FLORISTIC QUALITY ASSESSMENT WITH WETLAND CATEGORIES AND EXAMPLES OF COMPUTER APPLICATIONS FOR THE STATE OF MICHIGAN

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Kim D. Herman
Wildlife Division
Michigan Department of Natural Resources
6833 Hwys US-2, 41 & M-35
Gladstone, Michigan 49837

Linda A. Masters
Conservation Research Institute
375 W. First St.
Elmhurst, Illinois 60126

Michael R. Penskar
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, Michigan 48909-7944

Anton A. Reznicek
University of Michigan Herbarium
North University Building
Ann Arbor, Michigan 48109-1057

Gerould S. Wilhelm
Conservation Research Institute
375 W. First St.
Elmhurst, Illinois 60126

William W. Brodovich
King & MacGregor Environmental, Inc.
5860 N. Canton Center Road, Suite 387
Canton, Michigan 48187

Kevin P. Gardiner
Natural Heritage Program, Wildlife Division
Michigan Department of Natural Resources
P.O. Box 30444
Lansing, Michigan 48909-7944

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For information or assistance on this publication, contact the MICHIGAN DEPARTMENT OF NATURAL RESOURCES, NATURAL HERITAGE PROGRAM, WILDLIFE, P.O. BOX 30180, LANSING, MI 48909.

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Copies of this publication are available from the Michigan Department of Natural Resources, Wildlife Division, Natural Heritage Program, P. O. Box 30444, Lansing, MI 48909-7944. Questions regarding this publication should be directed to Ms. Kim Herman at the above address.

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I. FLORISTIC QUALITY ASSESSMENT

INTRODUCTION

Large areas of Michigan have been modified extensively from their presettlement condition (Chapman 1984, Crispin and Rankin 1994, Comer and Albert 1993, Comer et al. 1993b, 1994). Primary effects on the landscape have been due to extensive logging and farming. More recently, residential, urban, industrial, and recreational development have markedly altered the Michigan landscape. Hydrology, fire, and other important abiotic processes have been disrupted or altered. According to the Michigan Department of Natural Resources (1988), over 70 percent of Michigan's original wetlands have been drained or filled, while many remaining wetlands are no longer representative of original landscape types (Comer et al. 1993b).

As a consequence, much of Michigan's native biota is now restricted to relatively small and often isolated tracts of landscape across the state. With intensive pressure on Michigan's remaining natural lands, particularly in southern Lower Michigan, there is a need for a consistent and practical method for identifying and recognizing the potential significance of remnant areas for the long-term survival of Michigan's native biodiversity. Presented here is a simple, consistent, and repeatable method for evaluating the relative significance of tracts of land in terms of their native floristic composition.

Floristic Quality Assessment (FQA) is a tool to assist environmental consultants, scientists, natural resource managers, land stewards, environmental decision-makers, and restorationists in assessing the floristic, and implicitly, natural significance of any given area throughout Michigan. Floristic Quality Assessment will not replace criteria or methodology already employed by various resource agencies. This assessment system is not intended for use as a stand-alone method, but it can be applied to complement and corroborate other methods of evaluating the natural quality of a site.

Applications of this system include the identification of remnant habitats of native floristic significance, comparisons between different sites, long-term monitoring of floristic quality, monitoring the progress of habitat restoration, and the use of National Wetland Categories to assist in the identification of wetlands. FQA can also be used to help make permitting decisions and to develop performance standards and mitigation criteria (Wilhelm 1991, 1992, and 1993, Andreas and Lichvar 1995, Herman 1994).

METHODOLOGY

The Floristic Quality Assessment system for Michigan is modeled after that developed for the Chicago Region described in Swink and Wilhelm (1994). To develop the FQA for Michigan it was essential to compile a thorough list of the vascular plants known to occur in the state (Penskar et al. 2001, Appendix C). The Michigan Plant Database in Appendix C comprises 1,815 native taxa and 914 non-native (adventive) taxa, for a total of 2,729 taxa (Figure 1). This list is not to be regarded as a definitive flora, but as a utility database, only to be used as a reference for applications of the FQA for Michigan. The revisions to the database include: the addition of 11 native and 38 non-native taxa, changes in nomenclature (i.e., synonyms such as *Scirpus* to *Schoenoplectus*), the addition of life history (annual, biennial, perennial) to the physiognomic categories, and an update of the status category (endangered, threatened, special concern or extirpated) to match the March 1999 Michigan Special Plants List.

Life history categories largely follow Wilhelm and Masters (1995) and Taft et al (1997). Gray's manual of botany (Fernald, 1950) and the online USDA Plant Database (see Section IV – Resources) were also consulted. Nomenclature largely follows Michigan Flora (Voss 1996, 1985, 1972). Other references consulted include Case (1987) for all Michigan orchids, Case and Case (1997) for trillium, Gleason and Cronquist (1991) for selected genera, and Barnes and Wagner (1981) for several woody plant taxa. For pteridophytes (ferns and fern allies), we followed the treatments provided in the Flora of North America, Volume 2 (Morin et al. 1993).

Coefficients of Conservatism

The concept of species conservatism is the foundation for floristic quality assessment. Each native Michigan species was assigned a **coefficient of conservatism** (*C*)[1] following the methodology and philosophy detailed in Swink and Wilhelm (1994) and Wilhelm and Masters (1995). Coefficients of conservatism range from 0 - 10 and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-European settlement condition (Figure 1). A *C* of 0, therefore, is given to plants such as *Acer negundo* (box elder) that have demonstrated little fidelity to any remnant natural community, *i.e.* may be found almost anywhere, while a *C* of 10 is applied to those plants like *Potentilla fruticosa* (shrubby cinquefoil) that are almost always restricted to a presettlement remnant, *i.e.* a high quality natural area. Intermediate values are assigned to taxa such as *Quercus bicolor* (swamp white oak) or *Trillium grandiflorum* (large white trillium), when it is certain it is faithful to remnant natural communities, but it is uncertain that the condition of the community from which it comes is still representative of presettlement condition, *i.e.* the community may be degraded.

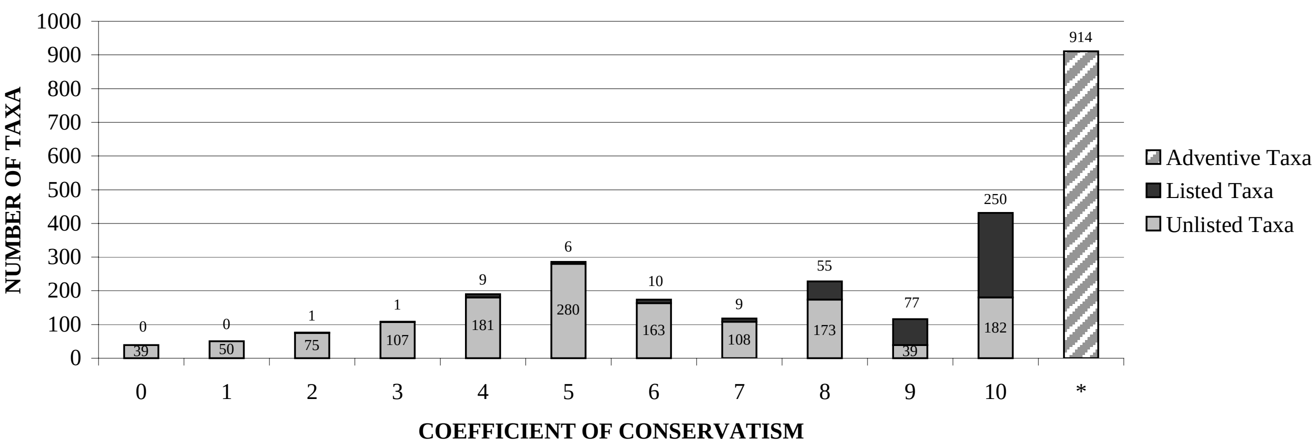

Figure 1: Number of adventive[2] plants and the distribution of coefficients of conservatism for native Michigan plant taxa, including the proportion of listed[3] plant taxa for each coefficient of conservatism.

