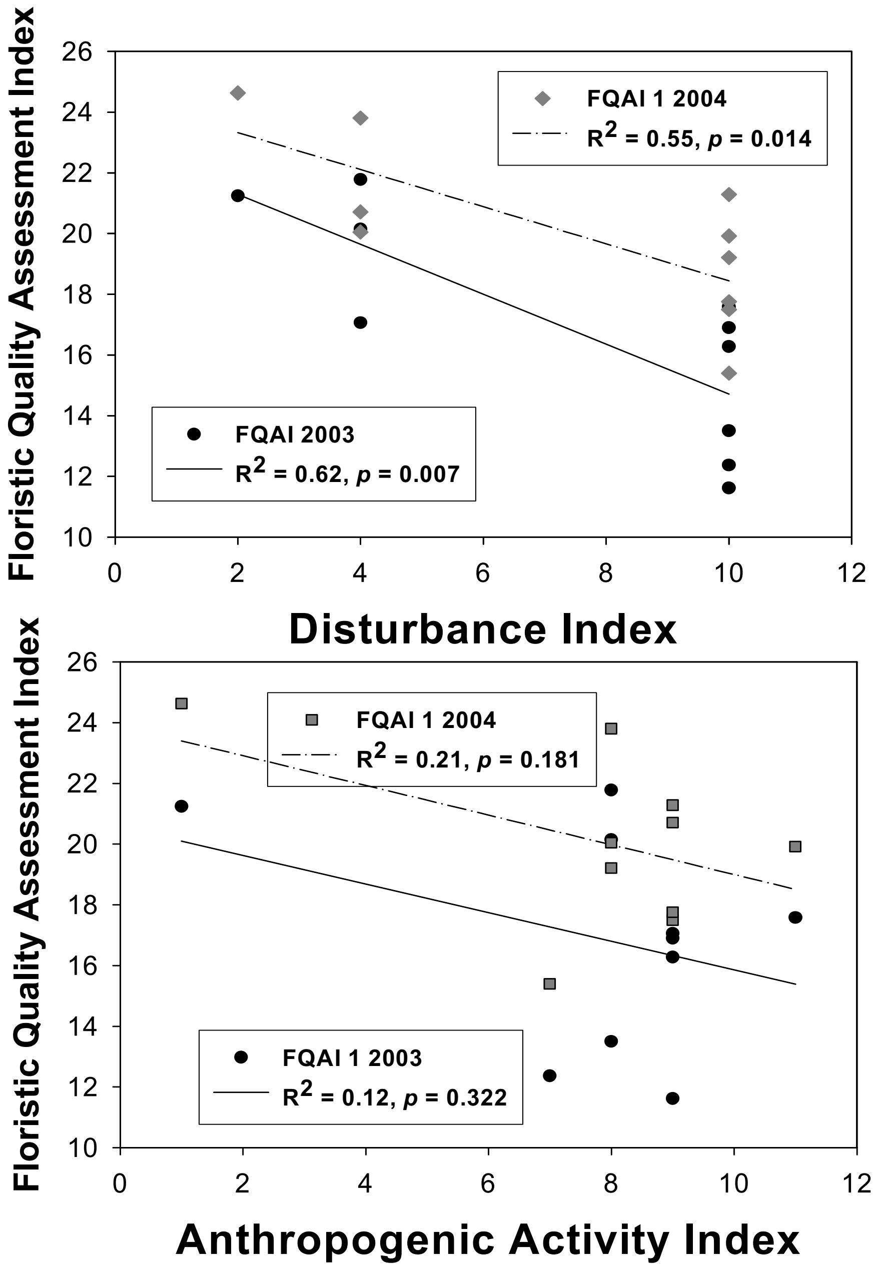

Figure 12. Relationship between the FQAI 1 and two disturbance indices (DI and AAI) for ten wetland sites sampled in 2003 and 2004.

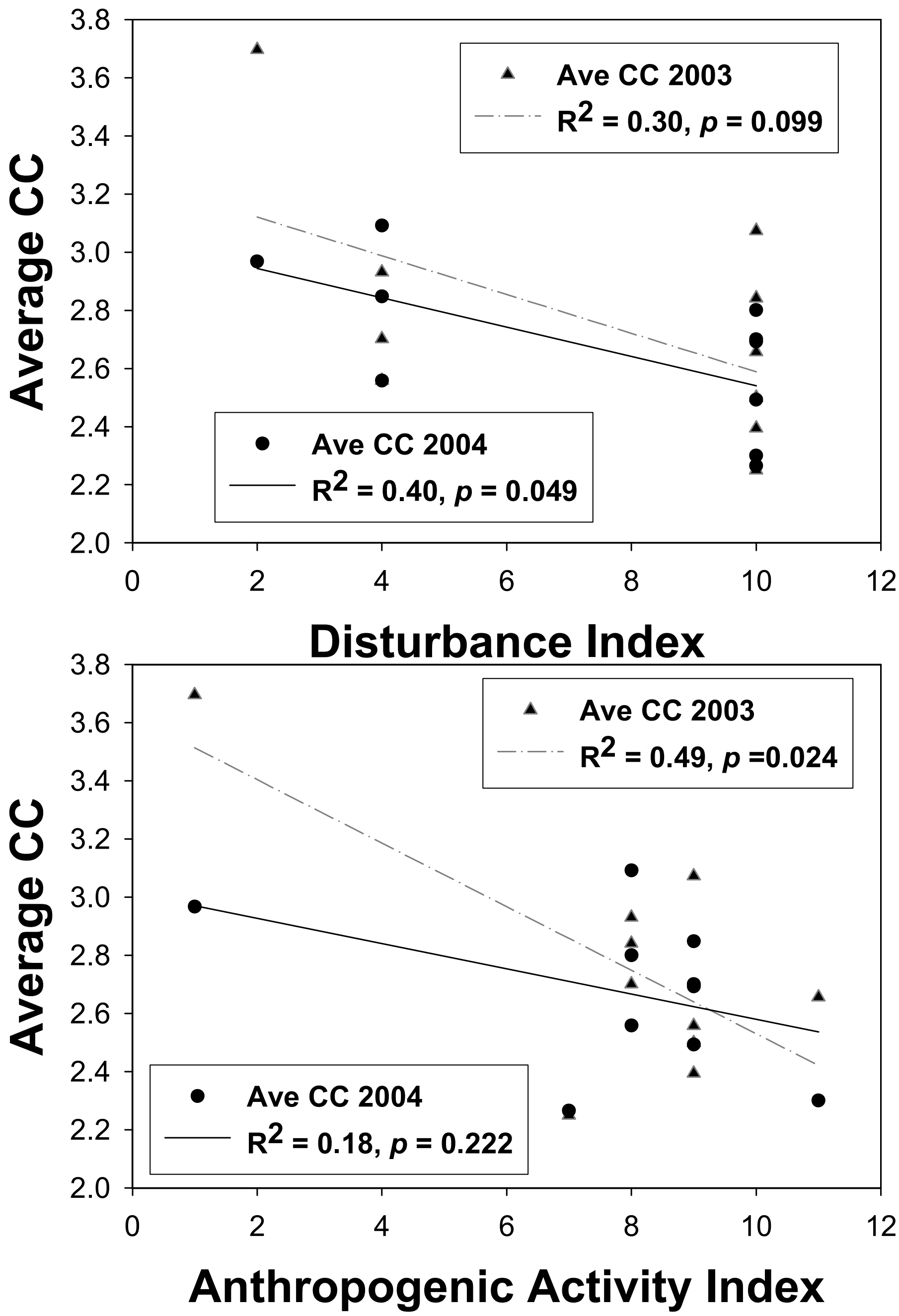

Figure 13. Relationship between average CC and two disturbance indices (DI and AAI) for ten wetlands sampled in 2003 and 2004.

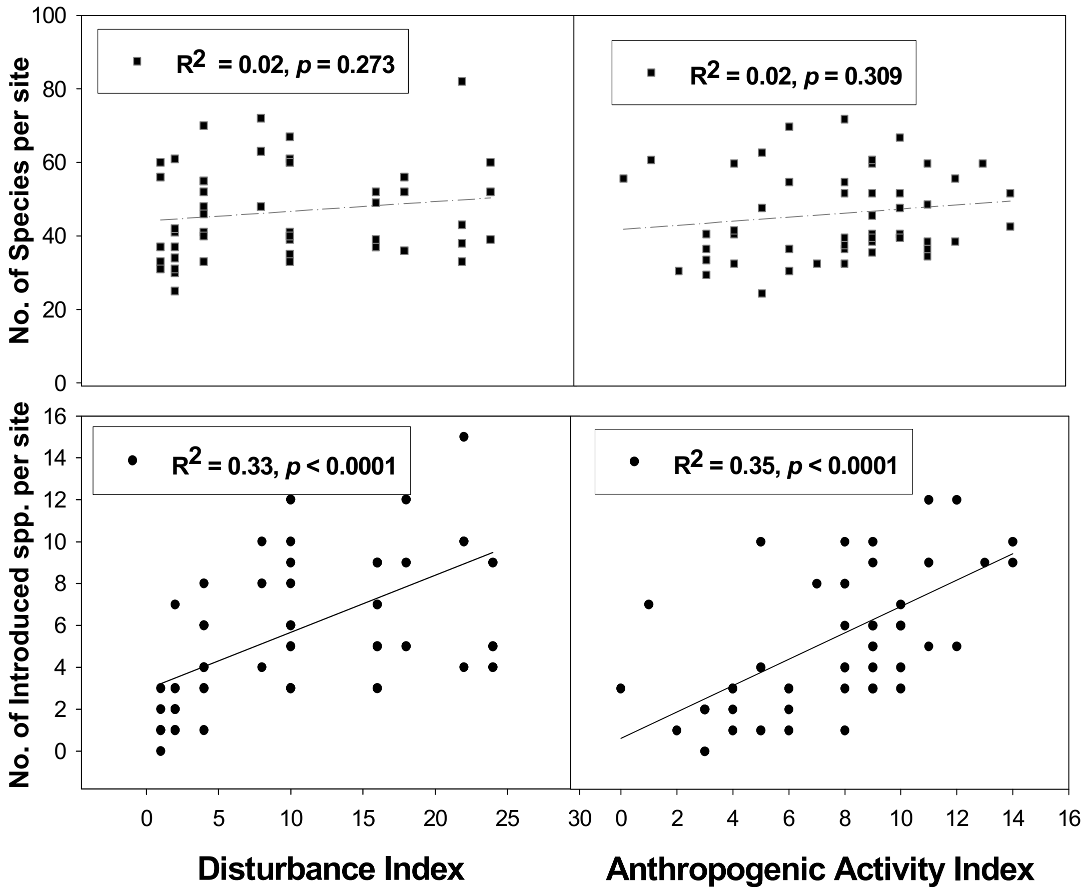

Figure 14. Relationship between number of introduced species and number of species per site and two disturbance indices (DI and AAI) for 53 wetland sites sampled in 2004.

