

AN EVALUATION OF INDIANA'S FLORISTIC QUALITY ASSESSMENT

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ABSTRACT. Floristic Quality Assessment (FQA) is a valuable assessment tool for managers of natural areas, restoration ecologists, and conservationists. As a result, it has spread from initial use in the Chicago region to much of the upper midwestern U.S. The recently formulated database of coefficients of conservatism (C values) for Indiana will now permit FQA to be done statewide. This database was compared with those of neighboring states and significant differences were evident; however, these differences should only be of consequence if multiple state comparisons are being attempted. The C values for the Indiana counties included in the *Plants of the Chicago Region* are on average higher than those for Indiana as a whole. As a result, the Indiana State database should be employed for analyses that focus on state level conservation activities, as opposed to those concerned with the four state region around southern Lake Michigan. The performance of mean C (C_{av}) and the floristic quality index (FQI) for 28 reference sites were analyzed. In general, the guidance for interpreting these indices, laid out in Swink & Wilhelm (1994), holds. However, for at least one Natural Region of the state, namely the Central Till Plain, high quality natural areas did not score above $C_{av} = 4.1$. On the other hand, these same sites had high FQI values of 59 or higher. Both hydric and xeric reference sites attained high C_{av} ; but the range was somewhat higher for hydric sites such as the calcareous fen or acidic seeps. Checklists with 100 or more species tolerate undersampling and may be expected to have less than 0.1 unit of fluctuation in C_{av} with further sampling effort. For sites with smaller checklists, more intensive sampling is likely to result in fluctuations of ± 0.2 units. An analysis of the impact of adventive species suggests that natural quality has been compromised when adventive diversity lowers C_{av} by more than 0.7 units. Further evaluation of FQA for sites with moderate or marginal natural quality is still imperative for better understanding FQA metrics in Indiana.

Keywords: Natural area assessment, Indiana flora, mean C, floristic quality index, FQI, plant conservation

Plants of the Chicago Region (Swink & Wilhelm 1979) promoted many innovations in the study of regional floras. Foremost among them was the development of the Natural Areas Rating Index designed to generate objective metrics for rating the natural quality of plant communities. In the most recent edition, Swink & Wilhelm (1994) offered further refinements of the rating system and renamed the overall methodology Floristic Quality Assessment (FQA). The success of FQA is apparent in its spread from the Chicago region to a large portion of the upper midwestern U.S. The necessary species databases for performing FQA have been formulated for Illinois (Taft et al. 1997), Michigan (Herman et al. 1996), Ohio (Andreas et al. 2004), Wisconsin (Bernthal 2003), and, very recently, Indiana (Rothrock 2004). To paraphrase Swink

& Wilhelm (1994), FQA allows botanists in those states an unbiased, repeatable system for (1) identifying areas of high natural value; (2) making comparisons among different sites, regardless of community type; (3) long-term monitoring of remnant natural areas; and (4) monitoring of *de novo* habitat restorations.

The philosophy and methods of FQA are fully detailed in Swink & Wilhelm (1994) as well as in the various state level FQA's reports. Briefly, however, the system depends upon the coefficient of conservatism (C) assigned to each species found in a state or regional flora. The C values, which range from zero to ten, are an estimate of the fidelity of an individual species to an undisturbed plant community that characterized the region before European settlement. For example, species of the fern genus *Osmunda* have high C

values, while native but ruderal *Chenopodium* species have low C values. The C values may be used to calculate several indices of community quality—mean C (C_{av}) and floristic quality index (FQI). Swink & Wilhelm (1994) suggest that species inventories from sites of natural quality will attain a C_{av} of 3.5 or higher. Those with high natural quality might be expected to have a C_{av} of 4.5 or greater. The second metric, FQI, considers not only species quality but also species richness. Sites with natural quality attain values of 35 or higher, while those with FQI in excess of 45 are noteworthy remnants of a region's natural heritage.

Recently each species in the vascular flora of Indiana was assigned C values (Rothrock 2004). The assignment of C values was done by a team of botanists who have observed the behavior of the over 2000 species native to Indiana. The development of the species database was done independently of the floras of other states. These independent evaluations are necessary because species may have regionally adapted populations and frequently have variations in behavior due to differences in the ecological context in which the species grows. However, the fact that the species databases are independently derived in each state raises questions relating to the new Indiana database. How consistent is the assignment of C values among states? Since the *Plants of the Chicago Region* (Swink & Wilhelm 1994) includes seven Indiana counties, how distinct is that species database from the one for Indiana as a whole? Although interpretative rules for C_{av} and FQI are available in the literature (Swink & Wilhelm 1994), how well do they apply to the Indiana setting? This report is the first of several that will evaluate the nature and performance of FQA in Indiana. The specific objectives are: (1) to examine the distribution of C values in the Indiana database and compare it with those of other states, (2) to compare the Indiana database with that of the Chicago region in particular, and (3) to validate C_{av} and FQI metrics by applying FQA to checklist inventories available for Preserves and other reference sites.