In Michigan, certain species are known to exhibit varying degrees of conservatism over their statewide range, and thus the *C* assigned reflects what would be expected most commonly

[1] Coefficients of conservatism were assigned by Anton Reznicek, Michael Penskar, and William Brodovich with assistance from Gerould Wilhelm.
[2] Adventive taxa are plants spreading into Michigan from a source outside of Michigan since pre European settlement.
[3] Listed taxa refer to plant taxa listed as endangered, threatened , extirpated, or special concern by the State of Michigan.

throughout the state.[4] For example, *Thuja occidentalis* (northern white cedar) in southern Michigan is highly restricted to relatively few habitats and would justify a *C* of 8 or 9. Northward, however, this species inhabits a much broader range of natural communities and disturbed sites and would justify a *C* of 1 or 2; in this case, the assigned *C* is 4. While a number of species are widely distributed within the state, a small percentage exhibits a bimodal range of conservatism. Such species however, will have little influence on the measured floristic quality of any given site. Note the normal distribution of the coefficients of conservatism from 0 - 9 (Figure 1). By including those taxa with *C* = 10 with the distribution of coefficients of conservatism, the overall distribution becomes left skewed (Figure 1), similar to that for Illinois (Taft 1997).

The fidelity or faithfulness concept is not new. Phytosociologists have long used this as a practical application of empirical observation (Braun-Blanquet 1932). It is theoretically possible to measure empirically the fidelity of each of the approximately 1815 native plant taxa in Michigan (Figure 1) to given natural communities. We recognized it is not possible to take such measurements in the near future and that coefficients of conservatism have been effectively applied to different geographic regions without such measurements (Coastal Plain – Allain, pers. comm.; Northeast Ohio - Andreas and Lichvar 1995; Ohio – Andreas et al. in prep.; Wisconsin – Bernthal, pers. comm.; Iowa – Drobney pers. comm.; Missouri - Ladd 1997; Southern Ontario – Oldham et al. 1995; Chicago Region - Swink and Wilhelm 1979, 1994; Kentucky – Shea et al. in prep.; Illinois - Taft et al. 1997; Northern Great Plains – Northern Great Plains Working Group 2001). Therefore, we placed the "subjectivity up front" in assigning *a priori* a coefficient of conservatism to each native species in Michigan. As stated in Swink and Wilhelm (1994) *we cannot know the presettlement vegetational composition or structure for any given site, nor can we know how it would have changed over time* in the absence of European settlement. Therefore, we have employed as benchmarks our collective knowledge and understanding of species fidelity to the remaining high quality natural communities and otherwise disturbed lands in Michigan.

Floristic Quality Index

Floristic Quality Assessment is applied by calculating a **mean coefficient of conservatism** ($\overline{C}$) and a **floristic quality index** (*FQI*) from a comprehensive list of plant species obtained from a particular site. This is done by summing the coefficients of conservatism (*C*) of an inventory of plants and dividing by the total number of plant taxa (*n*), yielding an average or the mean coefficient of conservatism ($\overline{C} = \sum C/n$). The $\overline{C}$ is then multiplied by the square root of the total number of plants ($\sqrt{n}$) to yield the floristic quality index ($FQI = \overline{C}\sqrt{n}$). The square root of *n* is used as a multiplier to transform the mean coefficient of conservatism and allow for better comparison of the *FQI* between large sites with a high number of species and small sites with fewer species. Sites with the same $\overline{C}$ may have different *FQIs*, and sites with the same *FQI* may have different $\overline{C}s$ (Figures 2 and 3) (Goforth et al. 2001, Taft et al. 1997). For further discussion of this variation, refer to Taft et al. (1997) and Wilhelm and Masters (1995) in Appendix F. Some have found the $\overline{C}$ may be a more predictable indicator of floristic quality when comparing among similar natural communities such as remnant hardwood forests in Ontario (Frances et al. 2000) and river floodplains in Michigan, although this may be due to small sample sizes and narrow dispersion of $\overline{C}$ values (Goforth et al. 2001).

[4] The Michigan FQA differs from the Chicago Region application in that coefficients of conservatism were developed for a considerably larger geographic area and over a greater north to south gradient.

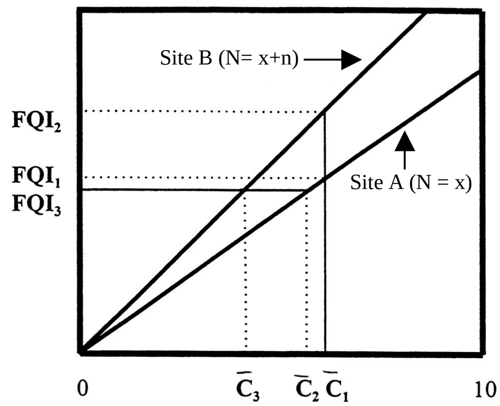

Figure 2: Baseline model comparing the Floristic Quality Index (FQI) and Mean Coefficients of Conservatism ($\overline{C}$) from two sites with differing total species richness (N). The example illustrates where two sites with different total species richness but similar mean coefficient of conservatism ($\overline{C}_1$) will differ in floristic quality indices (FQI_1 and FQI_2) and where two sites with similar floristic quality indices (FQI_3) will differ in mean coefficients of conservatism ($\overline{C}$) (Taft et al. 1997).