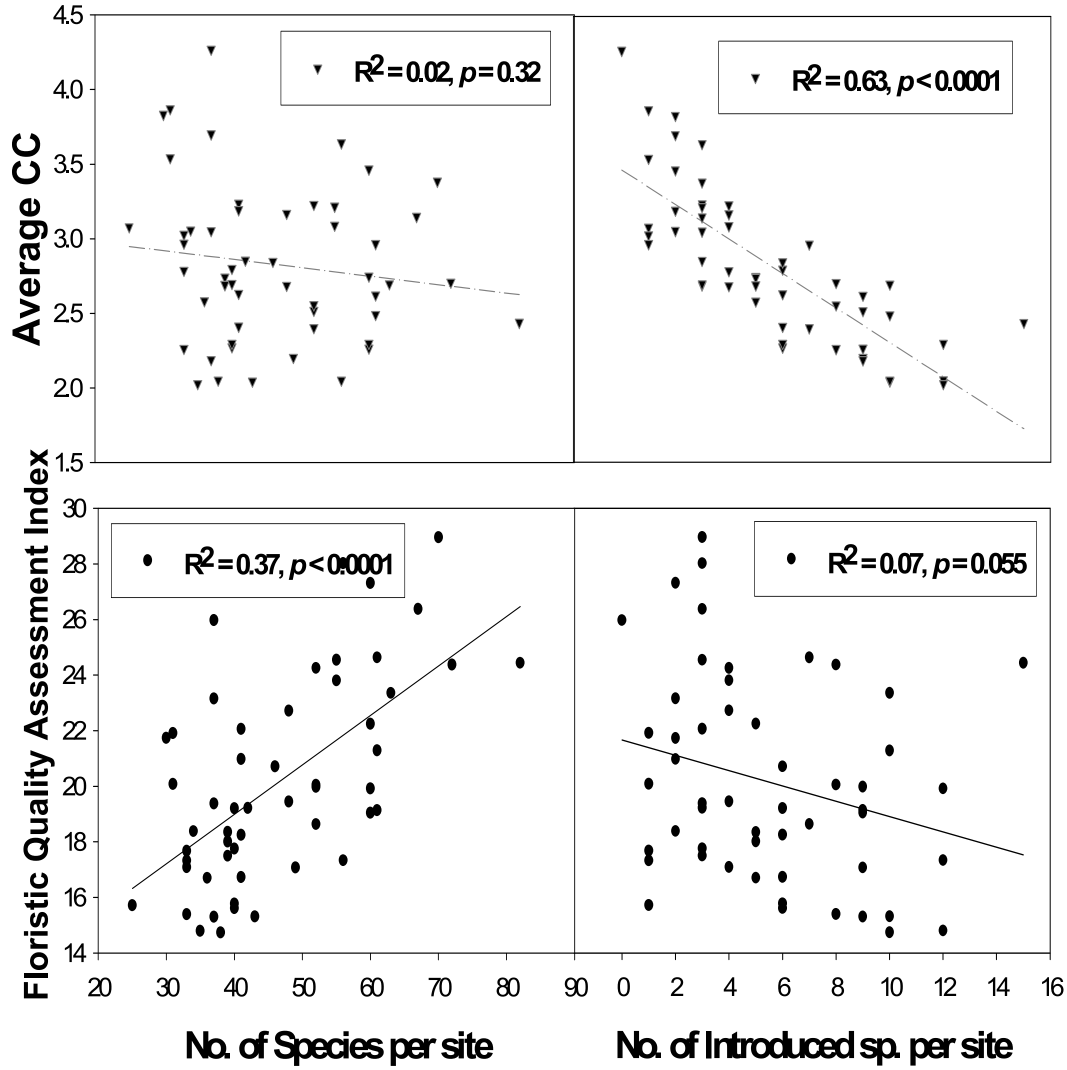

Figure 15. Relationship between FQAI 1 and number of species and number of introduced species, also, average CC and number of species and number of introduced species per site of 53 wetlands sampled in 2004.

Testing the Importance of Type and Intensity of Disturbance In and Around Wetlands to Predict Floristic Quality

The AAI is comprised of five different measures or metrics of human disturbance**,** each ranked from 0 to 3, as described in the methods sections. Linear regression analyses were used to measure the degree to which each metric correlated with the FQAI 1, the various modifications of index, average CC and number of invasive species. Additionally, the first tier of the DI flow chart was treated as a separate metric, the intensity of land use surrounding each site. Sites were assigned 0 to 3 based on whether they were situated in a forest or natural grassland = 0, fallow cropland or pasture = 1, row crop agriculture = 2, or urban land-cover = 3. Then sites were linearly regressed against the aforementioned indices. It should be noted that these scores did not change between years or between seasons for sites which were sampled twice. The average CC and FQAI 3 were all significantly negatively correlated with all five types of disturbance (metrics) included in the AAI calculations. The FQAI 1 was significantly correlated only with landscape use, type of buffer and habitat heterogeneity. Although the FQAI 1 showed a negative trend, it was not correlated with hydrological alteration ($R^2 = 0.057$, $p = 0.85$) or immediate disturbance within site ($R^2 = 0.049$, $p = 0.113$). The average CC was highly correlated with all types of disturbance, but was most sensitive to type of buffer (Figure 16). Additionally, the average CC demonstrated a tighter relationship to all 5 metrics than any other index. The FQAI 1 and 3 both had the strongest correlation to landscape use (Figure 16). As for number of invasive species, a significant correlation was evident with all 5 metrics, with immediate disturbance within wetland being the strongest predictor of number of invasive species (Figure 17). The DI landscape usage metric was shown to be significantly correlated to all indices (FQAI 1,2, 3 and average CC). The average CC exhibited the strongest correlation ($R^2 = 0.317$, $p < 0.0001$) to landscape usage among the indices tested. Interestingly, the correlation was stronger between the DI land use metric and number of invasive species ($R^2 = 0.304$, $p \leq 0.0001$) than the AAI metric 1 ($R^2 = 0.125$, $p = 0.009$), which ranks sites based on surrounding landscape use as well as intensity.

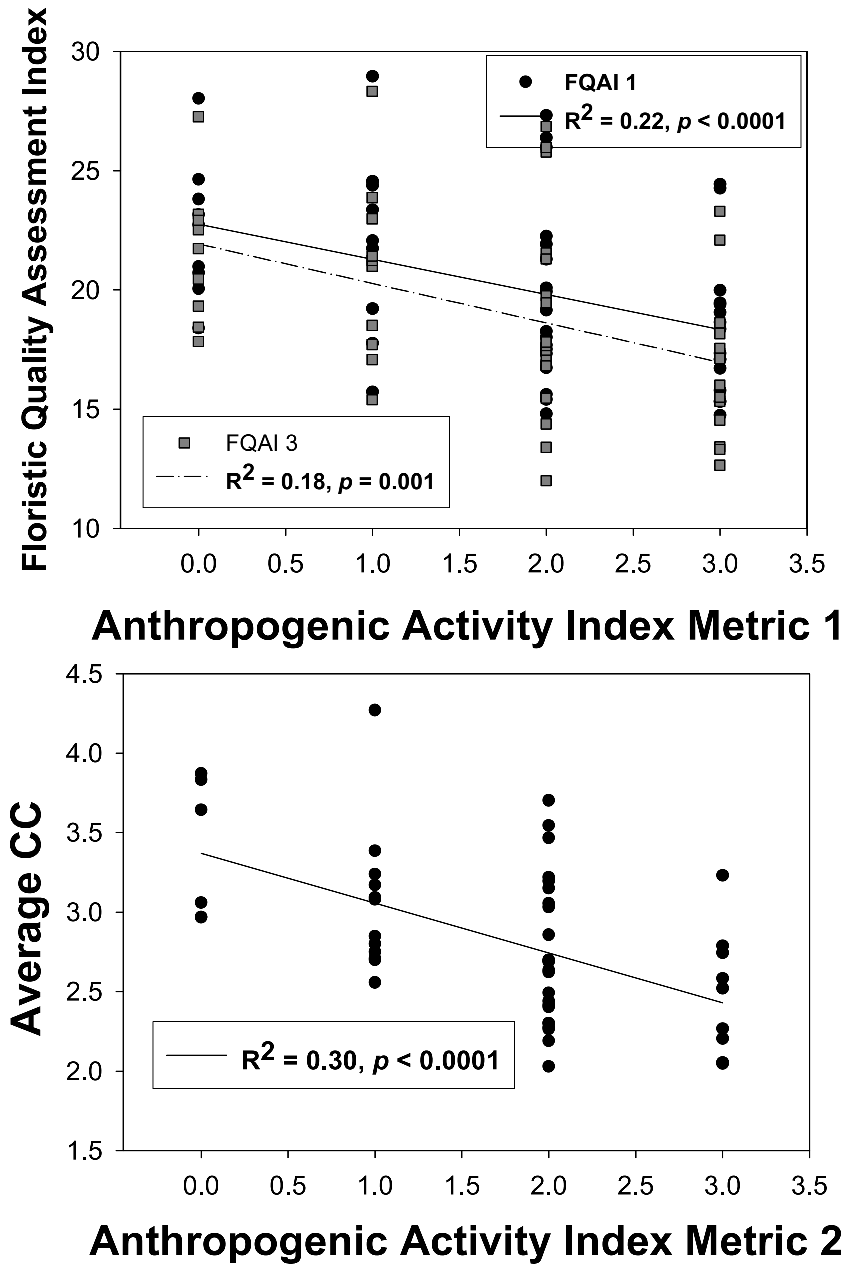

Figure 16. Relationship between FQAI 1 and 3 and the AAI metric 1 (landscape use) scores, also, the average CC and AAI metric 2 (buffer type and width) scores for 53 wetland sites sampled in 2004.

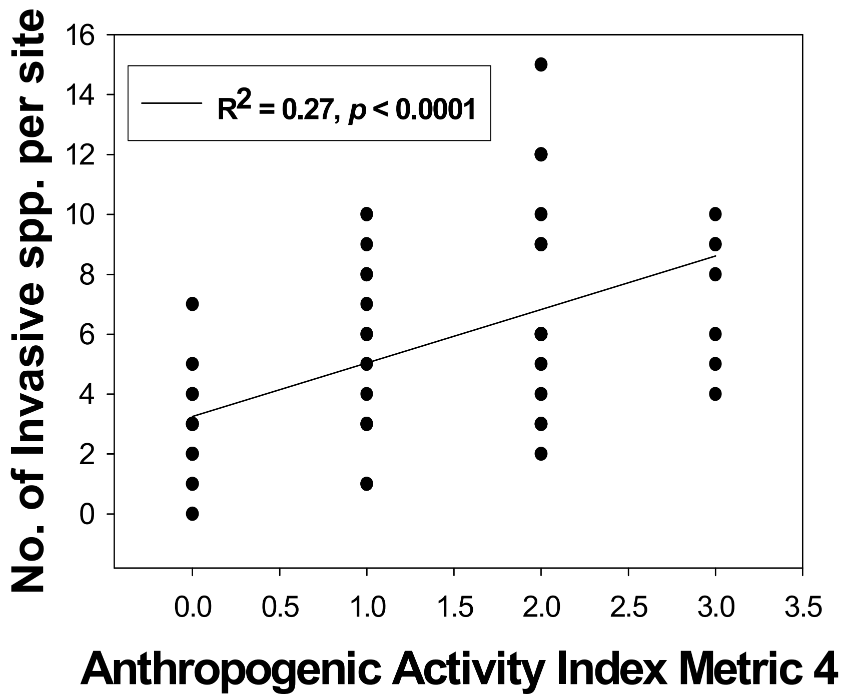

Figure 17. Relationship between the AAI metric 4 (level of immediate disturbance) and number of invasive species for 53 wetland sites sampled in 2004.

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CHAPTER IV:

CONCLUSIONS

The end product of indices of biological integrity is a single score, an aggregation of multiple measures of ecological properties. As a consequence of the variability introduced by multiple measures the final index number is criticized because it may be obscuring more important biological relationships (Yoder, 1991 and Karr and Chu, 1999). One way with which to ameliorate this effect is to choose a measure of ecological integrity that is composed of a limited number of components and is simple to calculate, such as the FQAI. Another way to allay critics is to choose one well defined class of wetlands and sample representatives of this class throughout an entire range and intensity of human induced disturbances available in the study area (e.g., dominate landscape use, buffer type, etc.), as was utlized in this study (EPA, 2002, Karr and Chu, 1999, Lopez and Fennessy, 2002).

Perhaps the most important aspect of the FQAI is the initial assignment of coefficients of conservatism to the regional flora. The distribution of CC values for wetland species in Mississippi does not compare well with other regions. For example, of the 1,309 native taxa recognized in the Dakotas (NGPAP, 2001), 20% of species were assigned a CC of 10, accounting for the largest single subset of species. Furthermore, 43% of the species were assigned a CC of 8 or higher. Thus, almost half of the species recorded had CC values as high as or higher than the highest ranked species in the present study. Also, plant species in the Dakotas had an overall average CC of 6.1, including aquatic and upland species.