METHODS

Coefficients of conservatism databases were amassed from the Chicago region

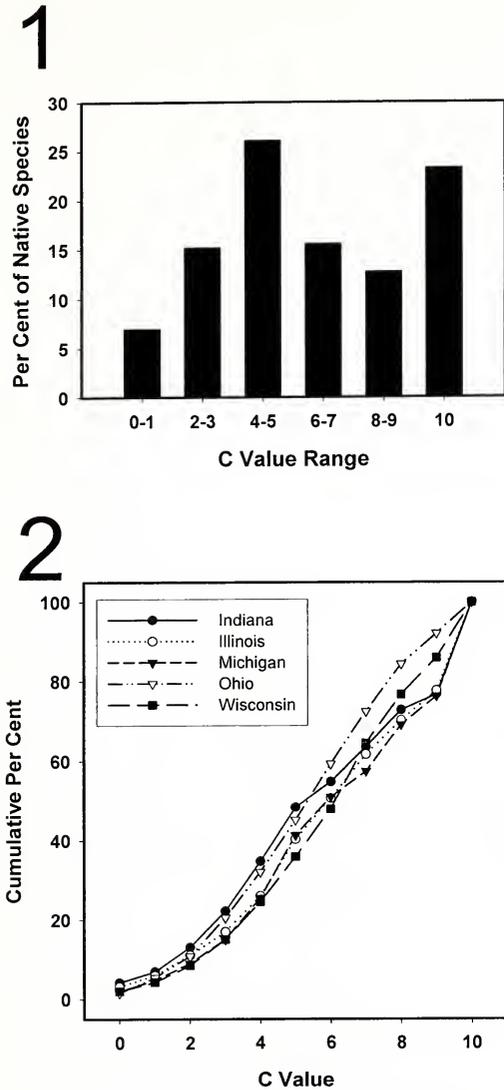
(Swink & Wilhelm 1994), Illinois (Taft et al. 1997), Indiana (Rothrock 2004), Michigan (Herman et al. 1996), Ohio (Andreas et al. 2004), and Wisconsin (Bernthal 2003). These were compared graphically and numerically. Species in the Indiana and state-level databases were enumerated by C value. Goodness-of-fit tests were performed to compare Indiana tallies with those of neighboring states. For each state database, C category tallies were plotted as cumulative percentage of the total flora. Because of the overlapping geographical range of C values for the Chicago region and those of the State of Indiana, more detailed numerical comparisons were made for these two databases. These comparisons include the divergence of assigned C values within each C category as well as the more general divergence regardless of C category.

In order to calibrate the C_{av} and FQI metrics for Indiana, 28 inventory checklists were gathered from the literature and unpublished data. Standard FQA was performed on these checklists using Floristic Quality Assessment Computer Program (Wilhelm & Masters 1999). Standard FQA calculates C_{av} and FQI twice, the first based upon native species alone and the second based upon total species (i.e., native plus adventive). The C_{av} is simply the mean of C values for species in the inventory, while FQI is: $FQI = (C_{av} \sqrt{\text{number of species}})$.

In assessing the inventory checklists it was observed that species totals varied broadly (as few as 32 and as many as 536 total species). A preliminary analysis was conducted to ascertain the potential impact that undersampling might have upon C_{av} . In particular, the stability of C_{av} was assessed by calculating the running means for each inventory and finding by inspection the equilibrium point. Equilibrium was defined as the point where the running mean ceased varying by more than 0.2 units from the final C_{av} .

RESULTS AND DISCUSSION

Comparison of state databases of C values.—The Indiana flora consists of 2017 native taxa and almost 800 adventive taxa (K. Yatskievych unpubl. data). Approximately 24% of native taxa were assigned a C = 10, the highest fidelity category (Fig. 1). These species are thought to be very sensitive to human modification of their habitat. Often they



Figures 1, 2.—Indiana C values. 1. Histogram showing the distribution of Indiana C values (native species only); 2. Comparison of Indiana C values with those of Illinois, Michigan, Ohio, and Wisconsin based upon cumulative percent.

are at the extreme of their geographic range (e.g., *Cornus canadensis*), sometimes they are rare elements in the Indiana flora (e.g., *Adlumia fungosa*), or occur in specialized niches such as found in the extreme habitat of a *Sphagnum* bog (e.g., *Menyanthes trifoliata*) or the complex community structure of a remnant prairie (e.g., *Gentiana puberulenta*). A second large cohort of species was deemed to have C = 4 or 5 (Fig. 1). Species with C =