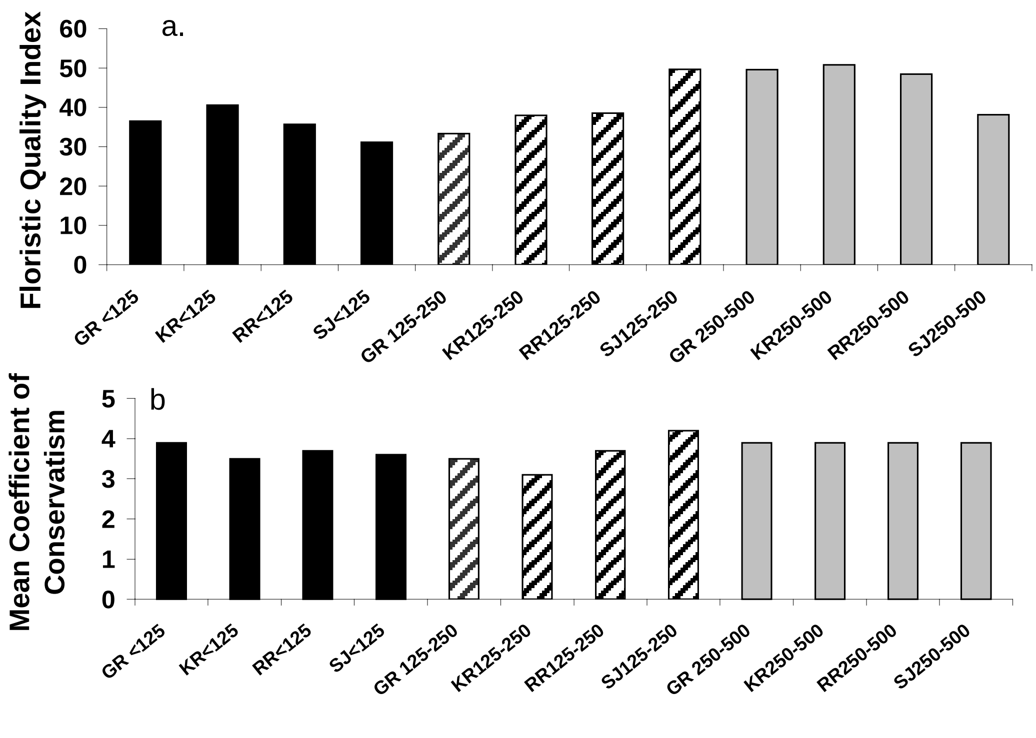

Figure 3: Floristic data from 12 riparian sites (GR = Grand River, KR = Kalamazoo River, RR = River Raisin , SJ = St. Joseph River) in southern Michigan grouped by buffer width (<125m black, 125-250m striped, 250-500m gray) showing equal mean coefficients of conservatism (b) and different floristic quality indices (a) in the 250-500 buffer width. The Kalamazoo River and Raisin River 125 – 250m buffer sites show similar floristic quality indices (a) with different mean coefficients of conservatism (b) (Goforth et al. 2001).

Based upon recent tests of the FQA system in Michigan in a wide variety of habitats, certain patterns have emerged. The range of coefficients of conservatism (*C*) of the plant taxa found in most of our undeveloped lands is 0 - 2, whereas 85% of the total native flora has a *C* of 4 or greater (Figure 1). The entire native flora has a $\overline{C}$ of 6.5. This indicates the principal elements of our native systems are poorly represented in the landscape today. Most of the remaining undeveloped land registers floristic quality indices (*FQI*) of less than 20 and has minimal significance from a natural quality perspective. Areas with a *FQI* higher than 35 possess sufficient conservatism and richness that they are floristically important from a statewide perspective. Areas registering in the 50s and higher are extremely rare and represent a significant component of Michigan's native biodiversity and natural landscapes.

Coefficients of Wetness

Analogs to the coefficients of conservatism are derived from the five main National Wetland Indicator Categories given by Reed (1988) and are referred to as **coefficients of wetness** (*W*) (Wilhelm 1992 - Appendix G). Michigan taxa not treated by Reed (1399 taxa) were assigned wetland indicator categories *de novo*.[5] The National Wetland Indicator Categories define the estimated probability for which a species occurs in wetlands (Table 1) (Reed 1988, Wilhelm 1989, 1992). Positive signs (+) indicating a wet tendency and negative signs (-) indicating a dry tendency are attached to the three "facultative" categories to express these exaggerated tendencies for those species (Reed 1988). Coefficients of wetness (*W*) have been assigned by Wilhelm (1989, 1992) to the eleven wetland indicator categories:

> OBL = -5, FACW+ = -4, FACW = -3, FACW- = -2, FAC+ = -1, FAC = 0, FAC- = 1, FACU+ = 2, FACU = 3, FACU- = 4, UPL = 5.

Table 1: Wetland category definitions and coefficients of wetness (*W*).

Wetland Category	Symbol	*W*	Definition
Upland	UPL	5	Occurs almost never in wetlands under natural conditions (estimated < 1% probability).
Facultative Upland	FACU	3	Occasionally occurs in wetlands, but usually occur in non-wetlands (estimated 1% - 33% probability).
Facultative	FAC	0	Equally likely to occur in wetlands or non-wetlands (estimated 34% - 66% probability).
Facultative Wetland	FACW	-3	Usually occurs in wetlands, but occasionally found in non-wetlands (estimated 67% - 99% probability).
Obligate Wetland	OBL	-5	Occurs almost always in wetlands under natural conditions (estimated > 99% probability).

[5] Wetland categories for taxa not treated by Reed (1988) were taken from Swink and Wilhelm (1994). Taxa not treated by Swink and Wilhelm were assigned by Anton Reznicek and Michael Penskar.

Wetness Index

Coefficients of wetness (*W*) of taxa recorded from a site inventory (*n*) can be averaged and the mean regarded as a **wetness index** ($\overline{W} = \sum W/n$). If the wetness index ($\overline{W}$) is zero or below, then the site has a predominance of wetland species (Wilhelm 1989). The $\overline{W}$ does not consider dominance as measured by percent cover of any species. Wilhelm (1989, 1991, 1992, 1993) hypothesizes that a wetness index calculated using only native species is a stronger indication of wetland status than a wetness index that includes adventive species. This is demonstrated by comparing the distribution of wetland status between native and adventive taxa. The 1815 native Michigan taxa show sensitivity to soil moisture ranging from wet to dry conditions as indicated by their inverse normal distribution (Figure 4). The 914 adventive plant taxa show a skewed distribution, with substantially more taxa in the upland categories (617) relative to all wetland categories combined (297) (Figure 5). Consult the Computer Program Application Section that follows and Appendix G for a more detailed explanation of this hypothesis and the application of the wetness index.

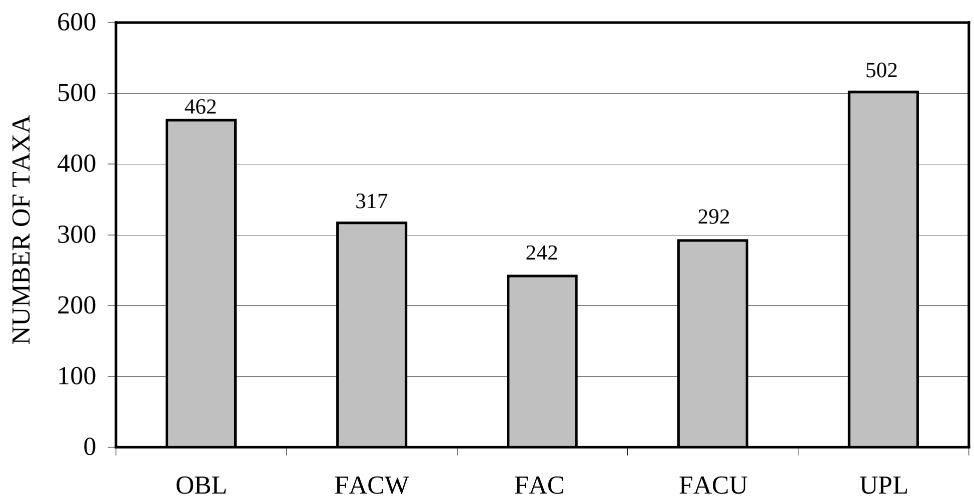

Figure 4: The distribution of wetland categories for the native plant taxa of Michigan**.**