The biggest overall difference between this list of plant species and those published in other regions is the absence of species assigned a CC of 9 or 10. This can be explained by the absence of rare species, which typically are associated with rare or threatened habitats. The present study was not concerned with the assessment of threatened or endangered habitats, and as a result, sites of that caliber were not sampled. Beaver and farm ponds were abundant across the area sampled and were easily accessible. Rare Mississippi wetland communities, such as wet pine savannahs, although high in species richness and proportions of rare species, were not within the region of consideration and thus were not surveyed.

Another bias in this data set is the relatively small number of species identified. Other groups that have assembled lists of CC values included almost all species located within the boundaries of that particular state or region, whereas this list does not attempt to consider all species that could be found in Mississippi. This list is the accumulation of species that were identified while sampling 53 wetland sites in 2003 and 2004. The lack of many species that occur in the area and sampling only the most general type of wetlands, emergent palustrine wetlands, limits the comprehensiveness of this list. Therefore, this list should not be thought of as the definitive list of species that occur in wetlands in Mississippi, but as an initial attempt at developing coefficients of conservatism for the state. This list also should serve to facilitate testing and use of the FQAI and similar assessment methodologies in the region.

The FQAI 1 and its modifications (FQAI 2 and 3) were correlated significantly with increasing human modification to wetlands across north and south Mississippi. Although all indices were correlated with human disturbance (measured with the DI and AAI), the modified versions of the FQAI were more closely correlated to anthropogenic perturbation, their correlation coefficients ranging from 0.18 to 0.28 (DI) and 0.30 to 0.42 (AAI). It would appear that increasing the amount of information used to calculate the FQAI, such as including all species, increases the amount of variation explained in regression analyses. Cohen et al. (2004) reached the same conclusion. Exotic species are widely used to indicate impairment to biological systems and the results of this study suggest there is a strong correlation between number of introduced species and amount of human disturbance to wetlands. Therefore, modifying the FQAI to include non-native species will help to improve its accuracy and sensitivity to increasing human activity.

When compared with the average CC, the FQAI 1 does not have as close an association to the two measures of human disturbance. Although the rationale for weighting (dividing the sum of CC values by the square root of the number of native species) the FQAI was to reduce the effect of species richness on floristic quality scores (Wilhelm and Ladd 1988), it seems to have accomplished the opposite. The FQAI and all its modifications were significantly correlated to total and native species richness, while the average CC was not. It has been suggested that increased species richness may improve the resiliency of a system through greater functional redundancy (e.g., Peterson et al., 1998); species richness (native or total species) was not correlated with disturbance indices in wetland systems sampled for this study. Based on this evidence, the average CC would appear to be a better predictor of wetland quality without the potential weaknesses of the FQAI.

Wetlands which were sampled between seasons and years tended to have an increased number species identified the second sampling period, the change in number of species was because of changes in growth and flowering periods and a more effective sampling method respectively. Sites with an increase number of species, regardless of the conservatism reflected by these supplemental species, had augmented FQAI scores. The increase in the FQAI scores seems to be a result of the close association between species richness and FQAI scores. Although the difference between number of species sampled for the years 2003 and 2004 could have been confounded by temporal changes in species richness, it is more likely, as indicated by the species area curves, that our sampling methods evolved to be more efficient and effective, thereby providing an improved representation of species present. Interestingly, although the FQAI scores did change between years, both years were significantly correlated with human disturbance. This suggests that although sites did have different scores for the second sampling period, they did not change in relative quality to the other sites. Based on these findings, it seems that a standardized protocol for vegetation survey is in order for states and regions that regularly employ the FQAI as a means to assess the ecological integrity of wetlands to avoid spurious comparisons between wetlands.

Differences between seasonal FQAI values warrants a caution when comparing sites sampled in different seasons. Even though the sites which were sampled for this study were not undergoing changes in type or intensity of disturbance during the sampling periods, more species were recorded in the summer vs. the spring. The increase in species recorded was probably caused by the fact that a large portion of wetland plant species start or continue their life cycle mainly in the summer and autumn months, thereby allowing a more effective identification in the later months of the growing season. The consequence of this occurrence is that most sites sampled in the spring will have a lower FQAI score, regardless of native conservatism, than sites sampled in the summer months. Although sites will have lower FQAI scores in the spring, my results show that there is a correlation between spring floristic quality and level of human activity. Thus, wetland sites did not change in relative floristic quality, but floristic quality should be compared only within seasons, not between. The results of Lopez and Fennessy (2002) were very similar, although they looked at summer vs. autumn values. The average CC did not reflect the same increase as the FQAI values and was relatively unchanged among seasons.

The responsiveness of the FQAIs and the average CC to the AAI indicates that a more inclusive and semi-quantitative disturbance ranking system would be a more useful and versatile method of assessing the type and intensity of human activity in and around wetlands in Mississippi. Cohen et al. (2004) reached the same conclusion in Florida and tested a disturbance index based on information acquired through GIS, called the Landscape Development Index (LDI), which was developed by Brown and Vivas (2005).

The LDI, although useful in Florida, where it was developed, has yet to be proven useful in Mississippi (Ervin, et al., 2005), but provides a framework to develop a completely objective method of assigning a rank, representing the amount of human disturbance, for a designated area.

Unfortunately, the assignment of CC values to plant species is more closely tied to human subjectivity. Coefficients of conservatism values are based on the perspective of one or more expert opinions regarding the probability of finding species in areas experiencing a certain level of disturbance. By the same note, the effectiveness of FQAI values is assessed against a numeric rank of human disturbance, which may be assigned somewhat subjectively (Cohen et al., 2004 and Wilcox, et al., 2002. By isolating the botanists when assigning the CC, a measure of disagreement between professionals could be made, which may be integrated into the final scores of the CC, as suggested by Cohen et al., (2004). While the present study utilized independent assignment of the CC values, the botanists who accepted the task were more or less taxa specialists; as a consequence, no expert was able to confidently provide a preliminary CC assignment to all species, resulting in no statistical way of examining disagreement. Another special problem not encountered in this study, but one that may appear as more plant species in Mississippi are assigned CC values, is that of naturally occurring hybrids. In Indiana (Rothrock, 2004), 100 of the approximately 3000 plant species have formed observed hybrids. For the most part hybrids were ignored during the assignment process in IN and only hybrids which exhibited species-like qualities, such as reproducing within the hybrid population, were treated as a separate species and assigned a value.

A review of studies testing the FQAIs bolsters the conclusions reached by this study (Table 8). I examined eleven published studies, governmental reports and documents. All studies with sufficient information on the relationship between FQAIs and species richness showed a significant positive relationship; however, the majority of studies reported no such correlation between species richness and average CC. There were two studies in which the FQAI was not significantly correlated with human disturbance, but upon further investigation, these two studies tested the FQAI in forested areas. The dominant type of vegetation sampled, namely woody species, typically displays a delayed response to environmental disturbances (Cronk and Fennessy, 2001), which could produce an uninformative floristic quality score. It seems the FQAI would not be useful or in need of further modification and assessment in systems dominated by woody vegetation, as was suggested by Ervin et al. (2005). All studies with sufficient information reported a significant relationship between average CC and level of human disturbance.

Overall, the FQAI is a useful tool for assessing the vegetative quality of wetlands in Mississippi; however, the average CC seems to be a better predictor of wetland quality without the inherent weaknesses exhibited by the FQAI. The results of this study suggest that improvements to the FQAI, such as including non-native plant species in the calculation, a uniform plant sampling protocol for system or region, comparing scores within, rather than among seasons, and developing a less subjective method of assigning CC values, would improve the accuracy and validity of the assessment. Possible future endeavors for modifying the index include developing a weighted average.

Table 8. Summary of published studies, reports, and documents on average coefficients of conservatism (Ave CC) and the Floristic Quality Assessment Index (FQAI).

System indicates what type of ecosystem was studied. A list of whether there was a statistical correlation (+) or not (—) reported between level of human activity (Disturbance) and the FQAI and average CC, also, between species richness (Spp.Richness) and the FQAI and average CC. The N/A indicates there was insufficient information for that particular category. An (+*) indicates a positive correlation. Table 8 continued on next page.

		Correlations			
Authors		Disturbance		Spp.Richness	
Study Area	System	FQAI	Ave CC	FQAI	Ave CC
Francis et al. (2000) Southern Ontario	Deciduous woodlots	—	+	+*	—
Lopez et al. (2002) Ohio	Depressional wetlands	+	+	+*	—
Mushet et al. (2002) North Dakota	Depressional wetlands	+	+	N/A	N/A
Nichols (1999) Wisconsin	Lakes	+	+	+*	—
Kercher et al. (2004) Wisconsin	Depressional wetlands	N/A	+	N/A	—
Matthews et al. (2003) Illinois	Wetlands	N/A	N/A	+*	+*
Rooney et al. (2002) Wisconsin	Upland forest	—	+	+*	—
Fennessy et al. (1998) Ohio	Wetlands	+	N/A	+*	N/A
Wilhelm et al. (1988) Illinois	Prairies	+	+	N/A	N/A

Table 8. (Concluded)

Authors Study Area	System	Correlations Disturbance. FQAI	 Ave CC	 Spp.Richness FQAI	 Ave CC
Cohen et al. (2004) Florida	Depressional wetlands	+	+	N/A	—
Andreas et al. (2004) Ohio	Various wetlands	+	+	+*	+*

Each species sampled at a site would be assigned its corresponding CC value, then those values would be multiplied by the species relative frequency or abundance, the products then summed and an average taken. Species, native or introduced, with higher relative frequency should have a greater influence on the floristic quality of an area (Cohen et al., 2004). This weighted average method, developed and used with amphibians by assigning each species a tolerance coefficient and named the Amphibian Quality Assessment Index, has been used successfully in predicting the ecological integrity of wetlands in Ohio (Miccahion, 2002). Another possible use of the FQAI and the average CC would be to integrate them into a vegetative IBI, as a means of lessening the potential bias associated with the assessments (Mack, 2000). According to the results of this study and others, assessing the biological integrity of wetlands using floristic assessments would be beneficial to state and federal agencies assigned to track and monitor water quality. Some of those benefits include, identifying areas of ecological significance, tracking changes in mitigated and restored wetlands, and aiding water quality permitting decisions. As the FQAI or other floristic assessments seem likely to be adopted by other regions and states in North America, there is a strong need to continue testing and developing this index.

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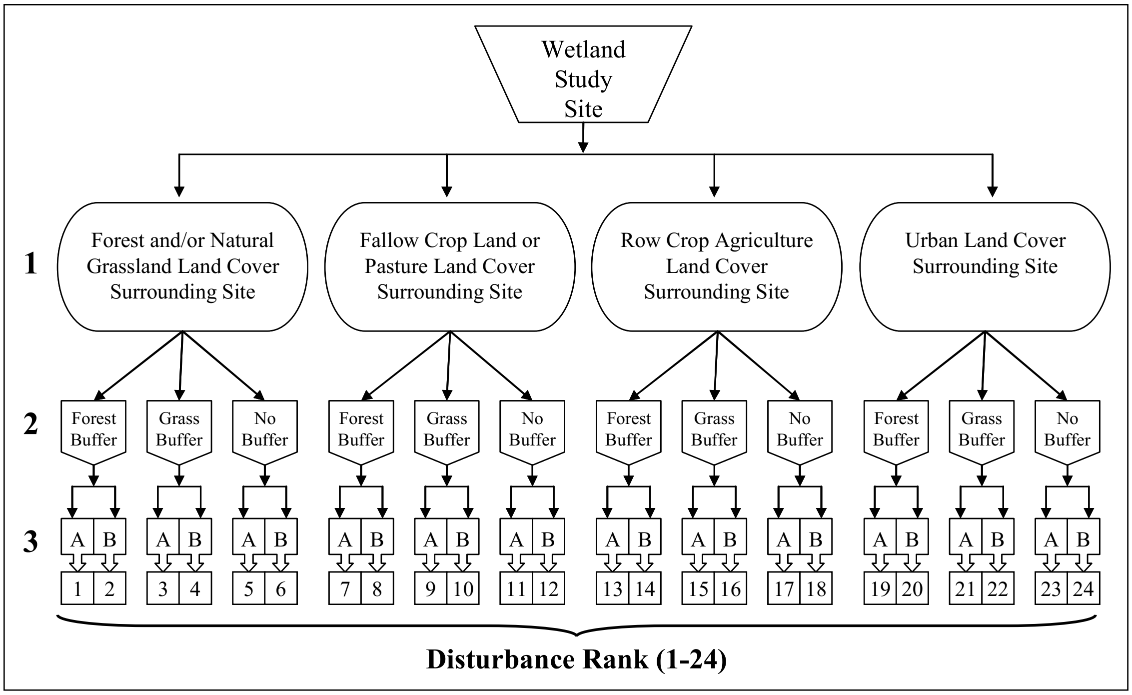
APPENDIX A

DISTURBANCE INDEX (DI)



A hierarchical flow chart used to rank wetland sites based on three types and intensities of human activities. The first level (1) represents the dominant human activity on the landscape surrounding the wetland, the second level (2) describes the type of buffer immediately surrounding the wetland and the third level (3) represents the hydrology present in the wetland: A) unmodified, naturally occurring, B) altered hydrology by human activity. The boxed numbers represent were the wetland is ranked along a gradient of human disturbance.
Redrawn from Lopez and Fennessy (2002).