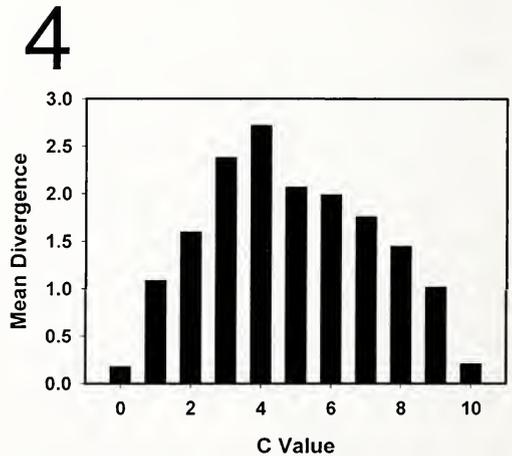
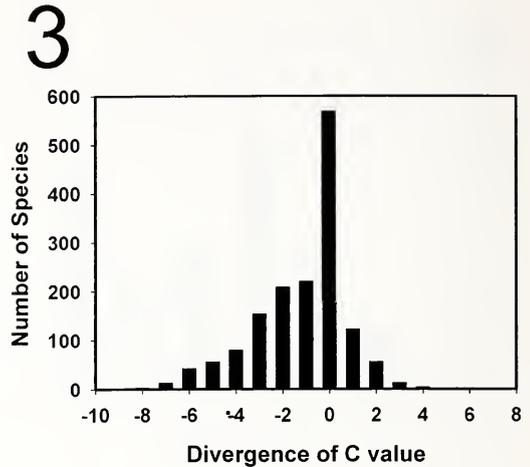
5 are understood as being tolerant of much human disturbance but the community in which they occur retains its identity as being one from pre-settlement Indiana. By contrast, C = 4 suggests that the species will occasionally thrive in an anthropogenic community type. Familiar species in this cohort include *Enemion biternatum* (C = 5) and *Anemone virginiana* (C = 4). Finally, those species assigned to C = 0 or C = 1 are the most tolerant or weedy of native species. These include *r*-selected annuals such as *Ambrosia* spp. Not surprisingly these highly tolerant species represent the smallest cohort in Fig. 1. They most often are found in disturbance sites of low species diversity and may be ecological generalists. In addition, these species are very likely to share habitat with the numerous adventive species.

For those unfamiliar with FQA it should be observed that the nearly 800 adventive species are not formally assigned a C value. The earlier Natural Areas Rating Index (Swink & Wilhelm 1979) did assign negative values to adventive species, a practice applauded by Alix & Scribailo (1998). However, an alternative approach has been adopted that allows one to assess both the natural value of a site and the somewhat separate question of how much impact adventive species are having on the site. Thus, in standard floristic analysis, as shown below (Appendix), FQA metrics are calculated twice: the first utilizes only native species, the second includes adventives species that have been assigned a default value of C = 0.

The overall distribution of Indiana taxa into cohorts of C values is broadly similar to those of neighboring states (Fig. 2). Nonetheless, all are significantly different from that of Indiana (e.g., Indiana-Illinois. $n = 4114$, Chi Square value = 78, $P < 0.0001$). Ohio and Indiana values have a very similar proportion of species assigned C = 4 or less, but strongly diverge in the high range. This suggests that the experience of Ohio botanists led them to score relatively more taxa as C = 7 or 8 rather than 10. Conversely, Illinois and Michigan C values have their widest divergence from Indiana's in C = 3 or 4. Of the states examined, the distribution of C values for Wisconsin had the most overall difference in C values. Compared to Indiana, Wisconsin had relatively few C = 4 or 5 but a higher proportion at C = 8

and 9. Although perhaps there are biological reasons for the differences in the distribution of C values among the various states, most likely these are due to variations in human judgment between the panels of botanists tasked with assigning C values. In practice these variation should have little impact on FQA, at least within a single state. FQA is intended to provide *a priori* means of ranking natural values or a standard for year-to-year monitoring of an individual site and so only demand that each practitioner draw from a standard database of C values and that the derived metrics be calibrated for their flora.

Comparison of Indiana and Chicago region C values.—For seven counties in the extreme northwest portion of Indiana there are actually two sets of C values, those created for the Chicago flora and those for Indiana as a whole (Swink & Wilhelm 1994; Rothrock 2004). Analysis shows that approximately 30% of species in common between Indiana and the Chicago region were categorized into the same C cohort (Fig. 3). At the same time, the two sets of coefficients have obvious differences. More than $\frac{1}{3}$ of Indiana species diverged from Chicago C values by 1–3 cohorts and on average Indiana C values were 1.2 cohorts lower than those of the Chicago region. According to Fig. 4, the lower C values for the Indiana database were the result of differences in ranking across most of the C scale, but the largest differences were among Indiana species assigned C values of 3 and 4 (Fig. 4) where the C values had a mean divergence of 2.4 or more. By far the least difference corresponded to those of C = 0 or C = 10 where mean divergence was less than 0.2. These results indicate that the most sensitive as well as the most tolerant species are easy to recognize and have stable ecological behavior throughout the Chicago and Indiana region. On the other hand, midrange species were, on average, assigned higher C values in the Chicago region. Rothrock (2004) hypothesized two biological reasons for this pattern. First, some of the species involved have a southern distribution from the Gulf of Mexico northward along the Mississippi Embayment into southern Indiana. These species may also have outlier, disjunct populations in dune relict communities in northwestern Indiana. The second hypothesis posits that the ability of some plant species to disperse, invade, and be-