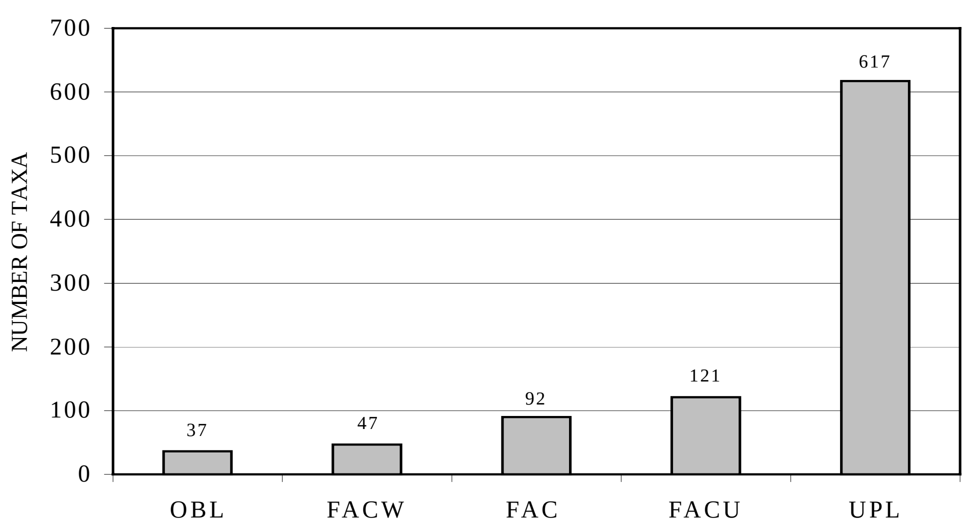

Figure 5: The distribution of wetland categories for adventive plant taxa in Michigan.

Physiognomy

The computer applications for FQA and the associated plant data bases traditionally include the physiognomic classes, since it is possible for community structure to change overtime without correlative changes in the *FQI* or $\overline{C}$ (Taft et al. 1997). The distribution of plant taxa by physiognomic classes show most plants in Michigan are native, perennial, dicot forbs (811), followed by adventive, perennial, dicot forbs (323) and adventive, annual, dicot forbs (291) (Figure 6). Native sedges and grasses comprise 23% of Michigan's native taxa and predominate in numbers over the adventive sedges and grasses (Figure 6). Life history categories are useful for protecting annual and biennial plants from over collection and potential local extirpation.

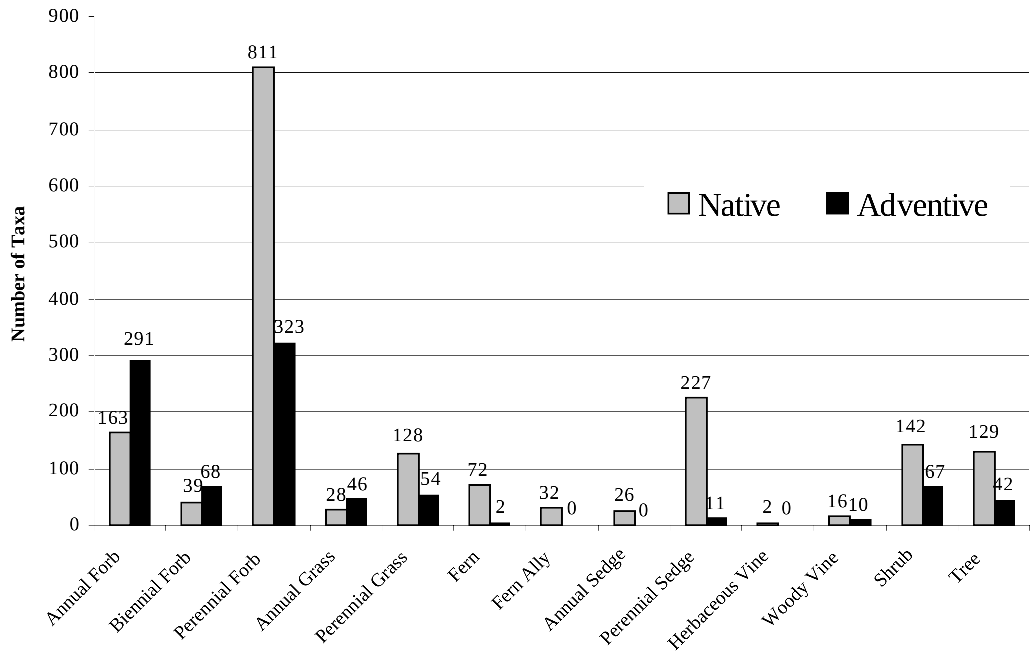

Figure 6: Distribution of native and adventive taxa of Michigan by physiognomic class

APPLICATION

Usefulness in deriving information from selected indicator species has long been valued by plant ecologists for community classification along environmental gradients (Magurran 1988, Whittaker 1975). Floristic Quality Assessment goes further in recognizing that all plant species at a location convey information about a site due to their adaptation to a unique set of biotic and abiotic conditions. As applied by the FQA system, plant taxa, when assessed in the aggregate, can give more information than an individual indicator taxon or even a group of indicators, often used for classification purposes.

Plant lists are often compiled during environmental site assessments and provided as appendices in environmental documents with little or no analysis beyond determining their wetland affinities or their legal status under federal and state endangered species acts. Often the ecological importance of species richness is not emphasized or recognized. Thus, FQA helps to give meaning to a group of plant species, beyond their presence on a list, by providing the mean coefficient of conservatism ($\overline{C}$) and the floristic quality index (*FQI*), which anyone can utilize and interpret.

The application of FQA is dependent on the aggregate presence of species in any area. With consistent application of the FQA system, the information derived from the $\overline{C}$ of the entire constellation of species within a site gives the system its robustness. Therefore, it is important the site surveyor be diligent and consistent in writing down ALL plant taxa observed at a site and to sufficiently cover the site's territory during standardly accepted times of the growing season. Essential to the successful use and application of the FQA system is the participation of botanists with a good knowledge of the Michigan flora and experience in conducting field inventories.

There are several applications of FQA. The following four are discussed in Swink and Wilhelm (1994) and by Wilhelm and Masters (1995 - Appendix F): (1) the identification of remnant native habitats of floristic significance, (2) the comparison of floristic quality among different sites, (3) long-term monitoring of floristic quality in natural areas, and (4) monitoring of habitat restoration. Use of the wetland categories as an aid in the identification of wetlands is discussed below and in Appendix G.

Floristic Quality Assessment can also be used to assist in making permitting decisions and developing performance standards and mitigation criteria (Andreas and Lichvar 1995, DuPage County Stormwater Management Committee 1992, Herman 1994, Swink and Wilhelm 1994, Wilhelm 1991, 1992, 1993, Wilhelm and Masters 1995 - Appendix F). The floristic quality index derived from an inventory provides information regarding a site's natural quality potential, which can also be used in certain sampling protocols. The *FQI* of individual quadrats established along a transect may be used to establish baseline data serving as a benchmark for future monitoring of changes in floristic quality during site restoration or site rehabilitation efforts. If one is comparing floristic quality data among similar communities, i.e. fen to fen, or bog to bog, data must be obtained using a standard ecological sampling design for comparison between sites. Details of survey methods and effort should accompany any reporting of inventory or sampling results derived from applying the FQA because indiscriminate comparisons of floristic quality with dissimilar methods used in evaluation can be misleading (Taft et al. 1997).