APPENDIX B

ANTHROPOGENIC ACTIVITY INDEX (AAI)

ANTHROPOGENIC ACTIVITY INDEX
(AAI version specified for north and central Mississippi)

Site: **Study:** **Crew:** **Date:**

Metric 1. Surrounding Land Use Intensity (500 m surrounding buffer)
_______ **Points**

	Very Low- as expected at reference site	No evidence of disturbance, mature forest, grassland	0
	Low- mostly undisturbed, some human influence	Old fields, secondary forest, shrubby woodlots	1
	Moderate- a significant amount of human influence	Active pasture, high road density, newly fallowed fields, wildlife habitat management, other intermittent agricultural practices	2
	High- Intensive use of land up to buffer or wetland margin	Urban, residential, industrial operations, row cropping, other intensive agricultural operations	3

Metric 2. Intactness and Effectiveness of Buffer (up to approximately 50 m surrounding site)
_______ **Points**

	Best- ~50 m wide, as expected for reference site	Mature forest, grassland	0
	Moderate- 50-25 m wide, some human influence	Mixture of grassland and secondary forest, old fields, shrubby woodlots	1
	Fair- 25-10m wide with significant human influence	Active pasture, newly fallowed field, adjacent roads, wildlife habitat management, other intermittent agricultural practices	2
	Poor- no effective buffer	Row cropping, turf vegetation, adjacent urban development, impervious surfaces, other intensive agricultural practices	3

Metric 3. Hydrologic Alteration
_______ **Points**

	Very Low- as expected at reference site	No evidence of disturbance	0
	Low- low intensity alteration	or past alteration not currently affecting wetland	1
	Moderate- significant, visible influence	Current and active	2
	High- intensive activity	Major disturbance currently and actively effecting hydrology	3

Examples of Alterations

Ditch inlet		Point source inlet		Other (describe):
Tile inlet		Installed weir, outlet		
Berm/dam		Levee		
Road bed		Used for drainage		

Subtotal from this page: _________

ANTHROPOGENIC ACTIVITY INDEX
(AAI version specified for north and central Mississippi, page 2)

Site: Study: Crew: Date:

Metric 4. Habitat alteration (within wetland)
______ Points

	Very Low- as expected at reference site	No evidence of human activity	0
	Low- low intensity, or not currently affecting wetland	Some removal of vegetation, but vegetation is recovering	1
	Moderate- significant alteration of either vegetation or substrate	Vehicle use, grazed, livestock hooves, coarse woody debris removal, mowed	2
	High- intensive disturbance of vegetation and substrate	Dredging, filling, tiling, disking, vehicle use, tree/shrub removal, removal of emergent vegetation	3

Specify Other Activities:

Metric 5. Habitat Quality and Microhabitat Heterogeneity
______ Points

	Best- large amount of habitat heterogeneity, high diversity of microhabitats	Small proportion of open water, 0-25%, large amount of emergent and submersed vegetation and coarse woody debris, some standing dead trees	0
	Moderate- significant amount of habitat heterogeneity	25-50% open water, some woody debris	1
	Fair- small amount of habitat heterogeneity	50-75% open water, no woody debris	2
	Poor- small amount of habitat heterogeneity, low quality habitat	75-100% open water	3

Subtotal from this page: ________

Additional factors or concerns:

Metric 1 _____

Metric 2 _____

Total Anthropogenic Activity Index Score

Metric 3 _____

Metric 4 _____

Metric 5 _____

APPENDIX C

DATA SUMMARY AND LOCATION OF 53 WETLAND SITES

SURVEYED IN 2004

Data summary and location of 53 wetland sites surveyed in 2004. The disturbance score (Dist. Score) was calculated by the Disturbance Index (DI) and the Anthropogenic Activity Index (AAI). Each site's Floristic Quality Assessment Index scores (FQAIs 1-3), number of native species (N), number of non-native species (I), total number of species (N), average CC score (AveCC) and location (GPS coordinates) is provided. Appendix C is continued on the next page.

Site	Dist. Score		FQAIs			No. of spp.			AveCC	GPS coordinates
	DI	AAI	1	2	3	N	I	T		
45NCF1	16	11	17	16	15	40	9	49	2.2	33°57.571'N 88°42.840'W
45NCFP	16	10	19	16	17	45	7	52	2.4	34°03.803'N 88°12.167'W
45NCF2	18	12	17	15	15	44	12	56	2.0	34°05.887'N 88°41.983'W
82HwyBP	8	8	24	20	23	64	8	72	2.7	33°29.686'N 88°54.952'W
Aliceville	2	5	16	16	15	24	1	25	3.1	33°13.554'N 88°17.081'W
Benwood	16	8	19	18	19	34	3	37	3.0	33°56.721'N 89°28.528'W
Big Black	4	6	29	26	28	67	3	70	3.4	33°23.144'N 89°37.004'W
Brodnax	10	11	15	13	12	23	12	35	2.0	33°29.411'N 88°54.352'W
Burnsville	10	10	26	23	26	64	3	67	3.1	34°50.701'N 88°17.600'W
CanalSec	4	5	23	19	22	44	4	48	3.2	34°21.557'N 88°24.649'W
Chewalla	2	3	22	22	21	28	2	30	3.8	34°44.341'N 89°19.896'W
Coldwater	4	10	17	16	15	35	6	41	2.4	34°06.535'N 90°07.785'W
Columbus	24	9	24	22	23	48	4	52	3.2	33°31.185'N 88°28.833'W
Cow Pen	8	10	19	18	19	44	4	48	2.7	34°47.48'N 90°03.10'W
Dahomey	4	8	18	15	17	32	1	33	3.0	33°42.722'N 90°56.465'W
Davis Lake	1	0	28	27	27	53	3	56	3.6	34°02.032'N 88°56.743'W
Eden barr	8	14	20	17	18	43	9	52	2.5	32°58.117'N 90°23.119'W
Eden will	8	9	17	15	15	31	5	36	2.6	32°57.992'N 90°21.302'W
I-55	22	8	17	15	16	29	4	33	2.8	33°48.494'N 89°50.357'W
I-78	2	4	22	22	21	38	3	41	3.2	34°34.472'N 89°09.418'W

Appendix C Continued.

Site	Dist. Score DI	AAI	FQAIs 1	2	3	No. of spp. N	I	T	AveCC	GPS coordinates
Lake Patsy	22	14	15	15	13	33	10	43	2.0	34°22.582'N 89°32.925'W
Larry's	2	3	18	17	18	32	2	34	3.1	33°15.934'N 88°48.550'W
MP1	10	9	18	18	17	35	6	41	2.6	33°31.925'N 88°52.252'W
MP3	10	9	19	18	18	52	9	61	2.6	33°31.383'N 88°52.266'W
MPscrapp	10	10	16	15	14	34	6	40	2.3	33°31.008'N 88°52.167'W
Morgan bk	16	11	15	13	13	28	9	37	2.2	33°13.824'N 90°10.195'W
Morgan hill	1	4	17	16	17	32	1	33	3.0	33°15.074'N 88°46.326'W
Natchez	2	3	21	21	20	39	2	41	3.3	32°48.031'N 89°41.254'W
Panther	4	6	25	21	24	52	3	55	3.2	32°49.802'N 90°35.387'W
Pearl	2	6	23	23	22	35	2	37	3.7	32°40.405'N 89°88.613'W
RT.50	2	6	20	20	20	30	1	31	3.5	33°34.302'N 88°26.998'W
Senatobia	22	9	24	19	22	67	15	82	2.4	34°37.070'N 89°56.838'W
Smith	22	8	15	14	13	28	10	38	2.0	33°26.757'N 88°47.396'W
Sturgis	2	4	19	19	18	39	3	42	2.9	33°20.087'N 89°02.289'W
Tallahatchie	4	10	16	15	15	34	6	40	2.3	33°46.164'N 90°07.538'W
Tishimingo	8	5	23	18	21	53	10	63	2.7	88°19.220'N 34°30.311'W
TNF Burr	1	2	22	22	22	30	1	31	4.0	33°13.814'N 89°03.726'W
TNF Lily	1	4	27	24	27	58	2	60	3.5	33°15.773'N 89°07.970'W
TNF Rush	1	3	26	26	26	37	0	37	4.3	33°15.944'N 89°07.736'W
Tupelo	24	13	19	18	18	51	9	60	2.3	34°18.674'N 88°42.028'W
Tuscumbia	10	9	22	21	21	55	5	60	2.7	34°56.223'N 88°35.423'W
West Point	24	12	18	15	17	34	5	39	2.7	33°35.782'N 88°39.499'W
TrimCane	16	11	18	16	17	34	5	39	2.7	33°31.26'N 88°50.87'W

Appendix C Concluded.

Site	Dist. Score DI	Dist. Score AAI	FQAIs 1	FQAIs 2	FQAIs 3	No. of spp. N	No. of spp. I	No. of spp. T	AveCC	GPS coordinates
HSBP	2	1	25	21	23	54	7	61	3.0	34°49.818'N 89°26.699'W
HSFP	10	9	17	17	17	36	3	39	2.7	34°50.517'N 89°27.968'W
HSM1	10	9	18	15	17	37	3	40	2.7	34°50.439'N 89°28.024'W
HSM2	10	9	19	18	18	34	6	40	2.8	34°50.420'N 89°27.561'W
MP2	10	9	21	17	19	51	10	61	2.5	33°53.275'N 88°86.493'W
MP4	10	11	20	19	18	48	12	60	2.3	33°31.943'N 88°52.607'W
N8	4	8	20	17	18	44	8	52	2.6	33°16.484'N 88°51.554'W
N10	4	9	21	19	19	40	6	46	2.8	33°16.521'N 88°51.609'W
N11B	4	8	24	22	23	51	4	55	3.1	33°16.688'N 88°51.986'W
NFP	10	7	15	13	13	25	8	33	2.3	33°18.023'N 88°45.869'W

APPENDIX D

LIST OF SPECIES SURVEYED FROM 53 WETLANDS IN 2003 AND 2004

For the most up to date nomenclature, the PLANTS Database (USDA) was followed, with a few exceptions: Carex spp. followed the Flora of North America vol. 23 (Cyperaceae) (1993) and Solidago spp. followed Radford, et al. (1968). Species identifications were made first with Godfrey and Wooten (1979, 1981) for most obligate wetland species, Cyperaceae and Poaceae. Most upland species (forbs and graminoids) were first identified with Radford, et al. (1968) and Hitchcock (1971). Determination of species origin and wetland indicator status (NI = no wetland indicator status assigned for Region 2) was a compilation of personal communication with professionals and numerous sources, including botanical key descriptions and the PLANTS Database (USDA). It should be noted that the PLANTS Database should not be the only source when determining origin, because of unresolved inconsistencies in their database; the Flora of North America was considered the definitive source for this information where possible. Growth form and life history traits were designated using the PLANTS Database. Eight growth forms were identified, Forb, Graminoid (Gram), Carex, Fern, Herbaceous Vine (H-Vine), Woody Vine (W-Vine), Shrub, Tree, annual (A) and perennial (P).