Figures 3, 4.—Comparison of Indiana C values with those of the Chicago region. 3. Divergence of C values on a species by species basis; 4. Mean deviation within C value cohorts.

come established has been altered in areas with intensive agricultural and suburban/urban development as seen in parts of central and northwestern Indiana.

Calibration of mean C and FQI for Indiana.—Given the differences between C values of the Chicago area and those of Indiana as a whole, this section examines available checklists for sites in Indiana and their performance in inventory level FQA analysis. These sites are largely ones expected to have medium or high natural values, but they also encompass several with low natural value. It is anticipated that future papers will more carefully focus upon FQA of restoration and

mitigation sites and provide case studies that use transect as well as inventory data.

Among the checklists analyzed, C_{av} (native species) ranged from a low of 2.7 for a seasonally-flooded basin (Taylor University campus, Grant County) to a high of 6.3 for the Lime Lake Nature Preserve (Appendix). The resulting C_{av} values are coherent given the histories of these sites. The seasonally-flooded basin is strongly dominated by perennial species that can tolerate periodic mowing during the dry periods of summer. In turn, it is surrounded by broad expanses of mowed turf. By contrast, the wetland habitat included in the checklist from Lime Lake Nature Preserve has experienced minimal direct human and little change in hydrology. It retains a mosaic of marl seeps and pools, wet hummocks, and fen and lake-margin vegetation. During the past decade it has been subjected to fire management and control of exotic species.

The sites subjected to FQA (Appendix) included a wide range of community types, sizes, and wetness. The driest sites, as determined by National Wetness Categories for plant species, were the Perry County sandstone glade, Lookout Point and Wea Creek prairies, and Versailles State Park limestone glade. All of these sites had C_{av} (native species) of at least 4.0 with the highest value reaching 4.9. At the opposite end of the wetness spectrum were Fox Lake and Saugany Lake and the seeps at Turkey Run State Park. Their C_{av} (native species) had a somewhat higher range than that of the driest sites, ranging from 4.9 to 5.4. Nonetheless, these results indicate that habitats across the range of wetness can record a high level of ecological integrity based upon these C_{av} values.

The checklists in the Appendix represent a diversity of site sizes and sampling efforts. They had as few as 32 and as many as 536 total plant species. An analysis of running C_{av} values was undertaken in order to better understand the stability of C_{av} among sites with varying species diversity and sampling intensities (Fig. 5). Checklists with 100 or more total species attained stable C_{av} (i.e., 0.2 or less deviation from the final value) when 40–80% of species were tallied. For checklists of less than 100 species, C_{av} was generally unstable until at least 75% of species were included in the running mean (Fig. 5). These results suggest that in making comparisons

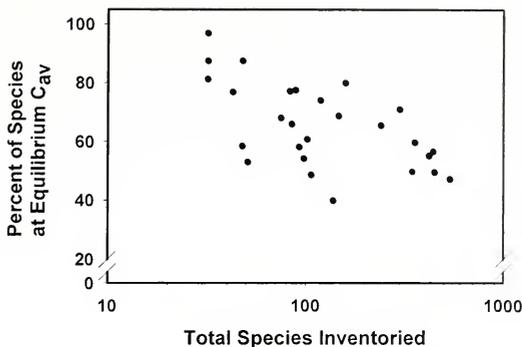


Figure 5.—Scatter plot showing the relationship between total diversity at a site and the percent of species attained when the running mean of C values reached equilibrium (i.e., running $C_{av} = 0.2$ units of final C_{av}).

between sites where the inventory checklists are restricted in size, one might anticipate that variations on the order of 0.2 units merely represent noise in the data and could potentially emanate from overlooking a few species in the site tally.

For this study, checklists were most available for forested natural areas in the Central Till Plain Natural Region. These include Botany Glen, Fall Creek Gorge, Fogwell Forest, Ginn Woods, Mounds State Park, and Wilbur Wright Fish and Wildlife Area (Appendix). With the exception of the special case of Mounds State Park, C_{av} (native species) had a narrow range: 3.8–4.1. Because of the presence of the high quality fen at Mounds State Park, the park overall had a C_{av} for native species of 4.5. On the other hand, when the analysis was more limited to the large floodplain forest and seeps within the park, C_{av} was lowered to 4.0. Thus, the analyses available to date indicate that the best natural woodland sites in the Central Till Plain, whether for historical or for innate biological reasons, have a limited number of species from the highest fidelity categories. Their C_{av} (native species) plateau in the low 4 range.