In addition, as discussed in the following by Taft et al. 1997, the assessment of ecosystem integrity based on a single index will be insufficient to account for all relevant aspects. For example, the *FQI* or $\overline{C}$ when reported alone can be misleading (Figure 2). Species richness (number of species) by itself can also be an insensitive indicator of habitat quality since it is possible for a degraded site to support a similar or greater number of taxa than an intact, high quality site. Six measures of biological integrity for wetlands have been suggested by Keddy et al. 1993. These include species diversity, indicator guilds, exotic species, rare species, plant biomass and amphibian biomass. Keddy et al. (1993) views diversity as an essential indicator of integrity, but also recommends assessing guild diversity. FQA readily addresses the first four recommended measures, provides a wetness index and can be applied to wetland and upland vegetation. Moreover, it can be expanded to include other community traits or other particular interests (Taft et al. 1997) (see summary tables in Appendices A and B). The transect computer application as shown in Appendix B also allows for the calculation of relative frequency, relative dominance, and importance values.

Two examples from Michigan, not detailed in Appendices B and F, are presented here. The first example discusses uses of the FQA in helping to make resource-permitting decisions and to establish performance standards and mitigation criteria. The second example discusses the use of the wetness index ($\overline{W}$) in the identification of problematic wetlands and their boundaries.

Permitting, Performance Standards, and Mitigation Criteria

Michigan has a variety of resource protection laws where the application of FQA can be useful. These include Parts 365 (Endangered Species Protection), 303 (Wetland Protection), 301 (Inland Lakes and Streams) and 353 (Sand Dunes Protection and Management) of Public Act 451 of 1994 (as amended). The following is an example excerpted from Herman (1994) where the FQA system was used as a performance standard and for establishing mitigation criteria in an endangered species permit for the Detroit Metropolitan Wayne County Airport expansion.

In 1989, expansion of the Detroit Metro Airport was expected to result in the on-site loss of three plant species listed as threatened under the M-ESA. The three species were *Aristida longispica* (slender three-awned grass), *Juncus brachycarpus* (short fruited rush), and *Ludwigia alternifolia* (seed box). The three species were found within remnant lakeplain wet-mesic prairies and mesic sand prairies. The statutory requirements of Part 365 (Endangered Species Protection) of P.A. 451 of 1994 were enhanced by making compliance with this act a condition of the state wetland permit. The provisions of the endangered species permit allowed the translocation of affected plants and seed bank to an off-site location, which had been excavated and graded to match the land contours and hydrology of the airport site. Unaffected areas on the airport were required to be protected and monitored as a baseline to compare the success of the translocated plants. Hydrology, soil moisture, and vegetation are being monitored for ten years.

The criteria for success, required by the permit, states that at the off-site mitigation location, populations of threatened plants must be at least as large and viable as populations eliminated by the airport expansion. In addition, the mitigation area is required to be free of aggressive weeds such as *Lythrum salicaria* (purple loosestrife), the species **diversity index** should be stable or show an increase in native species diversity throughout the monitoring period, and it should show a stable or increasing floristic quality index and mean coefficient of conservatism. As a contingency measure, the permit requires that if the mitigation fails, then a similar but larger and intact lakeplain prairie in Wayne or Monroe counties must be purchased and managed.

DuPage County, Illinois in implementing its stormwater and flood plain ordinance uses a $\overline{C} = 3.5$ as a criteria for identifying "critical" wetlands and requires mitigation for the loss of these wetlands in the form of 3:1 acre wetland replacement (DuPage County Stormwater Management Committee, 1992). Administrative rules to the Illinois Wetland Policy Act of 1989 (20 ILCS 830, 17 Ill. Adm. Code 1090) also requires a 5.5:1 replacement ratio for mitigating loss of wetlands with a native floristic quality greater than 20 ($FQI \geq 20$) or a mean coefficient of conservatism greater than or equal to 4 ($\overline{C} \geq 4.0$). Wilhelm (1991, 1992, 1993) suggests, based on monitoring data obtained from Chicago region restoration sites, that areas with known high floristic quality ($FQI \geq 35$) cannot be routinely restored to their original floristic quality and therefore are unmitigable. Conversely, lower quality wetlands registering *FQI* in the teens and twenties may be mitigable.

Identification of Problematic Wetlands

Some Michigan natural communities that may be classified as wetlands are considered problematic because they can be difficult to distinguish from adjacent uplands (MacKinnon 1994). These natural communities are exemplified by some wooded dune and swale complexes, wet and wet-mesic prairies, including lakeplain prairies, coastal plain marshes, and alvars (MNFI 1990). These problematic communities, with the exception of alvars, all overlay coarse, well drained soils and often support a mix of wetland and upland species, especially at the upland-wetland boundaries (MacKinnon 1994). These communities often are not recognized as wetlands because of the upland vegetation component, sandy soils, and either small size or non-contiguousness to an inland lake or stream. Thus they are vulnerable to development largely because it is mistakenly assumed that wetland permits are not needed (MacKinnon 1994)[6].

Comer and Albert (1993) compared elevations along transects with the wetland indices ($\overline{W}$) for species from corresponding ridges and swales in Michigan to help clarify the relationship between landforms and vegetation within wooded dune and swale complexes in Michigan and to help determine their wetland status under the Goemare-Anderson Wetlands Act. At Sturgeon Bay (Emmet County), high wind-sorted dune ridges support upland vegetation clearly distinguishable from adjacent swales (Figures 4 and 5). Forested beach ridges, with soils of medium to course sand, show wetness indices from 0 - 3 indicating a proportionally higher number of plants in upland categories. Soil moisture conditions can change dramatically, with slight elevational changes reflected in the development of soil organic material and plant species. On lower ridges, moisture may be noticeably higher and soil organic material accumulation is greater (4-25 cm) with $\overline{W}$ below 0 indicating a higher proportion of plants in wetland categories.

MacKinnon (1994) points out that most swales in wooded dune and swale complexes are protected by the Michigan wetlands act because they are contiguous to the Great Lakes or a nearby surface water. However, it is often less clear for wetlands found in the glacial lakeplain counties of Michigan where topographic relief is measured in only a few feet. The FQA methodology combined with the use of wetness indices may become extremely useful in helping not only to determine a wetland boundary based on the presence of native wetland plants, but also to help practitioners recognize a wetland and its floristic significance in the first place. It is precisely the remnant lakeplain prairies on the glacial lakeplain that are rarest and most at risk of being unknowingly destroyed (MacKinnon 1994; Comer et al. 1995).

[6] Michigan's wetlands are regulated under "Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, Act 451 of the Public Acts of 1994, being sections 324.30301 to 324.30323 of the Michigan Compiled Laws Annotated. Permits are required for filling in, dredging from, constructing or developing in, or draining surface waters from wetlands. Wetlands less than five acres in size, that are not contiguous to surface waters, and all non-contiguous wetlands in counties with populations of under 100,000 are not subject to permit review (MacKinnon 1994).