Species	Ave CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Acalypha rhomboidea Raf.	4	N	Virginia three seeded mercury	Forb	A	Euphorbiaceae	FAC-
Acer negundo L.	4	N	boxelder	Tree	P	Aceraceae	FACW
Acer rubrum L.	4	N	red maple	Tree	P	Aceraceae	FAC
Acmella oppositifolia (Lam.) R.K. Jansen	4	N	oppositleaf spotflower	Forb	P	Asteraceae	FACW
Agalinis divaricata (Chapm.) Pennell	2	N	pineland false foxglove	Forb	A	Scorphulariaceae	FACU
Agalinis fasciculata (Ell.) Raf.	1	N	beach false foxglove	Forb	A	Scrophulariaceae	FAC+
Anagallis minima (L.) Krause	3	N	Chaffweed	Forb	A	Primulaceae	FACW+
Agrostis gigantea Roth	0	I	redtop	Gram	P	Poaceae	NI
Agrostis hyemalis (Walt.) B.S.P.	2	N	winter bentgrass	Gram	P	Poaceae	FAC
Allium canadense L.	2	N	meadow garlic	Forb	P	Liliaceae	FACU-
Alnus serrulata (Ait.) Willd.	4	N	hazel alder	Tree	P	Betulaceae	FACW+
Alopecurus carolinianus Walt.	3	N	Carolina foxtail	Gram	P	Poaceae	FACW
Alternanthera philoxeroides (Mart.) Griseb.	0	I	alligatorweed	Forb	P	Amaranthaceae	OBL
Amaranthus australis (Gray) Sauer	2	N	southern amaranth	Forb/Shrub	A	Amaranthaceae	OBL
Ambrosia artemisiifolia L.	1	N	annual ragweed	Forb	A	Asteraceae	FACU
Ambrosia trifida L.	1	N	giant ragweed	Forb	A	Asteraceae	FAC
Ammannia coccinea Rottb.	5	N	valley redstem	Forb	A	Lythraceae	FACW+
Ammannia latifolia L.	6	N	pink redstem	Forb	A	Lythraceae	OBL

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Ampelopsis arborea (L.) Koehne	2	N	peppervine	H-Vine	P	Vitaceae	FAC+
Ampelopsis cordata Michx.	2	N	heartleaf peppervine	W-Vine	P	Vitaceae	FAC+
Apios americana Medik.	4	N	groundnut	H-Vine	P	Fabaceae	FACW
Apocynum cannabinum L.	2	N	Indian hemp	Forb	P	Apocynaceae	FAC-
Arnoglossum plantagineum Raf.	8	N	groovestem Indian plantain	Forb	P	Asteraceae	FACU
Arthraxon hispidis (Thunb.) Makino	0	I	small carbgrass	Gram	A	Poaceae	FACU+
Arundinaria gigantea (Walt.) Muhl.	4	N	giant cane	Shrub	P	Poaceae	FACW
Axonopus fissifolius (Raddi) Kuhlm	3	N	common carpetgrass	Gram	A	Poaceae	FACW-
Azolla caroliniana Wild.	4	N	Carolina mosquitofern	Fern	A	Azollaceae	OBL
Baccharis halimifolia L.	2	N	eastern baccharis	Tree	P	Asteraceae	FAC
Bacopa rotundifolia (Michx.) Wettst.	3	N	disk waterhyssop	Forb	P	Scorphulariaceae	OBL
Berchemia scandens (Hill) K. Koch	4	N	Alabama supplejack	H-Vine	P	Rhamnaceae	FACW
Betula nigra L.	5	N	river birch	Tree	P	Betulaceae	FACW
Bidens aristosa (Michx.) Britt.	2	N	bearded beggarticks	Forb	A	Asteraceae	FACW
Bidens discoidea (Torr.&Gray) Britt.	3	N	small beggarticks	Forb	A	Asteraceae	FACW
Bidens frondosa L.	2	N	devil's baggartick	Forb	A	Asteraceae	FACW
Bidens laevis(L.) B.S.P.	2	N	smooth beggartick	Forb	A	Asteraceae	OBL
Boehmeria cylindrica (L.) Sw.	3	N	smallspike false nettle	Forb	P	Urticaceae	FACW+
Boltonia diffusa Ell.	3	N	small doll's head daisy	Forb	P	Asteraceae	FAC
Brasenia schreberi J.F. Gmel.	5	N	watershield	Forb	P	Cabombaceae	OBL
Briza minor L.	0	I	little quaking grass	Gram	P	Poaceae	FAC
Bromus japonicus Thunb. ex Murr.	0	I	Japanese brome	Gram	A	Poaceae	FACU
Brunnichia ovata (Walt.) Shinners	3	N	American buckwheat	W-Vine	P	Polygonaceae	FACW
Bulbostylis ciliatifolia (Ell.) Fern. var. *ciliatifolia*	4	N	capillary harisedge	Gram	A	Cyperaceae	FACU
Callicarpa americana L.	1	N	American beautyberry	Shrub	P	Verbenaceae	FACU-
Callitriche heterophylla Pursh.	3	N	twoheaded water-starwort	Forb	A	Callitrichaceae	OBL
Campsis radicans (L.) Seem ex Bureau	3	N	trumpet creeper	H-Vine	P	Bignoniaceae	FAC
Cardamine pennsylvanica Muhl. ex Wild	3	N	Pennsylvania bittercress	Forb	P	Brassicaceae	FACW+
Cardiospermum halicacabum L.	1	N	love in a puff	H-Vine	P	Sapindaceae	FAC
Carex albolutescens Schwein.	1	N	greenwhite sedge	Gram	P	Cyperaceae	FAC+
Carex atlantica Baily sub. *capillacea* (B.) Reznick	7	N	prickly bog sedge	Gram	P	Cyperaceae	FACW
Carex aureolensis Steud.	4	N		Gram	P	Cyperaceae	OBL

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Carex caespitosa L. var. *ramosa* Dewey	7	N		Gram	P	Cyperaceae	NI
Carex cherokeensis Schwein.	1	N	Cherokee sedge	Gram	P	Cyperaceae	FACW-
Carex crinita Lam.	6	N	fringed sedge	Gram	P	Cyperaceae	FACW+
Carex crus-corvi Shuttw. Ex Kunze	5	N	ravenfoot sedge	Gram	P	Cyperaceae	OBL
Carex festucacea Schkuhr ex Wild.	2	N	fescue sedge	Gram	P	Cyperaceae	FACW
Carex granularis Muhl. ex Wild.	2	N	meadow sedge	Gram	P	Cyperaceae	FACW
Carex joorii Baily	8	N	Cypress swamp sedge	Gram	P	Cyperaceae	OBL
Carex longii Mackenzie	2	N	Lona's sedge	Gram	P	Cyperaceae	OBL
Carex lupulina Muhl. ex Wild.	5	N	hopsedge	Gram	P	Cyperaceae	OBL
Carex lurida Wahlenb.	3	N	shallow sedge	Gram	P	Cyperaceae	OBL
Carex pigra Naczi	4	N		Gram	P	Cyperaceae	NI
Carex squarrosa L.	5	N	squarrose sedge	Gram	P	Cyperaceae	FACW
Carex stricta Lam.	8	N	upright sedge	Gram	P	Cyperaceae	OBL
Carex tribuloides Wahlenb.	3	N	blunt broom sedge	Gram	P	Cyperaceae	FACW+
Carex typhina Michx.	5	N	cattail sedge	Gram	P	Cyperaceae	OBL
Carex vulpinoidea Michx.	3	N	fox sedge	Gram	P	Cyperaceae	OBL
Carya tomentosa (L.) Nutt. ex Ell.	3	N	mockernut hickory	Tree	P	Juglandaceae	NI
Celtis laevigata Wild.	4	N	sugarberry	Tree/Shrub	P	Ulmaceae	FACW
Cephanlathus occidentalis L.	5	N	bottonbush	Tree	P	Rubiaceae	OBL
Ceratophyllum demersum L.	2	N	coon's tail	Forb	P	Ceratophyllaceae	OBL
Chamaecrista fasciculata (Michx.) Green var. *fasciculata*	3	N	sleeping plant	Forb	A	Fabacaea	FACU
Chamaecrista nictitans (L.) Moench	3	N	patridge pea	Shrub/Forb	P	Fabaceae	FACU
Chamaesyce maculata (L.) Small	2	N	spotted sandmat	Forb	A	Euphorbiaceae	FACW
Chamaesyce nutans Lag. Small	1	N	eyebane	Forb	A	Euphorbiaceae	FACU
Chasmanthium latifolium (Michx.) Yates	6	N	Indian woodoats	Gram	P	Poaceae	FAC-
Chasmanthium laxum (L.) Yates	5	N	woodoats	Gram	P	Poaceae	FACW-
Chelone glabra L.	7	N	turtle head	Forb	P	Scrophulariaceae	OBL
Cicuta maculata L.	4	N	spotted water hemlock	Forb	P	Apiaceae	OBL
Cinna arundinacea L.	6	N	sweet wood reed	Gram	P	Poaceae	FACW
Cirsium vulgare (Savi.) Ten.	0	I	bullthistle	Forb	P	Asteraceae	FAC
Clematis virginiana L.	3	N	devil's darning needles	W-Vine	P	Ranunculaceae	FAC+
Commelina carolinana Walt.	4	N	Carolina dayflower	Forb	A	Commelinaceae	FAC
Commelina communis L.	0	I	asiatic dayflower	Forb	A	Commelinaceae	FAC

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Commelina virginica L.	5	N	Virginia dayflower	Forb	A	Commelinaceae	FACW
Conoclinium coelestinum (L.) DC.	3	N	blue mistflower	Forb	P	Asteraceae	FAC
Conyza canadensis (L.) Cronq. var. *canadensis*	2	N	Canadian horseweed	Forb	A	Asteraceae	FACU
Coreopsis falcata Boynt.	4	N	sickle tickseed	Forb	P	Asteraceae	FACW
Coreopsis tinctoria Nutt.	1	N	golden tickseed	Forb	A	Asteraceae	FAC
Cornus amomum P. Mill.	4	N	silky dogwood	Shrub	P	Cornaceae	FACW+
Cornus foemina P. Mill.	4	N	stiff dogwood	Tree/Shrub	P	Cornaceae	FACW-
Croton capitatus Michx.	2	N	doveweed	Forb	A	Euphorbiaceae	FACW+
Cuphea carthagenensis (Jacq.) J.F. Macbr.	3	N	Colombian waxweed	Forb	A	Lythraceae	FACW
Cuscuta compacta Juss. ex Choisy	3	N	compact dodder	H-Vine	P	Cuscutaceae	NI
Cynodon dactylon (L.) Pers.	0	I	Bermudagrass	Gram	P	Poaceae	FACU
Cynosciadium digitatum DC.	3	N	finger dogshade	Forb	A	Apiaceae	FACW
Cyperus acuminatus Torrey & Hooker	4	N	tapetip flatsedge	Gram	A	Cyperaceae	OBL
Cyperus compressus L.	0	I	poorland flatsedge	Gram	A	Cyperaceae	FACW
Cyperus croceus Vahl.	2	N	Baldwin's flatsedge	Gram	P	Cyperaceae	FAC
Cyperus echinatus (L.) Wood	2	N	glove flatsedge	Gram	P	Cyperaceae	FAC
Cyperus erythrorhizos Muhl.	2	N	redroof flatsedge	Gram	A	Cyperaceae	OBL
Cyperus esculentus L.	0	I		Gram	P	Cyperaceae	FAC
Cyperus flavescens L.	1	N	yellow flatsedge	Gram	A	Cyperaceae	OBL
Cyperus iria L.	0	I	ricefield flatsedge	Gram	A	Cyperaceae	FACW
Cyperus odoratus Vahl.	2	N	fragrant spikesedge	Gram	A	Cyperaceae	FACW
Cyperus pseudovegetus Steud.	2	N	marsh flatsedge	Gram	P	Cyperaceae	FACW
Cyperus retrorsus Chapman	2	N	pine barren flatsedge	Gram	P	Cyperaceae	FACU+
Cyperus squarrosus L.		N	bearded flatsedge	Gram	A	Cyperaceae	OBL
Cyperus strigosus L.	2	N	strawcolored flatsedge	Gram	P	Cyperaceae	FACW
Desmanthus illinoensis (Michx.) MacM. Ex B.L. Robbins & Fern	2	N	prairie bundle flower	Shrub	P	Fabaceae	FAC
Desmodium paniculatum (L.) DC.	4	N	panicledleaf ticktrefoil	Forb	P	Fabaceae	FACU
Dichanthelium clandestinum (L.) Gould	5	N	deertongue	Gram	P	Poaceae	FACW
Dichanthelium dichotomum (L.) Gould var. *dichotomum*	6	N	cypress witchgrass	Gram	P	Poaceae	FAC
Dichanthelium laxiflorum (Lam.) Gould	4	N	openflower rosette grass	Gram	P	Poaceae	FAC