Some wooded preserves outside of the Central Till Plain Natural Regions may have a meaningfully higher C_{av} (Appendix). The highest measured was Barker Woods from the Lake Michigan Natural Region ($C_{av} = 5.0$) and Bendix Woods from the Grand Prairie Natural Region ($C_{av} = 4.7$). Yellow Birch Ravine Nature Preserve from the Shawnee Hills

Natural Region ($C_{av} = 4.6$) was also of very high quality. Barker Woods has much swampy habitat with acidic soils but also includes some well drained parallel ridges with fine sandy soil. These unusual and diverse habitats harbor species near their southern range limit including a number of state rare, threatened or endangered species. By contrast, the old-growth Bendix Woods is a rich mesic woods with many high quality but not necessarily threatened or endangered species. The high C_{av} value for Yellow Birch Ravine Nature Preserve may be accounted for by the numerous microhabitats associated with bluffs and the wide range of exposures, moisture conditions, and substrate types.

According to experience in other states (Swink & Wilhelm 1994), restoration communities seldom attain C_{av} (native species) of 3.5 or above. The Upland Prairie Restoration marginally agrees with this pattern. By the fifth year, the 25 acre (72 ha) site had reached a $C_{av} = 3.2$ (Appendix) and, by the twelfth season, this value rose to $C_{av} = 3.7$. Since no new species have been observed on the site for at least the two seasons, this site may be at or near its maximum C_{av} . Also, as further discussed below, the other FQA metrics (total species C_{av} and FQI's) provide clear signals that this restoration site has not attained a community structure equivalent to a natural tallgrass prairie.

FQA typically entails first calculating site metrics with only native species and then with all species, native and adventive. The differences in these results can document the impact that exotic species are having upon a site. Several of the reference sites had problematic amounts of exotics and therefore allow us to examine their specific influence on C_{av} results. The Upland Prairie Restoration – 5th year (Appendix) had the largest difference between the two C_{av} values, 1.4 units. Since this site was converted from agricultural use to a tallgrass community, it still retained a legacy of non-native weeds, species such as *Cirsium arvense*, *Dipsacus fullonum*, and *Phalaris arundinacea*. By 12 years after planting the restoration, non-native species continued to lower C_{av} values strongly—by 1.2 units. Among non-restoration sites, Wilbur Wright Fish and Wildlife Area had the highest diversity of adventives, reducing C_{av} by 1.1 units. Some areas in Wilbur Wright Fish and Wild-

life Area (e.g., Unit 3 and 4) were dominated by adventive species and even the most intact area (Unit 2) frequently had an exotics problem. Among high quality natural areas, four sites had a divergence of native versus total C_{av} values of 0.7 units (Appendix). These include Botany Glen, Fall Creek Gorge, Ginn Woods, and Mounds State Park. Typically these sites had their diversity of adventive species concentrated on the margins of the natural areas or in successional communities that were a part of the overall property. Thus this amount of “exotics load,” while of concern, may not be sufficient to detract from the preservation potential of a site.

The second standard metric derived from FQA is that of floristic quality index (FQI). This metric provides a numerical summary based upon the quality as well as the richness of species. As one might expect, it is somewhat dependent upon the size of the natural area under consideration. Inventories that focused upon tiny (i.e., less than 1 ha), high quality glades, barrens, and prairie fragments had FQI's ranging from 27–42. Clearly, in these cases FQI does not always supply meaningful insight into their natural quality. On the other hand, given their limited size, several seep communities studied by Homoya (1984) had surprisingly high FQI's of 50.7 and 53.6. Among the checklists reviewed, five sites—Botany Glen, Fall Creek Gorge, Fogwell Forest, Ginn Woods, and Wilbur Wright FWA—had a C_{av} between 3.5–4.5 but also encompassed the complex of natural and successional communities found on a more commodious land area (i.e., greater than 10 ha in size). In each case their FQI for native species registered between 59–77, confirming their high natural area potential. As a contrasting condition, the Upland Prairie Restoration (in its 12th year), with its C_{av} of 3.7, merely achieved an FQI of 25.1. Unfortunately, at this time, we do not have additional Indiana examples of intensively inventoried sites with moderate C_{av} and FQI values. These would give us a better picture of the causes and extent of compromise of natural quality that would lead to these FQA outcomes.

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APPENDIX

FLORISTIC ASSESSMENT REFERENCE SITES

Each entry includes county level location, literature citation, natural region (based upon Homoya et al. 1985), available parameters (such as aerial extent or lake depth), a brief description of habitat and/or community type, and a listing of the basic FQA results for native species alone and for total species (i.e., native + adventives). C_{av} = mean coefficient of conservatism; FQI = floristic quality index.

