Floristic Quality Assessment in the Chicago Region and Application Computer Programs

Gerould S. Wilhelm
and
Linda A. Masters

The Morton Arboretum
Lisle, Illinois 60532

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Floristic Quality Assessment

Introduction

With the passage of the National Environmental Policy Act of 1969, we began to receive requests for evaluations and assessments concerning the natural quality or environmental integrity of a variety of open land areas, particularly regarding the likelihood that proposed impacts on such areas would be "irreversible or irretrievable." Qualitative judgments were called for in a context where "quality" as an environmental concept had only been discussed or contemplated at the most superficial levels. These early evaluations were ungratifying. How does one objectively declare an area as "high," "medium," or "low" in quality and then attempt to explain, in definitive terms, why such a declaration is neither arbitrary nor whimsical? Definitions that clarify meanings for these terms have been difficult to standardize. Changes in assessment personnel also have contributed to inconsistencies in evaluations. One person's "low" may well be another's "medium," depending on differing philosophical alignment or technical experience, both factors influencing evaluations that already can be viewed as subjective. These vague assessments soon sound trite, losing both impact and credibility. The repeatability of the application of such assessments is also problematic.

A standardized tool for use in natural area assessment was discussed in *Plants of the Chicago Region* (Swink & Wilhelm 1979) and expanded upon in the Fourth Edition (Swink & Wilhelm 1994).[1] Inherent in all methods used to evaluate natural quality is a certain amount of subjectivity. This method places the subjectivity up front, in the *a priori* assignment of conservatism coefficients to each of our native plant species. The goal was to design a system, based upon plants, that assesses natural quality repeatably and dispassionately, facilitates comparisons among sets of sites, and tracks changes in site quality over time. This method assesses the aggregate conservatism of the plants inhabiting a site, irrespective of the plant community. It avoids the use of frequency, dominance, physiognomy, or productivity of an individual plant species, primarily because positive or negative values with respect to plant community quality are either irrelevant or only ambiguously related to these factors. This method permits anyone with a reasonable knowledge of field botany to arrive at an evaluation product that reflects a consistent philosophy of assessment and is derived wholly from the existing plant species. In practice, this method has encouraged local uniformity in floristic quality assessment, enabling planners, land managers, applied ecologists, and other practitioners to make standard comparisons among various open land areas, to set conservation priorities, and to monitor site management or restoration efforts.

The Assessment Premise

A commonly accepted ecological tenet is that plants and animals grow in habitats to which they are adapted. A corollary is that if the habitat is changed, so also will the inhabitants change. Plant species, through millennia, have become adapted to the specific combinations of biotic and abiotic factors, processes, and floral and faunal interactions uniquely characterizing the site they inhabit. An area with a long history of biome-level stability, such as characterized most of the

[1] Swink & Wilhelm (1979) and Wilhelm & Ladd (1988) referred to this assessment system as the Natural Area Rating Index. It is now being referred to as the Floristic Quality Assessment (Swink & Wilhelm 1994) because natural areas can also be evaluated based upon natural features and biota other than vegetation.

presettlement landscape in the Midwest, will almost always support a diverse assemblage of conservative species in self-replicating, interactive arrays. This diversity and complexity facilitate system adaptability to the gradual but inexorable changes that occur in all landscapes on a scale of thousands of years. Environmental factors may change over time, but they usually are gradual and sufficiently buffered by system complexity to allow the system to adapt at a rate commensurate with the life cycles and the genetic dynamics of the populations of its component biota. The result is that each variance of topography, physiography, geographic position, and substrate is characterized by an essentially unique response and inhabitancy by plants and animals.

Impacts to native biological systems and processes associated with European settlement have occurred with a magnitude and rapidity without precedent in the history of the continent's biota. When changes to a habitat occur rapidly, it has been observed that the reduction of conservative species is proportional to the severity of these changes. Attrition of conservative plants occurs as plants suited to the changed habitats (less-conservative plants and non-native plants [weeds]), become increasingly ensconced. There is a striking difference between areas inhabited by a full component of conservative plants and animals and one inhabited prevailingly by weeds. Conservative systems contain a biodiversity involving species suited to long-term inhabitancy of an area. Weed communities, by comparison, are adapted either to regular, essentially catastrophic disturbance, or to the kinds of activities associated with cultural landscapes. These weed communities contain neither the biodiversity nor the aggregate adaptive ability to coalesce into self-sustaining, self-replicating systems. In our contemporary, fragmented landscapes, the conservative elements of our native systems, supplanted in place, have neither refugia, effective migration routes, nor the time to adapt or relocate. Rather, their populations are decimated time and time again until their local extirpation or ultimate extinction occurs. The destiny of many systems dominated by weeds is further destabilization, during which resources such as soil, nutrients, and water are often lost at rates faster than they are replaced.

Since the beginning of the Holocene, and perhaps for much of the Quaternary, an important component involved in the shaping of the landscape has been man. Human beings are not only governed by *stochastic* or random interactions within the ecosystem, but by *choice*. Fundamental interactions such as predation, competition, and foraging are now complicated by the fact that humans can *decide* to kick over one anthill, two anthills, all the anthills, or none of them--with no ecological parameter coming to bear on this decision other than a human ethic. Conservative species surviving today are present largely because their interaction with the human being has been one in which the human inhabitants chose not to kick over too many anthills. In the current cultural context, and with the contemporary technology of the late twentieth century, human beings have the power to choose life or death for most of our region's ecosystems. Gradual evolutionary processes can only continue to affect our remnant natural systems if these systems are managed under our stewardship to retain their biological richness.