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Dichanthelium sabulorum (Lam.) Gould & C.A. Clark var. *thinium* (Hitchc. & Chase) Gould & C.A. Clark	5	N	hemlock rosette grass	Gram	P	Poaceae	FACU
Dichanthelium spretum (J.A. Schultes) Freckman	8	N	Eaton's rosettegrass	Gram	P	Poaceae	NI
Digitaria filiformis (L.) Koel.	0	I	slender crabgrass	Gram	A	Poaceae	NI
Digitaria ischaemum (Schreb.) Schreb ex Muhl.	0	I	smooth crabgrass	Gram	A	Poaceae	UPL
Digitaria sanguinalis (L.) Scop.	0	I	hairy crabgrass	Gram	A	Poaceae	FAC-
Dioclea multiflora (Torr.& Gray) C. Mohr	3	N	Boykin's clusterpea	W-Vine	P	Fabaceae	FAC+
Diodia virginiana L.	4	N	Virginia bottonweed	Shrub	A	Rubiaceae	FACW
Diospyros virginiana L.	2	N	common persimmon	Tree	P	Ebenaceae	FAC
Dulichium arundinaceum (L.) Britt.	6	N	threeway sedge	Gram	P	Cyperaceae	OBL
Echinochloa colona (L.) Link	0	I	jungle rice	Gram	A	Poaceae	FACW
Echinochloa crus-galli (L.) Beauv.	0	I	barnyard grass	Gram	A	Poaceae	FACW-
Echinochloa walteri (Pursh) Heller	4	N	coast cockspur grass	Gram	A	Poaceae	OBL
Echinodorus cordifolius (L.) Griseb.	4	N	creeping burrhead	Forb	P	Alistmataceae	OBL
Eclipta prostrata (L.) L.	3	N	false daisy	Forb	A	Asteraceae	FACW-
Eichhornia crassipes (Mart.) Solms	0	I	common water hyacinth	Forb	P	Pontederiacea	OBL
Eleocharis obtusa (Wild.) J.A. Schultes	4	N	blunt spikerush	Gram	A	Cyperaceae	OBL
Eleocharis quadrangulata (Michx.) Roemer & J.A. Schultes	5	N	squarestem spikerush	Gram	P	Cyperaceae	OBL
Elephantopus carolinianus Raeusch.	1	N	Carolina elephantsfoot	Forb	P	Asteraceae	FAC
Elymus canadensis L.	3	N	Canada wildrye	Gram	P	Poaceae	FAC
Elymus virginicus L.	4	N	Virginia wildrye	Gram	P	Poaceae	FAC
Epilobium coloratum Biehler	7	N	purple willow	Forb	P	Onagraceae	OBL
Eragrostis hypnoides (Lam.) B.S.P.	5	N	teal lovegrass	Gram	A	Poaceae	OBL
Eragrostis pectinacea (Michx.) Nees ex Steud	2	N	tufted lovegrass	Gram	A	Poaceae	FAC
Eragrostis spectabilis (Pursh) Steud.	2	N	purple lovegrass	Gram	P	Poaceae	FACU
Erechtites hieraciifolia (L.) Raf. ex DC.	1	N	burnweed	Forb	A	Asteraceae	FAC-
Eryngium prostratum Nutt. ex DC.	2	N	creeping eryngo	Forb	P	Apiaceae	FACW
Eupatorium capillifolium (Lam.) Small	3	N	dogfennel	Forb	P	Asteraceae	FACU
Eupatorium fistulosum Barratt	4	N	trumpetweed	Forb	P	Asteraceae	FAC+
Eupatorium perfoliatum L.	3	N	common boneset	Forb	P	Asteraceae	FACW+
Eupatorium serotinum Michx.	2	N	lateflowering throughwort	Forb	P	Asteraceae	FAC

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiogynomy		Family	Wetland Indicator Status
Euphobia maculata L.	1	N	spotted sandmat	Forb	P	Euphorbiaceae	FACW
Euthamia tenuifolia (Pursh) Nutt. var. *tenuifolia*	4	N	slender goldentop	Forb	P	Asteraceae	FAC
Fimbristylis autumnalis (L.) Roemer & J.A. Schultes	2	N	slender fimbry	Gram	A	Cyperaceae	OBL
Fimbristylis caroliniana (Lam.) Fern.	4	N	Carolina fimbry	Gram	P	Cyperaceae	FACW+
Fimbristylis miliacea (L.) Vahl.	0	I	grassvine fimbry	Gram	A	Cyperaceae	OBL
Fimbristylis tomentosa Vahl.	4	N	woody fimbry	Gram	A	Cyperaceae	FACW
Forestiera acuminata (Michx.) Poir.	5	N	eastern swampprivet	Tree	P	Oleaceae	OBL
Fragaria virginiana Duchesne	5	N	Virginia strawberry	Forb	P	Rosaceae	FAC-
Fraxinus americana L.	4	N	white ash	Tree	P	Oleaceae	FACU
Fraxinus pennsylvanica Marsh.	4	N	green ash	Tree	P	Oleaceae	FACW
Galactia regularis (L.) B.S.P.	3	N	eastern milkpea	H-Vine	P	Fabaceae	NI
Galactia volubilis (L.) Britt.	3	N	downy milkpea	H-Vine	P	Fabaceae	FACU
Galium obtusum Bigelow	3	N	bluntleaf bedstraw	Forb	P	Rubiaceae	FACW-
Galium tinctorium L.	1	N	stiff marsh bedstraw	Forb	P	Rubiaceae	FACW
Galium triflorum Michx.	4	N	fragrant bedstraw	Forb	P	Rubiaceae	FACU
Gamochaeta purpureum (L.) Cabrera	2	N	spoonleaf purple everlasting	Forb	A	Asteraceae	UPL
Geranium carolinianum L.	1	N	Carolina geranium	Forb	A	Geraniaceae	NI
Gleditsia triacanthos L.	4	N	honeylocust	Tree	P	Fabaceae	FAC-
Glottidium vesicarium (Jacq.) Harper	0	I	rattle bush	Forb	A	Fabaceae	FAC+
Gossypium hirsutum L.	0	I	Upland cotton	Shrub	A	Malvaceae	UPL
Gratiola virginiana L.	3	N	roundfruit hedgehyssop	Forb	A	Scrophulariaceae	OBL
Habenaria repens Nutt.	4	N	bog orchid	Forb	P	Orchidaceae	OBL
Helenium amarum (Raff.) H. Rock	2	N	yellowdicks	Forb	A	Asteraceae	FACU-
Helenium autumnale L.	3	N	common sneezeweed	Forb	P	Asteraceae	FACW
Helenium flexuosum Raf.	1	N	purplehead sneezeweed	Forb	P	Asteraceae	FACW
Helianthus angustifolius L.	5	N	swamp sunflower	Forb	P	Asteraceae	FAC+
Heliotropium indicum L.	0	I	Indian heliotrope	Forb	A	Borganiaceae	FAC+
Heteranthera dubia (Jacq.) MacM.	5	N	grassleaf mudplantain	Forb	P	Pontederiaceae	OBL
Heteranthera reniformis R.& P.	5	N	kidneyleaf mudplantain	Forb	P	Pontederiaceae	OBL
Hibiscus laevis All.	3	N	halberdleaf rosemallow	Forb	P	Malvaceae	OBL
Hibiscus moscheutos L.	3	N	crimsoneyed rosemallow	Shrub	P	Malvaceae	OBL
Hydrocotyle ranunculoides L.F.	2	N	floating marshpennywort	Forb	P	Apiaceae	OBL
Hydrolea uniflora Raf.	3	N	oneflower false fiddleleaf	Forb	P	Hydrophyllaceae	OBL

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiogynomy		Family	Wetland Indicator Status
Hypericum hypericoides (L.) Crantz	3	N	St. Andrew's cross	Shrub	P	Clusiaceae	FAC
Hypericum mutilum L.	2	N	dwarf St. Johnswort	Forb	A	Clusiaceae	FACW
Impatiens capensis Meerb.	6	N	jewelweed	Forb	A	Balsaminaceae	FACW
Ipomoea cordatotriloba Dennst.	2	N	tievine	H-Vine	P	Convolvulaceae	FACU
Ipomoea hederacea Jacq.	1	N	ivyleaf morning-glory	H-Vine	A	Convolvulaceae	FAC-
Ipomoea lacunosa L.	4	N	whitestar	H-Vine	A	Convolvulaceae	FAC+
Ipomoea wrightii Gray	0	I	Wright's morning-glory	H-Vine	A	Convolvulaceae	FACW-
Itea virginica L.	4	N	Virginia sweetspire	Shrub	P	Grossulariaceae	FACW+
Iva annua L.	1	N	annual marshelder	Forb	A	Asteraceae	FAC
Jacquemontia tamnifolia (L.) Griseb.	2	N	hairy clustervine	H-Vine	A	Convolvulaceae	FACU-
Juncus acuminatus Michx.	3	N	tapertip rush	Gram	P	Juncaceae	OBL
Juncus coriaceus Mackenzie	4	N	leathery rush	Gram	P	Juncaceae	FACW
Juncus dichotomus Ell.	1	N	forked rush	Gram	P	Juncaceae	FACW
Juncus diffusissimus Buckley	2	N	slimpod rush	Gram	P	Juncaceae	FACW
Juncus effusus L.	3	N	common rush	Gram	P	Juncaceae	FACW+
Juncus elliottii Chapman.	1	N	Elliot's rush	Gram	P	Juncaceae	OBL
Juncus marginatus Rostk.	2	N	bighead rush	Gram	P	Juncaceae	OBL
Juncus nodatus Coville	2	N	stout rush	Gram	P	Juncaceae	OBL
Juncus polycephalus Michx.	3	N	manyhead rush	Gram	P	Juncaceae	OBL
Juncus scirpoides Lam.	3	N	needlepod rush	Gram	P	Juncaceae	FACW+
Juncus tenuis Wild.	1	N	poverty rush	Gram	P	Juncaceae	FAC
Juncus torreyi Coville	1	N	Torry's rush	Gram	P	Juncaceae	FACW
Juncus validus Coville	5	N	roundhead rush	Gram	P	Juncaceae	FACW+
Juniperus virginiana L.	1	N	eastern redcedar	Tree	P	Cupressaceae	FACU-
Justicia americana (L.) Vahl.	1	N	American water-willow	Forb	P	Acanthaceae	OBL
Justicia ovata (Walt.) Lindau.	2	N	looseflower water-willow	Forb	P	Acanthaceae	OBL
Krigia caespitosa (Raf.) Champers	1	N	weedy dwarf dandelion	Forb	A	Asteraceae	FACU+
Kummerowia striata (Thunb.) Schindl.	0	I	Japanese clover	Forb	A	Fabaceae	FACU
Kyllinga odorata Vahl.	0	I	fragrant spikesedge	Gram	A	Cyperaceae	FACW
Kyllinga pumila Michx.	1	N	low spikesedge	Gram	A	Cyperaceae	FACW
Leersia lenticularis Michx.	7	N	catchfly grass	Gram	P	Poaceae	OBL
Leersia oryzoides (L.) Sw.	3	N	rice cutgrass	Gram	P	Poaceae	OBL
Leersia virginica Wild.	6	N	whitegrass	Gram	P	Poaceae	FACW
Lemna minor L.	3	N	common duckweed	Forb	P	Lemnaceae	OBL
Leptochloa filiformis (Lam.) Beauv.	2	N	red sprangletop	Gram	A	Poaceae	FACW