1. Barker Woods Nature Preserve, LaPorte County (Riemenschneider & Reed 1985). Lake Michigan Natural Region. 12 ha. Poorly drained, medium to strongly acidic soils; abundant tree species include *Acer rubrum* and *Quercus palustris*. Parallel ridges of fine sandy soil; abundant tree species include *Q. rubra* and *Sassafras albidum*. Native species = 146, C_{av} = 5.0, FQI = 60.7; Total species = 159, C_{av} = 4.6, FQI = 58.4.

2. Bendix Woods Nature Preserve, St. Joseph County (Blodgett & Riemenschneider 1983). Grand Prairie Natural Region (Kankakee Sand Section). 11 ha. Old growth mixed hardwood forest. Native species = 112, C_{av} = 4.7, FQI = 49.3; Total species = 118, C_{av} = 4.4, FQI = 48.1.

3. Big Oaks National Wildlife Area (Basey & Badger 2004). Bluegrass Natural Region (Flats and Canyon Section). Dry, fire-managed grasslands dominated by *Andropogon virginicus* and *Solidago juncea*. Poorly drained soils with acidic upper horizon (pH as low as 4.0). Results are a composite from three sample areas: 5, 16, and 26. Native species = 39, C_{av} = 2.9, FQI = 18.1; Total species = 51, C_{av} = 2.2, FQI = 15.8.

4. Botany Glen, Grant County (Stonehouse et al. 2003). Central Till Plain Natural Region (Bluffton Till Plain Section). 18 ha. Mature upland woods, ravine woods, floodplain and seep, and old field. Native species = 295, C_{av} = 4.0, FQI = 68.5; Total species = 357, C_{av} = 3.3, FQI = 62.3.

5. Fall Creek Gorge Nature Preserve, Warren County (Tonkovich & Sargent 1993). Central Till Plain Natural Region (Entrenched Valley Section). 60 ha. Old growth mesic woods (*Acer saccharum*, mixed *Quercus* spp., *Fagus grandifolia*, and *Carya* spp.), wet woods, cliff and ravine communities, and large old field. Native species = 288, C_{av} = 3.8,

FQI = 64.1; Total species = 346, C_{av} = 3.1, FQI = 58.5.

6. Flint Barrens, Harrison County. Unpublished checklist. Highland Rim Natural Region (Mitchell Karst Plain Section). 24 ha. Chert barrens community in rolling sinkhole topography; dominated by *Schizachyrium scoparium* and *Sorghastrum nutans* with oak copses of mostly *Quercus stellata*. Native species = 276, C_{av} = 4.0, FQI = 67.2; Total species = 289, C_{av} = 3.9, FQI = 65.6.

7. Fogwell Forest Nature Preserve, Allen County (Rothrock 1997). Central Till Plain Natural Region (Bluffton Till Plain Section). 11 ha. Mature flatwoods dominated by *Acer saccharum*, *Fagus grandifolia*, *Quercus rubra*, and, near vernal pools, by *Quercus bicolor*; rich spring ephemeral flora; surrounded by housing subdivision, agricultural activity, and old fields. Native species = 210, C_{av} = 4.1, FQI = 59.3; Total species = 240, C_{av} = 3.6, FQI = 55.4.

8. Fox Lake, Steuben County. Unpublished checklist. Northern Lakes Region. Sample from 100 m. littoral zone along county road 200W. Includes an extensive bed of *Eleocharis* spp. Native species = 29, C_{av} = 5.4, FQI = 29.2; Total species = 30, C_{av} = 5.2, FQI = 28.7.

9. Ginn Woods, Delaware County (Ruch et al. 1998; Ruch et al. 2004). Central Till Plain Natural Region (Bluffton Till Plain Section). 61 ha. Old growth *Acer saccharum*-*Fagus grandifolia* forest with vernal pools and tree gap meadows; also includes a marshy area and woods-old field ecotone. Native species = 364, C_{av} = 3.9, FQI = 74.1; Total species = 441, C_{av} = 3.2, FQI = 67.3.

10. Hemlock Bluff Nature Preserve, Jackson County (Gray & Bacone 1979). Highland Rim Natural Region (Brown County Hills Section). 16 ha. Dry-mesic upland forest, bluff and ravine forest, floodplain forest; contains relictual *Tsuga canadensis*. Native species = 259, C_{av} = 4.0, FQI = 64.9; Total species = 299, C_{av} = 3.5, FQI = 60.4.