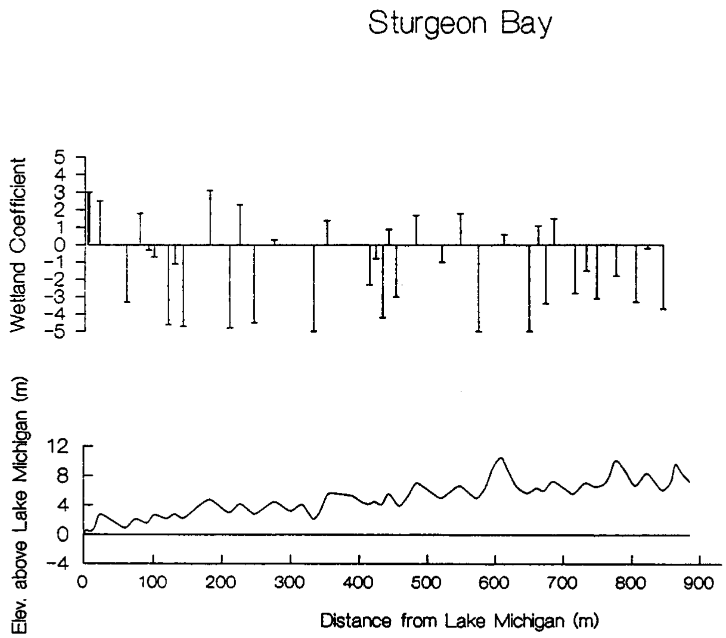

Figure 7: Elevational transect and corresponding wetness indices ($\overline{W}$) for the Sturgeon Bay wooded dune and swale complex Emmet County, MI (Comer and Albert 1993).

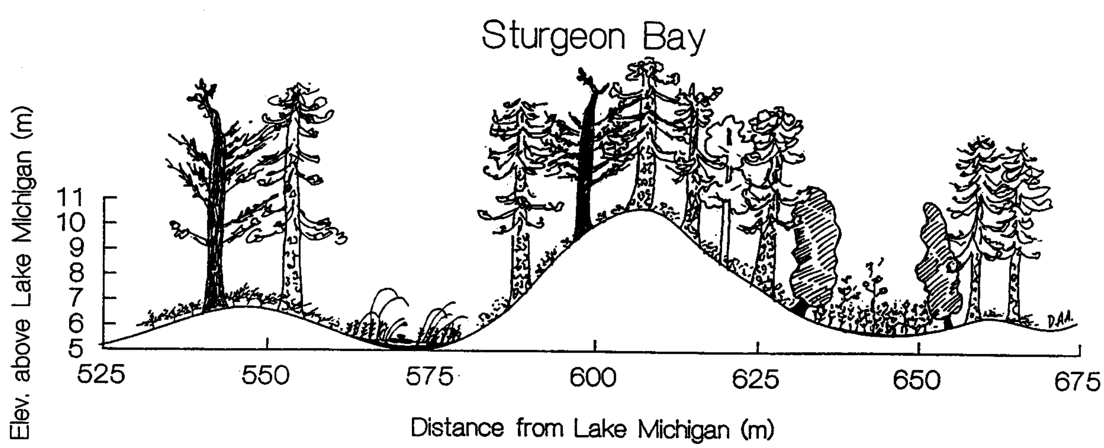

Figure 8: Illustration of the vegetation associated with a 150 meter portion of the transect at Sturgeon Bay, Emmet County, MI (Comer and Albert 1993).

DISCUSSION

The coefficient of conservatism is applied to a plant based upon its fidelity to a presettlement landscape, not its rarity or legal status. Although many plant species listed as endangered, threatened, or special concern by the State of Michigan are highly conservative, *C* = 8, 9, or 10, many are not, *C* = 4 - 7 (Figure 1). Many conservative, listed species are faithful to rare, high quality natural communities in Michigan. Such communities include prairies, where species rarity is largely attributable to habitat loss, and southern Michigan fens and bogs that have always been relatively rare. Losses of rare, high quality communities can have a serious impact on native biodiversity. Conversely, a number of rare species do not have a high fidelity to specific communities, or the communities to which they are faithful are relatively frequent. For example, the state threatened *Beckmannia syzigachne* (slough grass), *C* = 4, generally grows in wet places (Voss 1972), while respectively, the state threatened *Panax quinquefolius* (American ginseng), *C* = 10, grows in rich, mesic woods. Finally, many highly conservative species, such as *Potentilla fruticosa* (shrubby cinquefoil), with a *C* of 10 are not rare at all throughout Michigan.

All too frequently, areas where legally protected species are absent are considered expendable under current formal environmental evaluations. It is precisely because Floristic Quality Assessment is not based on species rarity or legal status that makes it a useful tool for assessing the natural quality of an area. Instead, FQA validates each plant taxa and goes beyond the simple measurement of species richness and abundance as defined and reviewed by Magurran (1988). FQA measures the extent and proportion to which constellations of conservative plants are present on a site (Swink and Wilhelm 1994, Wilhelm and Masters 1995 - Appendix F). Areas with a greater proportion of conservative species will have a greater $\overline{C}$ and higher *FQI*, alerting us to its or any community's floristic quality, potentially restorable floristic quality, and implicitly natural quality.

The decision to develop and provide a FQA system for Michigan was made because we recognized that its application could be useful in filling gaps in current natural quality assessment methods. The assignment of coefficients of conservatism for Michigan's native plants may be regarded as subjective, but it is based on the best estimates of botanists familiar with the flora and natural communities of Michigan. The methodology, however, is not subjective; it is standardized and repeatable, and requires only a skilled botanist to make an accurate and complete record of the plant species growing in a particular site.

Twenty three percent (418 species) of Michigan's native flora are extirpated, endangered, threatened, or listed as special concern by the State of Michigan. (Figure 1). Significant numbers of natural communities with conservative plants and associated animals are being lost piecemeal at an unprecedented rate throughout Michigan. We hope that the application of FQA on a statewide basis will help diminish somewhat the current rate of habitat loss due to ignorance of habitat or floristic quality. At a minimum, the use of the Floristic Quality Assessment system can provide decision makers with a standard, repeatable test for assessing the potential floristic and natural quality of a site, to be used in conjunction with other pertinent data and assessment tools prior to making important land-use decisions.

II. APPLICATION COMPUTER PROGRAMS

Those familiar with the first edition of the Floristic Quality Assessment will notice this edition is not accompanied by the original software application. In summer 2000, a new Windows-based program including both inventory and transect assessments was developed by Conservation Design Forum. This "stand-alone" software includes an up to date Michigan plant database. Copies of this program are available for purchase from The Conservation Research Institute, 375 W. First St., Elmhurst, IL 60126, or by telephone at (630) 559-2018.

The new program facilitates the application of the Floristic Quality Assessment system for the State of Michigan. The database consists of each species'[7] acronym, scientific name, common name, nativity, coefficient of conservatism (*C*) (0 = weedy, 10 = conservative, * = adventive), physiognomy, and National Wetland Category (Reed 1988) with its corresponding coefficient of wetness (*W*) (-5 = OBL, 0 = FAC, 5 = UPL). Adventive species are shown in ALL CAPS. See Appendix C for a listing of the database. There are two computer programs that use this database. The first evaluates a site inventory, and the second evaluates a sampling or monitoring transect. See Appendices A and B for examples of the Inventory and Transect Programs, respectively.