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiogynomy		Family	Wetland Indicator Status
Leptochloa panicoides (J. Presl.) A.S. Hitchc.	1	N	Amazon sprangletop	Gram	A	Poaceae	FACW
Lespedeza cuneata (Dum.-Cours) G.Don	0	I	Chinese lespedeza	Shrub	P	Fabaceae	NI
Lespedeza repens (L.) W. Bart	1	N	creeping lespedeza	Forb	P	Fabaceae	NI
Leucospora multifida (Michx.) Nutt.	2	N	narrowleaf paleseed	Forb	A	Scrophulariaceae	OBL
Ligustrum sinense Lour.	0	I	Chinese privet	Shrub	P	Oleacaeae	FAC
Limnobium spongia (Boc) L.C. Rich ex Steud	4	N	American spongeplant	Frob	P	Hydrocharitaceae	OBL
Lindernia dubia (L.) Pennell	4	N	yellowseed false-pimpernel	Forb	A	Scrophulariaceae	OBL
Lindernia dubia (L.) Pennell var. *anagallidea* (Michx,) Cooperrider	3	N	false-pimpernel	Forb	A	Scrophulariaceae	OBL
Liquidambar styraciflua L.	3	N	sweetgum	Tree	P	Hamamelidaceae	FAC+
Liriodendron tulipifera L.	2	N	tuliptree	Tree	P	Magnoliaceae	FAC
Lobelia cardinalis L.	2	N	cardinalflower	Forb	P	Campanulaceae	FACW+
Lobelia siphilitica L.	5	N	great blue lobelia	Forb	P	Campanulaceae	OBL
Lolium arundinaceum (Schreb.) S.J. Darbyshire	0	I	tall fescue	Gram	P	Poaceae	FAC-
Lolium pratense (Huds) S.J. Darbyshire	0	I	meadow ryegrass	Gram	P	Poaceae	FACU
Lolium prenne L. ssp. multiflorum (Lam.) Husnot	0	I	Italian ryegrass	Gram	A	Poaceae	FACU
Lonicera japonica Thunb.	0	I	Japanese honeysuckle	H-Vine	P	Caprifoliaceae	FAC-
Ludwigia alternifolia L.	5	N	seedbox	Forb	P	Onagraceae	OBL
Ludwigia decurrens Walt.	4	N	winged primrose-willow	Forb	A	Onagraceae	OBL
Ludwigia glandulosa Wah.	3	N	cylindricfruit primrose-willow	Forb	P	Onagraceae	OBL
Ludwigia leptocarpa (Nutt.) Hara	2	N	anglestem primrose-willow	Forb/shrub	P	Onagraceae	OBL
Ludwigia palustris (L.) Ell.	3	N	marshseedbox	Forb	P	Onagraceae	OBL
Ludwigia peploides (Kunth.) Raven	1	N	floating primrose-willow	Forb	P	Onagraceae	OBL
Ludwigia repens J.R. Frost.	3	N	creeping primrose-willow	Forb	P	Onagraceae	OBL
Lycopus americanus Muhl. ex W. Bart.	2	N	American water horehound	Forb	P	Lamiaceae	OBL
Lycopus rubellus Moench.	5	N	taperleaf water horehound	Forb	P	Lamiaceae	OBL
Lycopus virginicus L.	4	N	Virginia water horehound	Forb	P	Lamiaceae	OBL
Lysimachia nummularia L.	0	I	creeping Jenny	Forb	P	Primulaceae	FACW+
Lythrum alatum Pursh.	3	N	winged lythrum	Shrub	P	Lythraceae	FACW+
Lythrum lineare L.	3	N	wand lythrum	Forb	P	Lythraceae	OBL
Maclura pomifera (Raf.) Schnied.	2	N	osage orange	Tree	P	Moraceae	FACU
Magnolia virginiana L.	5	N	sweetbay	Tree	P	Magnoliaceae	FACU
Mecardonia acuminata (Walt.) Small	3	N	axilflower	Forb	P	Scrophulariaceae	FACW

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiogynomy		Family	Wetland Indicator Status
Melothria pendula L.	1	N	Guadeloupe cucumber	Vine	P	Curcurbitaceae	FACW-
Micranthemum umbrosum (J.F. Gmel.) Blake	4	N	shade mudflower	Forb	A	Scrophulariaceae	OBL
Microstegium vimineum (Trin.) A. Camus	0	I	Nepalese browntop	Gram	A	Poaceae	UPL
Mikania scandens (L.) Wild.	3	N	climbing hempvine	W-Vine	P	Asteraceae	FACW+
Mimulus alatus Ait.	5	N	sharpwing monkeyflower	Forb	P	Scrophulariaceae	OBL
Mitreola petiolata (J.F. Gmel.) Torr.& Gray	3	N	lay hornpod	Forb	A	Loganiaceae	FAC+
Morella cerifera (L.) Small	1	N	wax myrtle	Tree	P	Myricaceae	UPL
Morus rubra L.	5	N	red mulberry	Tree	P	Moraceae	FAC
Muhlenbergia schreberi J.F. Gmel.	2	N	nimblewill	Gram	P	Poaceae	FAC
Murdannia keisak (Hassk.) Hand.-Maz.	0	I	watermoving herb	Forb	P	Commelinaceae	OBL
Myosotis macrosperma Engelm .	4	N	largeseed forgetmenot	Forb	A	Boraginaceae	FAC
Myriophyllum aquaticum (Vell.) Verde.	0	I	parrot feather watermilfoil	Forb	P	Haloragaceae	OBL
Najas guadalupensis (Sprang.) Magnus	2	N	southern waternymph	Forb	A	Najadaceae	OBL
Nuphar lutea (L.) Sm.	3	N	spatterdock	Forb	P	Nymphaeaceae	OBL
Nymphaea ordorata Ait.	6	N	American white waterlily	Forb	P	Nymphaeaceae	OBL
Nyssa aquatica L.	6	N	water tupelo	Tree	P	Nyssaceae	OBL
Nyssa sylvatica var. *biflora* Marshall	7	N	swamp tupelo	Tree	P	Nyssaceae	OBL
Oenothera speciosa Nuttall.	1	N	pinkladies	Shrub	P	Onagraceae	NI
Oldenlandia uniflora L.	2	N	clustered mille graines	Shrub	A	Rubiaceae	FACW-
Oryza punctata Kotzchy ex. Steud.	0	I	redrice	Gram	A	Poaceae	NI
Oryza sativa L.	0	I	rice	Gram	A	Poaceae	FAC
Osmunda cinnamomea L.	6	N	cinnamon fern	Fern	P	Osmundaceae	FACW+
Osmunda regalis L.	6	N	royal fern	Fern	P	Osmundaceae	OBL
Oxalis corniculata L.	6	N	creeping woodsorel	Forb	A	Oxalidaceae	FACU
Oxypolis rigidior (L.) Raff.	8	N	stiff cowbane	Forb	P	Apiaceae	OBL
Panicum dichotomiflorum Michx.	2	N	fall panicgrass	Gram	P	Poaceae	FACW
Panicum rigidulum Bosc. ex Nees	3	N	redtop panicgrass	Gram	P	Poaceae	FACW
Panicum verrucosum Muhl.	3	N	warty panicgrass	Gram	P	Poaceae	FACW
Panicum virgatum L.	2	N	switchgrass	Gram	P	Poaceae	FAC+
Parthenocissus quinquefolia (L.) Planch.	1	N	Virginia creeper	H-Vine	P	Vitaceae	FAC
Paspalum dilatatum Poir.	0	I	dallisgrass	Gram	P	Poaceae	FAC+
Paspalum distichum L.	4	N	knotgrass	Gram	P	Poaceae	OBL
Paspalum laeve Michx.	4	N	field paspalum	Gram	P	Poaceae	FACW-
Paspalum notatum Fluegge	0	I	bahiagrass	Gram	P	Poaceae	FACU+
Paspalum urvillei Stued.	0	I	Vassey' grass	Gram	P	Poaceae	FAC

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Passiflora incarnata L.	2	N	purple passionflower	H-Vine	P	Passifloraceae	NI
Penthorum sedoides L.	5	N	ditch stonecrop	Forb	P	Crassulaceae	OBL
Phalaris caroliniana Walt.	2	N	Caroliniana canarygrass	Gram	A	Poaceae	FACW
Phyla lanceolata (Michx.) Greene	3	N	lanceleaf frogfruit	H-Vine	P	Verbenaceae	FACW+
Phyllanthus caroliniensis Walt.	4	N	Carolina leaf-flower	Forb	A	Euphorbiaceae	FAC+
Physalis heterophylla Nees	2	N	clammy groundcherry	Forb	P	Solanaceae	NI
Phytolacca americana L.	2	N	American pokeweed	Forb	P	Phytolaccaceae	FACU+
Pinus taeda L.	1	N	loblolly pine	Tree	P	Pinaceae	FAC
Plantago aristata Michx.	1	N	longbracted plantain	Forb	A	Plantaginaceae	NI
Plantago lanceolata L.	0	I	narrowleaf plantain	Forb	A	Plantaginaceae	FAC
Platanus occidentalis L.	2	N	American sycamore	Tree	P	Platanaceae	FACW-
Pluchea camphorata (L.) DC.	5	N	camphor pluchea	Forb	A	Asteraceae	FACW
Poa annua L.	0	I	annual bluegrass	Gram	A	Poaceae	FAC
Podophyllum peltatum L.	2	N	mayapple	Forb	P	Berberidaceae	FACU
Polygonum amphibium L.	3	N	water knotweed	Forb	P	Polygonaceae	FACW
Polygonum caespitosum Blume	0	I	oriental ladysthumb	Forb	A	Polygonaceae	FACW
Polygonum densiflorum Meisn.	5	N	denseflower knotweed	Forb	P	Polygonaceae	OBL
Polygonum hirsutum Walt.	1	N	hairy smartweed	Forb	P	Polygonaceae	OBL
Polygonum hydropiper L.	0	I	marshpepper knotweed	Forb	A	Polygonaceae	OBL
Polygonum hydropiperoides Michx.	3	N	swamp smartweed	Forb	P	Polygonaceae	OBL
Polygonum lapathifolium L.	0	I	curlytop knotweed	Forb	A	Polygonaceae	FACW
Polygonum pensylvanicum L.	4	N	Pennsylvania smartweed	Forb	A	Polygonaceae	FACW
Polygonum punctatum Ell.	3	N	dotted smartweed	Forb	A	Polygonaceae	FACW+
Polygonum sagittatum L.	7	N	arrowleaf tearthumb	H-Vine	P	Polygonaceae	OBL
Polygonum setaceum Baldw.	3	N	bog smartweed	Forb	P	Polygonaceae	FACW
Polypremum procumbens L.	1	N	juniper leaf	Forb	A	Buddlejaceae	FACU-
Populus deltoides Bartr. ex Marsh.	2	N	eastern cottonwood	Tree	P	Saliacaceae	FAC+
Potamogeton diversifolius Raf.	2	N	weatherthread pondweed	Forb	P	Potamogetonaceae	OBL
Potamogeton nodosus Poir.	2	N	longleaf pondweed	Forb	P	Potamogetonaceae	OBL
Potamogeton pusillus L.	2	N	small pondweed	Forb	P	Potamogetonaceae	FAC+
Proserpinaca palustris L.	4	N	marsh mermaidweed	Forb	P	Haloragaceae	OBL
Ptilimnium capilliaceum (Michx.) Raf.	3	N	herbwilliam	Forb	A	Apiaceae	OBL
Pueraria montana (Lour.) Merr. var. *lobata* (Wild.) Maesen & S. Almeida	0	I	kudzu	W-Vine	P	Fabaceae	NI
Pycnanthemum muticum (Michaux) Person	2	N	clustered mountainmint	Forb	P	Lamiaceae	FAC-