11. Lime Lake Nature Preserve, Steuben County. Unpublished checklist of fen, marl flats, and lake shore from the portion of the preserve lying south of I-80/90. Northern Lakes Natural Region. 20 ha. Wetland mosaic dominated by graminoids such as *Carex stricta*, *C. sterilis*, *Eleocharis rostellata*, and

Schoenoplectus acutus and *S. pungens* with a diverse mix of calciphilic forbs. Native species = 71, C_{av} = 6.3, FQI = 53.4; Total species = 75, C_{av} = 6.0, FQI = 52.0.

12. Lookout Point Gravel Hill Prairie, Tippecanoe County (Post et al. 1985). Central Till Plain Natural Region (Entrenched Valley Section). Less than 1 ha. Mid-grass prairie; the common species include the grasses *Bouteloua curtipendula*, *Schizachyrium scoparium*, and *Hesperostipa spartea* and forbs such as *Amorpha canescens*, *Symphytotrichum oblongifolium*, *Dalea purpureum*, *Erysimum capitatum*, and *Brickellia eupatorioides*. Native species = 74, C_{av} = 4.9, FQI = 41.7; Total species = 84, C_{av} = 4.3, FQI = 39.2.

13a. Mounds State Park, Madison County, Indiana (Rothrock et al. 1993). Central Till Plain Natural Region (Tipton Till Plain Section). 105 ha. Floodplain forest with seeps; wooded slopes and some bluffs; fen; upland woods; cultural areas with some old fields. Native species = 380, C_{av} = 4.5, FQI = 87.3; Total species = 448, C_{av} = 3.8, FQI = 80.4.

13b. Mounds State Park - fen. 2 ha. Actively managed by Division of Nature Preserves; low per cent cover of *Rhamnus frangula*. Native species = 96, C_{av} = 5.9, FQI = 58.0; Total species = 97, C_{av} = 5.9, FQI = 57.7.

13c. Mounds State Park - floodplain forest and seeps. Contains some residual *Machraa pomifera*, early stage infestation by *Alliaria petiolata*, and a major park trail and boat ramp. Native species = 130, C_{av} = 4.0, FQI = 45.2; Total species = 146, C_{av} = 3.5, FQI = 42.6.

14. Perry County Limestone Glade (Bacone et al. 1983). Shawnee Hills Natural Region (Crawford Upland Section). Less than 1 ha. Dominant herbaceous vegetation of *Sorghastrum nutans*, *Andropogon gerardii*, and *Schizachyrium scoparium*; diversity of forbs such as *Eryngium yuccifolium*, *Helianthus mollis*, *Gentiana quinquefolia*, and *Liatris aspera*. Native species = 47, C_{av} = 5.2, FQI = 35.7; Total species = 47, C_{av} = 5.2, FQI = 35.7.

15. Perry County Sandstone Glade (Bacone et al. 1983). Shawnee Hills Natural Region (Crawford Upland Section). Less than 1 ha. - long narrow strip at the top of a high cliff; trees include stunted *Juniperus virginiana*, *Quercus stellata* and *Q. marilandica*; shrubs include three *Vaccinium* spp. and *Kalmia latifolia*. Native species = 32, C_{av} = 4.8, FQI = 27.2; Total species = 32, C_{av} = 4.8, FQI = 27.2.

16. Plaster Creek Seep Springs, Martin County (Homoya 1984). Shawnee Hills Natural Region (Crawford Upland Section). Less than 1 ha.; pH 5.6–5.9. The dominant ferns *Osmunda cinnamomea* and *O. regalis* form hummocks; woody shrubs include *Hex verticillata*, *Photinia melanocarpa*, *Lindera benzoin*, and *Viburnum dentatum*; scattered

Sphagnum. Native species = 107, C_{av} = 5.2, FQI = 53.6; Total species = 107, C_{av} = 5.2, FQI = 53.6.

17. Saugany Lake, LaPorte County (Alix & Scribailo 1998). Northwestern Morainal Natural Region (Valpariso Moraine Section). 30 ha.; maximum depth 19.9 m. Spring-fed and almost completely surrounded by homes but rated as Class One (least eutrophic) by Indiana Department of Environmental Management; limited emergent zone. Native species = 43, C_{av} = 4.9, FQI = 31.9; Total species = 47, C_{av} = 4.4, FQI = 30.5.

18. Seasonally flooded basin and adjacent pond margin, Taylor University campus, Grant County. Central Till Plain Natural Region (Bluffton Till Plain Section). Unpublished checklist of east end of Taylor Lake and an adjacent marsh. 2 ha. Over the past three decades the marsh often has portions mowed during dry summer periods. Dominant species include *Typha* spp., *Hordeum jubatum*, *Juncus articulatus*, and *Agrostis gigantea*. Native species = 27, C_{av} = 2.7, FQI = 14.2; Total species = 36, C_{av} = 2.1, FQI = 12.3.