Both the Inventory and Transect programs access each species' record in the database through six letter acronyms. These acronyms are derived from the plant species' scientific name. **Using the acronym, eliminates the need to enter the full scientific name.**

Species -- The acronym of a binomial (two names) consists of the first three letters of the genus and the first three of the specific epithet. For example, the acronym for *Andropogon gerardii* is ANDGER. **An exception to this rule is the genus *Carex*.** Their acronyms consist of CX, followed by the first four letters of the epithet, for example, *Carex aggregata* = CXAGGR. Most acronyms are intuitive, but in some cases, where duplication occurs, non-intuitive acronyms are used to avoid data extraction errors. For example, ACESAU is the acronym for *Acer saccharum* and ACESAI is the acronym for *Acer saccharinum.* See Appendix C for a list of acronyms for all Michigan plants; see Appendix D for a list of non-intuitive acronyms[8].

Subspecies and Variety -- In the case of plants with recognized subspecies and varieties, the acronym consists of the first three letters of the genus, the first two letters of the species, and the first letter of the variety or subspecies. For example, the acronym for *Maianthemum canadense* var. *interius* is MAICAI. MAICAC is the acronym for *Maianthemum canadense* var. *canadense* where the typical variety is implied in the name. MAICAN, the intuitive acronym, in this nomenclatural context would be ambiguous and does not extract any plant in the database. As in the case of binomials, most trinomial acronyms are intuitive, but in some cases non-intuitive acronyms are used to avoid data extraction error. See Appendix D for a list of non-intuitive acronyms.

[7] The database also includes varieties and subspecies.

[8] In the new floristic quality assessment software, choices are presented if a duplicate acronym is entered. However, we have retained acronym lists in Appendices C and D as a useful reference.

III. LITERATURE CITED

Andreas, B. K. and R. W. Lichvar. 1995. “Floristic index for establishing assessment standards: A case study for northern Ohio.” Technical Report WRP-DE-8, U. S. Army Waterways Experiment Station, Vicksburg, MS. 16 pp. + Appendices.

Andreas, B. K., J. McCormac, and J. J. Mack. In Prep. Floristic Quality Assessment Index for Ohio. Ohio Biological Survey, Museum of Biological Diversity, Ohio State University, Columbus, Ohio.

Barnes, B. V. and W. H. Wagner, Jr. 1981. Michigan trees. Univ. Mich. Press, Ann Arbor, MI. 383 pp.

Braun-Blanquet, J. 1932. Plant sociology - the study of plant communities. McGraw-Hill Book Co., Inc., New York, NY. 439 pp.

Case, F. W., Jr. 1987. Orchids of the Western Great Lakes Region. Cranbrook Inst. Sci. Bull. 48. 147 pp.

Case, F.W., Jr. and R. B. Case. 1997. Trilliums. Timber Press. Portland, OR. 285 pp.

Chapman, K. A. 1984. An ecological investigation of grassland in southern lower Michigan. Masters Thesis. Western Michigan Univ., Kalamazoo, MI. 235 pp.

Comer, P. J. and D. A. Albert. 1993. A survey of wooded dune and swales complexes in Michigan. (CZM Project 13C-4.0) Michigan Natural Features Inventory, Lansing, MI. 159 pp. + Appendices.

Comer, P. J., D. A. Albert, L. Scrimger, T. Leibfried, D. Schuen, and H. Jones. 1993a. Historical wetlands of Michigan's coastal zone and southeastern lakeplain (CZM Project 309-5). Michigan Natural Features Inventory, Lansing, MI. 110 pp.

Comer, P. J., D. A. Albert, T. Leibfried, H. Wells, B. Hart, and M. Austin. 1993b. Historical wetlands of the Saginaw Bay watershed. Michigan Natural Features Inventory, Lansing, MI. Report for the Saginaw Bay Watershed Initiative, Office of Policy and Program Development, Michigan Department of Natural Resources. 67 pp.

Comer, P. J., B. Hart, H. Wells, T. Leibfried, K. Korroch, and D. Albert. 1994. Pre-European settlement landscape of the eastern half of northern Michigan. Michigan Natural Features Inventory, Lansing, MI. Report for the Hiawatha National Forest. 36 pp.

Comer, P. J., W. A. MacKinnon, M. L. Rabe, D. L. Cuthrell, M. R. Penskar, and D. A. Albert. 1995. A survey of lakeplain prairie in Michigan (CZM Project 94D-0.04). Michigan Natural Features Inventory, Lansing, MI. 234 pp.

Crispin, S. and D. Rankin. 1994. The conservation of biological diversity in the Great Lakes ecosystem: Issues and Opportunities. The Nature Conservancy Great Lakes Program Office, Chicago, IL. 118 pp.

DuPage County Stormwater Management Committee. 1992. Appendix E. Technical guidance for the DuPage Countywide stormwater and floodplain ordinance. DuPage County Stormwater Management Division, IL. 24 pp.

Francis, C. M., M. J. W. Austen, J. M. Bowles, and W. B. Draper. 2000. Assessing floristic quality in southern Ontario woodlands. Natural Areas Journal 20(1): 66 – 77.

Gleason, H. A. and A. Cronquist. 1963. Manual of vascular plants of Northeastern United States and adjacent Canada. Van Nostrand Co., Princeton, NJ. 810 pp.

Goforth, R. R.; D. S. Stagliano, J. Cohen, M. Penskar, Y. Lee, and J. Cooper. 2001. Biodiversity analysis of selected riparian ecosystems within a fragmented landscape. Michigan Natural Features Inventory Report No. 2001-06, Lansing, MI. 95 pp. + Appendix.

Herman, K. D. 1994. Uncharted territory - relocating threatened plants and reconstructing lakeplain prairie habitat. In Proceedings of a Symposium on Ecological Restoration, U. S. EPA, Washington, DC. EPA 841-B-94-003:143-154.

Herman, K. D., L. A. Masters, M. R. Penskar, A. A. Reznicek, G. S. Wilhelm, and W. W. Brodowicz. 1997. Floristic quality assessment: development and application in the State of Michigan (USA). Natural Areas Journal 17(3): 256-279.

Keddy, P. A., H. T. Lee and I. C. Wisheu. 1993. Choosing indicators of ecosystem integrity: wetlands as a model system. Pages 61 – 82 in S. Woodley, J. Kay and G. Francis, eds. Ecological integrity and the management of ecosystems. St. Lucie Press, Boca Raton, Florida. in Taft, J. B., G. Wilhelm, D. M. Ladd, and L. A. Masters. 1997. Floristic quality assessment for Illinois. Erigenia 15(1).

Ladd, D. 1997. Coefficients of conservatism for Missouri vascular flora. Unpublished report, The Nature Conservancy, St. Louis, MO. 53 pp.

MacKinnon, W. A. 1994. Report on the critical wetlands project: expanded identification of regulatory jurisdiction in non-contiguous wetlands, Part II: Results. Michigan Natural Features Inventory, Lansing, MI. 186 pp.

Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, NJ. 179 pp.

Michigan Department of Natural Resources, Land and Water Management Division. 1988. Wetland protection guidebook. Lansing, MI. 15 pp.