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Pyrrhopappus carolinianus (Walt.) DC.	1	N	Carolina desert-chicory	Forb	A	Asteraceae	FACU
Quercus alba L.	4	N	whiteoak	Tree	P	Fagaceae	FACU
Quercus falcata Michx.	4	N	southern red oak	Tree	P	Fagaceae	FACU-
Quercus laurifolia Michx.	5	N	laurel oak	Tree	P	Fagaceae	FACW
Quercus lyrata Walt.	6	N	overcup oak	Tree	P	Fagaceae	OBL
Quercus nigra L.	3	N	water oak	Tree	P	Fagaceae	FAC
Quercus phellos L.	3	N	willow oak	Tree	P	Fagaceae	FACW-
Ranunculus pusillus Poir.	2	N	low spearwort	Forb	A	Ranunculaceae	FACW+
Ranunculus sardous Crantz	0	I	hairy buttercup	Forb	P	Ranunculaceae	FAC+
Rhexia mariana L.	3	N	Maryland meadowbeauty	Forb	P	Melastomataceae	FACW+
Rhexia virginica L.	2	N	handsome harry	Forb	P	Melastomataceae	FACW+
Rhus copallinum L.	2	N	flameleaf sumac	Tree	P	Anacardiaceae	NI
Rhynchospora corniculata (Lam.) Gray	4	N	shortbristle horned beaksedge	Gram	P	Cyperaceae	OBL
Rhynchospora globularis (Chapman) Small	4	N	globe beaksedge	Gram	A	Cyperaceae	FACW
Rhynchospora glomerata (L.) Vahl.	3	N	clustered beaksedge	Gram	P	Cyperaceae	OBL
Rhynchospora rariflora (Michx.) Ell.	7	N	fewflower beaksedge	Forb	P	Cyperaceae	OBL
Rosa multiflora Thunb. ex Murr.	0	I	rose	W-Vine	P	Rosaceae	UPL
Rotala ramosior (L.) Koehne	3	N	lowland rotala	Forb	A	Lythraceae	OBL
Rubus argutus Link	4	N	sawtooth blackberry	Shrub	P	Rosaceae	FACU+
Rubus hispidus L.	3	N	bristly dewberry	Shrub	P	Rosaceae	FACW
Rubus trivialis Michx.	4	N	southern dewberry	Shurb	P	Rosaceae	FAC
Rumex acetosella L.	0	I	common sheep sorrel	Forb	P	Polygonaceae	FACU+
Rumex crispus L.	0	I	curly dock	Forb	P	Polygonaceae	FAC
Rumex pulcher L.	0	I	fiddle dock	Forb	P	Polygonaceae	FACW
Saccharum giganteum (Walt.) Pers.	3	N	sugarcane plumegrass	Gram	P	Poaceae	FACW
Sagina decumbens (Ell.) Torr.& Gray	1	N	trailing pearlwort	Forb	A	Caryophyllaceae	FACU
Sagittaria graminea Michx.	3	N	grassy arrowhead	Forb	P	Alismataceae	OBL
Sagittaria latifolia Wild.	3	N	broadleaf arrowhead	Forb	P	Alismataceae	OBL
Salix nigra Marsh.	3	N	black willow	Tree	P	Saliacaceae	OBL
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli	1	N	common elderberry	Tree	P	Caprifoliaceae	UPL
Saururus cernuus L.	1	N	lizard's tail	Forb	P	Saururaceae	OBL
Schizachyrium scoparium (Michx.) Nash var. *scoparium*	2	N	little bluestem	Gram	P	Poaceae	FACU
Scirpus cyperinus (L.) Kunth	4	N	woolgrass	Gram	P	Cyperaceae	FAC+

Appendix D. Continued

Species	AVE CC	Origin	Common name	Physiogynomy		Family	Wetland Indicator Status
Scutellaria integrifolia L.	5	N	helmet flower	Forb	P	Lamiaceae	UPL
Scutellaria lateriflora L.	4	N	blue skullcap	Forb	P	Lamiaceae	FACW+
Scutellaria parvula Michx.	5	N	small skullcap	Forb	P	Lamiaceae	FACU-
Senna obtusifolia (L.) Irwin & Barnelay	0	I	Java-bean	Forb/Shrub	P	Fabaceae	NI
Sesbania herbacea (P. Mill.) McVaugh	2	N	bigpod sesbania	Forb	A	Fabaceae	FACW-
Setaria parviflora (Poir.) Kerguelen	3	N	marsh bristlegrass	Gram	P	Poaceae	OBL
Setaria pumila (Poir.) Boemer & J.A. Schultes	0	I	yellow bristlegrass	Gram	A	Poaceae	OBL
Sida spinosa L.	1	N	prickly fanpetals	Forb/Shrub	P	Malvaceae	OBL
Sisyrinchium angustifolium P. Mill.	4	N	narrowleaf blue-eyed grass	Forb	P	Iridaceae	OBL
Sisyrinchium fuscatum Brickn	4	N	coastalplain blue-eyed grass	Forb	P	Iridaceae	FACU
Smilax bona-nox L.	3	N	saw greenbrier	W-Vine	P	Smilaceae	FAC
Smilax glauca Walt.	3	N	cat greenbrier	W-Vine	P	Smilaceae	FAC
Smilax rotundifolia L.	4	N	roundleaf greenbrier	W-Vine	P	Smilaceae	FAC
Solanum carolinense L.	3	N	Carolina horsenettle	Shrub	P	Solanaceae	FACU
Solanum ptychanthum Dunal	1	N	West Indian nightshade	Forb	A	Solanaceae	FAC
Solidago altissima L.	3	N	goldenrod	Forb	P	Asteraceae	FACU+
Solidago canadensis L. var. scabra	1	N	Canada goldenrod	Forb	P	Asteraceae	FACU
Solidago gigantea Ait.	4	N	giant goldenrod	Forb	P	Asteraceae	FACU
Solidago patula Muhl. ex Wild.	4	N	roundleaf goldenrod	Forb	P	Asteraceae	OBL
Sorghum bicolor (L.) Moench ssp. *bicolor*	0	I	grain sorghum	Gram	A	Poaceae	FACU
Sorghum halepense (L.) Pers.	0	I	Johnsongrass	Gram	P	Poaceae	FACU
Sparganium americanum Nutt.	7	N	American bur-reed	Forb	P	Sporganiaceae	OBL
Sphenoclea zeylandica Gaertn.	0	I	chickenspike	Forb	A	Shenocleaceae	OBL
Sphenopholis obtusata (Michx.) Scribn.	3	N	prairie wedgescale	Gram	P	Poaceae	FAC+
Sphenopholis pensylvanica (L.) A.S. Hitche.	7	N	swmap wedgescale	Gram	P	Poaceae	OBL
Spirodela polyrrhiza (L.) Schleid.	0	I	common duckmeat	Forb	P	Lemnaceae	OBL
Spirodela punctata (G.F.W. Mey) C.H. Thompson	0	I	dotted duckmeat	Forb	P	Lemnaceae	OBL
Steinchisma hians (Ell.) Nash	5	N	gaping grass	Gram	P	Poaceae	OBL
Styrax americanus Lam.	8	N	American snowbell	Tree	P	Styracaceae	FACW
Symphyotrichum dumosum (L.) Nesom var. *dumosum*	3	N	rice button aster	Forb	P	Asteraceae	FAC
Taxodium distichum (L.) L.C.Rich	5	N	bald cypress	Tree	P	Taxodiaceae	OBL
Teucrium canadense L.	3	N	Canada germander	Forb	P	Lamiaceae	FACW-
Thalia dealbata Fraser ex Roscoe	8	N	Powdery alligator-flag	Forb	P	Marantaceae	OBL

Appendix D. Concluded

Species	AVE CC	Origin	Common name	Physiognomy		Family	Wetland Indicator Status
Toxicodendron radicans (L.) Kuntze	1	N	eastern poison ivy	W-Vine	P	Anacardiaceae	FAC
Trachelospermum difforme (Walt.) Gray	4	N	climbing dogsbane	W-Vine	P	Apocynaceae	FACW
Trepocarpus aethusae Nutt. ex DC.	2	N	whitenymph	Forb	A	Apiaceae	FACW
Triadenum walteri (J.G.Gmel.) Gleason	4	N	greater marsh St. Johnswort	Forb	P	Clusiaceae	OBL
Tridens strictus (Nutt.) Nash	3	N	longspike tridens	Gram	P	Poaceae	FACW
Trifolium pratense L.	0	I	red clover	Forb	P	Fabaceae	FACU-
Trifolium repens L.	1	N	white clover	Forb	P	Fabaceae	FACU
Tripsacum dactyloides(L.) L.	3	N	eastern gamagrass	Gram	P	Poaceae	FAC+
Typha latifolia L.	4	N	broadleaf cattail	Forb	P	Typhaceae	OBL
Ulmus alata Michx.	3	N	winged elm	Tree	P	Ulmaceae	FACU
Ulmus americana L.	2	N	American elm	Tree	P	Ulmaceae	FACW
Ulmus rubra Muhl.	4	N	slippery elm	Tree	P	Ulmaceae	FACW
Urochloa platyphylla (Munro ex Wright) R. Webster	2	N	broadleaf signalgrass	Gram	A	Poaceae	FAC+
Utricularia gibba L.	5	N	humped bladderwort	Forb	A	Lentibulariceae	OBL
Utricularia purpurea Walt.	5	N	eastern purple bladderwort	Forb	A	Lentibulariceae	OBL
Valerianella radiata (L.) Dufr.	1	N	beaked cornsalad	Forb	A	Valerianaceae	FAC-
Valerianella umbilicata (Sullivant) Wood	2	N	navel cornsalad	Forb	A	Valerianaceae	FAC
Verbena brasiliensis Vell.	0	I	Brazilian vervain	Shrub	A	Verbenaceae	FAC-
Verbena urticifolia L.	1	N	white vervain	Forb	A	Verbenaceae	FAC+
Vernonia altissima Nutt.	1	N	ironweed	Forb	P	Asteraceae	FAC+
Vernonia gigantea (Walt.) Trel.	1	N	giant ironweed	Forb	P	Asteraceae	FAC+
Veronica arvensis L.	1	N	corn speedwell	Forb	A	Scrophulariaceae	NI
Viburnum nudum L.	5	N	possumhaw	Tree	P	Caprifoliaceae	FACW+
Vicia minutiflora F.G. Dietr.	2	N	pygmy flower vetch	H-Vine	A	Fabaceae	FAC
Vitis cinerea (Engelm.) Millard	4	N	graybark grape	W-Vine	P	Vitaceae	FAC+
Vitis rotundifolia Michx.	4	N	muscadine	W-Vine	P	Vitaceae	FAC+
Vitis vulpina L.	2	N	forest grape	W-Vine	P	Vitaceae	FAC+
Wolffia brasiliensis Weddell	2	N	Brazilian watermeal	Forb	P	Lemnaceae	OBL
Wolffia punctata Griseb	2	N	watermeal	Forb	P	Lemnaceae	OBL
Woodwardia areolata (L.) T.Moore	5	N	netted chainfern	Fern	P	Blechnaceae	FAC-
Xanthium strumarium L.	1	N	rough cocklebur	Forb	A	Asteraceae	FACU
Zizaniopsis miliacea (Michx.) Doell & Aschers	5	N	giant cutgrass	Gram	P	Poaceae	FACU
AVE CC for all species	**2.8**						