19a. Turkey Run State Park - seep area 1, Parke County (Ebinger & Bacone 1981). Central Till Plain Natural Region (Entrenched Valley Section). Less than 1 ha. Cool, slight alkaline seep dominated by *Carex sterilis*, *Selaginella apoda*, *Bidens aristosa*, and *C. leptalea*. Native species = 30, C_{av} = 5.4, FQI = 29.8; Total species = 32, C_{av} = 5.1, FQI = 28.8.

19b. Turkey Run State Park - seep area 2. Less than 1 ha. Three zones: zone 1 dominated by *Carex sterilis*, *Eleocharis erythropoda*; zone 2 by *Impatiens capensis* and *Rorippa nasturtium-aquaticum*; zone 3 by *Acorus calamus*. Native species = 40, C_{av} = 5.1, FQI = 32.1; Total species = 43, C_{av} = 4.7, FQI = 31.0.

20. Twin Swamp Nature Preserve, Posey County (Mark & Gordon 2004). Southern Bottomlands Natural Region. 242 ha. A preliminary checklist of herbaceous species as reflected in the lack of cyperaceous species and the report of only three grass species. Native species = 125, C_{av} = 3.6, FQI = 40.2; Total species = 138, C_{av} = 3.3, FQI = 38.2.

21a. Upland Prairie Restoration - 1997 (5th year), Grant County. Central Till Plain Natural Region (Bluffton Till Plain Section). 10 ha. Unpublished checklist. Planted in 1993; burned annually, spot herbicide treatment of several aggressive exotic species. Dominant native species include *Andropogon gerardii*, *Ratibida pinnata*, *Monarda fistulosa*, *Desmodium canadense*, and *Silphium* spp. Native species = 36, C_{av} = 3.2, FQI = 19.3; Total species = 65, C_{av} = 1.8, FQI = 14.4.

22b. Upland Prairie Restoration - 2004 (12th year): Native species = 46, C_{av} = 3.7, FQI = 25.1; Total species = 67, C_{av} = 2.5, FQI = 20.8.

23. Versailles State Park Limestone Glade, Ripley County (Homoya 1987). Bluegrass Natural Re-

gion (Switzerland Hills Section). Less than 1 ha. Xeric, rocky slope with stunted trees (primarily *Quercus muhlenbergii*); dominant herbs include *Andropogon gerardii*, *Silphium trifoliatum*, *Physostegia virginiana*, *Lithospermum canescens*, and *Brickellia eupatorioides*. Native species = 80, C_{av} = 4.4, FQI = 39.0; Total species = 83, C_{av} = 4.2, FQI = 38.3.

24. Wabash Breaks Gravel Hill Prairie, Tippecanoe County (Post et al. 1985). Central Till Plain Natural Region (Entrenched Valley Section). Less than 1 ha. See community description under Lookout Point above (No. 12). Native species = 92, C_{av} = 4.3, FQI = 41.0; Total species = 102, C_{av} = 3.9, FQI = 38.9.

25. Wea Creek Gravel Hill Prairie, Tippecanoe County (Post et al. 1985). Central Till Plain Natural Region (Entrenched Valley Section). Less than 1 ha. See community description under Lookout Point above (No. 12). Native species = 76, C_{av} = 4.0, FQI = 35.1; Total species = 89, C_{av} = 3.4, FQI = 32.4.

26. Wening-Sherrit Seep Springs, Dubois County (Homoya 1984). Southwestern Lowlands Natural Region. Less than 1 ha.; pH 5.8-5.9. Mid-canopy of *Toxicodendron vernix* and *Alnus serrulata*; the dominant ferns *Osmunda cinnamomea* and *O. regalis* form hummocks; scattered *Sphagnum*. Native species = 90, C_{av} = 5.3, FQI = 50.7; Total species = 93, C_{av} = 5.2, FQI = 49.9.

27. Wilbur Wright Fish and Wildlife Area (Ruch et al. 2002). Central Till Plain Natural Region (Tipton Till Plain Section). 416 ha. A heterogeneous mix of upland woods, wooded slopes and ravines, seeps and swales, floodplain forest, sedge meadow and marsh, old fields, and wildlife plantings; strong anthropogenic modification and numerous exotic species. This analysis deletes species that were apparently planted but were not spreading. Native species = 388, C_{av} = 3.9, FQI = 77.3; Total species = 536, C_{av} = 2.8, FQI = 65.8.

28. Yellow Birch Ravine Nature Preserve, Crawford County (Yatskievych & Yatskievych 1987). Shawnee Hills Natural Region (Crawford Upland Section). 176 ha. Sandstone bluff and ravines with bottomland dominated by beech-maple forest and drier ridgetops by oaks and hickories; numerous microhabitats; also old fields. Has a history of lumbering and other human disturbance. Native species = 385, C_{av} = 4.6, FQI = 90.4; Total species = 420, C_{av} = 4.2, FQI = 86.5.

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