Michigan Natural Features Inventory. 1990. Draft description of Michigan natural community types. Lansing, MI. (Unpublished manuscript revised April 2, 1990). 34 pp.

Oldham, M., W. Bakowsky, and D. Sutherland. 1995. Floristic quality assessment for southern Ontario. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario.

Penskar, M. R., A. A. Reznicek, W. W. Brodovich, G. S. Wilhelm, L. A. Masters, K. D. Herman, and K. P. Gardiner. 2001. Michigan plants database. In Herman, K. D., L. A. Masters, M. R. Penskar, A. A. Reznicek, G. S. Wilhelm, W. W. Brodovich, and K. P. Gardiner. 2001. Floristic Quality Assessment with Wetland Categories and Examples of Computer Applications for the State of Michigan. Michigan Department of Natural Resources, Wildlife Division, Natural Heritage Program. Lansing, MI. 19 pp. + Appendices.

Reed, P. 1988. National list of plant species that occur in wetlands: Michigan. U. S. Fish and Wildlife Service, Department of Interior Biological Report: NERC-88/18.22.23. 31 pp. + Appendices.

Semple, J. C. and G. S. Ringius. 1983. The goldenrods of Ontario. Univ. of Waterloo Biology Series No. 26. Waterloo, Ontario. 84 pp.

Semple, J. C. and S. B. Heard. 1987. The asters of Ontario: *Aster* L. and *Virgulus* Raf. Univ. of Waterloo Biology Series No. 26. Waterloo, Ontario. 88 pp.

Shea, M., D. White, M. Evans, and D. Ladd. in prep. Floristic quality assessment for Kentucky, Kentucky Academy of Sciences.

Swink, F. & G. Wilhelm. 1979. Plants of the Chicago Region. Third Edition. Morton Arboretum, Lisle, IL. 922 pp.

Swink, F. & G. Wilhelm. 1994. Plants of the Chicago Region. Fourth Edition. Indiana Academy of Science, Indianapolis, IN. 921 pp.

Taft, J. B., G. Wilhelm, D. M. Ladd, and L. A. Masters. 1997. Floristic quality assessment for Illinois. Erigenia. 15(1).

The Northern Great Plains Floristic Quality Assessment Panel. 2001. Coefficients of conservatism for the vascular flora of the Dakotas and adjacent grasslands. U.S. Geological Survey, Biological Resources Division, Information and Technology Report USGS/BRD/ITR--2001-0001. 33pp

Voss, E. G. 1972. Michigan Flora. Part I. Gymnosperms and monocots. Bull. Cranbrook Inst. Sci. 55 and Univ. Michigan Herbarium, MI. 488 pp.

Voss, E. G. 1985. Michigan Flora. Part II. Dicots (Sauraceae-Cornaceae). Bull. Cranbrook Inst. Sci. 59 and Univ. Michigan Herbarium, MI. 724 pp.

Voss, E.G. 1996. Michigan Flora. Part III. Dicots (Pyrolaceae-Compositae). Bull. Cranbrook Inst. Sci. 61 and Univ. of Michigan Herbarium. xix + 622 pp.

Whittaker, R. H. 1975. Communities and ecosystems. Macmillan Publishing Co., Inc., New York, NY. 385 pp.

Wilhelm, G. & D. Ladd. 1988. Natural area assessment in the Chicago Region. Trans. 53rd N. A. Wild. and Nat. Res. Conf. pp. 361 - 375.

Wilhelm, G. 1989. Wetland vegetation and quality assessment of wetland areas at the three areas along Michigan roadsides in Berrien County. Unpublished Report to the Michigan Department of Transportation. Morton Arboretum, Lisle, IL. 15 pp.

Wilhelm, G. 1991. Vascular vegetation of Lake County, Illinois, with special reference to its use in wetland mitigation. Morton Arboretum, Lisle, IL. 64 pp.

Wilhelm, G. 1992. Technical comments on the proposed revisions to the 1989 wetland delineation manual. Erigenia 12:41 -50.

Wilhelm, G. 1993. The limits of wetland mitigation. Unpublished Presentation to EPA Ecol. Rest. Conf., Chicago, IL.

Wilhelm, G. & L. A. Masters. 1995. Floristic quality assessment in the Chicago Region and application computer programs. Morton Arboretum, Lisle, IL. 17 pp.

IV. RESOURCES

Websites

The following is a list of useful web sites for those searching for information and photos of Michigan's Flora and related assessment systems.

Aquatic Plants Database
http://aquat1.ifas.ufl.edu/database.html

Biota of North America Home Page (Synonymized Checklist for North America Plants)
http://www.bonap.org/

Northern Prairie Biological Resources
http://www.npwrc.usgs.gov/resource/taxa_P.htm

Links to Plant Databases
http://botany.about.com/science/botany/msub8.htm?once=true&

Orchids of Wisconsin
http://www.wisc.edu/botany/Orchids/Orchids_of_Wisconsin.html

Stein's Virtual Herbarium (Photos of several Michigan species)
http://home.usit.net/~info7/plants.html

University of Michigan Herbarium
http://www.herb.lsa.umich.edu/

USDA Plants National Database
http://plants.usda.gov/

Vascular Plants of Wisconsin
http://wiscinfo.doit.wisc.edu/herbarium/

Contacts

The following is a list of contacts for Floristic Quality Assessments that have been or are being developed for other geographic regions.

Coastal Plain – Contact Larry Allain. Email: Larry_Allain@usgs.gov

Chicago Region – Contact Sara Utter, The Conservation Research Institute, 375 W. First St., Elmhurst, IL 60126. Email: SUtter@cdfinc.com

Illinois - in Eregenia, No. 15, November 1997 available for $10. Contact the Illinois Native Plant Society c/o George Johnson, 9917 Reese Road, Harvard, IL 60033. Email: geomarjo@mc.net

Iowa – Contact Pauline Drobney, US Fish and Wildlife Service. Email: Pauline_Drobney@fws.gov

Ohio – Contact Barbara Andreas, c/o Ohio Biological Survey, Museum of Biological Diversity, Ohio State University, Columbus, OH 43212-1192. Email: Barbara.Andreas@tri-c.cc-oh.us

Kentucky – Contact Margaret Shea; Bernheim, PO Box 130, Clermont, KY 40110.
Email: mshea@bernheim.org.

Michigan – Contact Kim Herman, Michigan Department of Natural Resources, 6833 Hwys US-2, 41 & M-35, Gladstone, MI 49837. Email: hermank@state.mi.us

Missouri – Contact Beth Churchwell, The Nature Conservancy, St. Louis Field Office**,**
2800 S. Brentwood Blvd., St. Louis, MO 63144. Email: bchurchwell@tnc.org

Northern Great Plains - Contact David Mushet, U.S.Geological Survey, Northern Prairie Wildlife Research Center, 8711 37th Street SE, Jamestown, ND 58401.

Ontario – Contact Michael Oldham, Natural Heritage Information Centre, Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, Peterborough, Ontario K9J 8M5,Canada.
Email: michael.oldham@mnr.gov.on.ca

Wisconsin - Contact Thomas Bernthal, Wetland Ecologist, Wisconsin Department of Natural Resources, P.O. Box 7924, Madison, WI 53707-7921. Email: berntt@dnr.state.wi.us