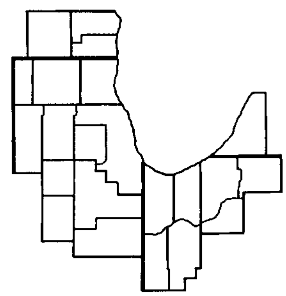
Today, the Chicago region flora consists of two significant categories of plants--those native to the region and those naturalized from provinces outside the region. Of the 2,530 kinds of vascular plants known from the Chicago region, more than one-third were not here prior to European settlement. Of the nearly 900 introduced weeds known to have appeared spontaneously in the Chicago region, scarcely 150 are generally successful, yet they dominate more than 95 percent of the vegetated landscape. These weeds are highly adapted to the kinds of disturbances and landscape alterations that have characterized sedentary agricultural societies since primitive times. Clearly, a tract of land occupied prevailingly by weeds or non-conservative native species cannot be viewed as a natural area and is quite replaceable. Our interest in natural area identification and floristic quality assessment focuses on the extent and proportion to which constellations of conservative species are present.

METHODOLOGY

A vast proportion of our landscape is severely degraded and fragmented, and the remaining land has varying degrees of floristic quality or integrity. Since the degree to which conservative plants are present on a tract of land is an important factor in our definition of natural area,[2] an assessment method must be able both to index the presence of conservative plants and to discriminate amongst tracts of land with differing levels of floristic integrity.

Coefficient of Conservatism (C)

This assessment method is based upon a fundamental character of the Chicago region[3] flora itself. It has long been recognized that plants display varying degrees of tolerance to disturbance, as well as varying degrees of fidelity to specific habitat integrity. This concept of species "conservatism" is the basis for the assessment method. The floristic quality of an area is reflected in its inhabitancy by conservative plant species. The basic tool of this method is an evaluation checklist of the plants of the Chicago region. Each native species on the checklist has been given a **coefficient of conservatism** (*C*), ranging from 0-10.



Chicago Region

In general, the concept can be demonstrated by the following illustrations. Someone brings to us a specimen of *Lepidium virginicum,* and asks, on a scale of 0-10, how confident we are that the specimen was taken from a remnant natural plant community. We would have to say that we have no confidence, but that in all likelihood it was taken from a highway verge or the edge of a parking lot. Someone else brings in *Aster borealis,* and we are virtually 100% confident that it was taken from a remnant fen, and probably one that was not terribly degraded. Another brings in *Galium triflorum;* we are fairly certain that it came from some sort of remnant wooded area, but we can say little one way or the other about how degraded it is.

In the first case we can assign *Lepidium virginicum* a *C* of 0, since we had no confidence that it came from a natural community. *Aster borealis,* on the other hand, can be assigned a *C* of 10 since we have virtually 100% confidence that it came from an intact natural community. *Galium triflorum* can be given a 5 *C* value since we are certain that it came from a remnant natural community, but have little confidence that the area was not degraded. This conceptual spectrum can be expressed in a range of scaled values described as coefficients of conservatism.

[2] The term "natural area" has been used in many ways. In some cases it even has legal implications. Our definition of natural area is land on which existing plant communities approximate the condition just prior to settlement in the early 1800's. We cannot know the presettlement vegetational composition or structure for any given site, nor can we know how it would have changed over time. All we do know is that once an extant community of conservative plants is obliterated, in today's ecological context its biotic integrity is gone forever. Implicit in this botanical approach is the ecological health of the system as a whole (Wilhelm & Ladd 1988). We are seeking to define natural area such that its floristic integrity, and all that that implies, would be irrecoverably compromised in the event of trauma or neglect.

[3] The Chicago Region consists of Kenosha, Racine, and Walworth counties in Wisconsin; Boone, Cook, DeKalb, DuPage, Grundy, Kane, Kankakee, Kendall, Lake, McHenry, and Will counties in Illinois; Jasper, Lake, LaPorte, Newton, Porter, St. Joseph, and Starke counties in Indiana; and Berrien County, Michigan.

Introduced plants, by their very nature, were uninvolved in the native landscape prior to European settlement, so coefficients of conservatism are not applied to them.

As one might imagine, the conceptual differences between a plant with a 0 value and a 1 value are slightly discernible, as are those differences between a 1 and a 2, a 2 and a 3, or a 9 and a 10. However, the conceptual differences between a 0 value and a 3 value are more distinct. Concern over whether or not a particular plant receives a 0 or a 2, rather than a 1 value, is compensated by averaging the values in their application, as will be explained below.

Because the ecological contexts of native and introduced plants are so inherently disparate in character, introduced plants are necessarily and explicitly excluded from the floristic assessment. It is difficult to gauge the significance of the occurrence of introduced species. Some weeds, such as *Agrostis alba* or *Poa pratensis*, are virtually ubiquitous in the region, so they are almost inevitably detected somewhere in a site, if only along or near a trail. Such an occurrence does not signify significant degradation in an area. It is the presence and proportion of conservative native species which underlies the definition of natural area, not the presence or absence of weeds *per se*. Certainly, if weeds are occupying the area to a deleterious extent, or their presence is a reflection of habitat alteration, their occurrence will be measured indirectly by a diminishment in conservative species. Again, it is the extent to which a tract of land supports conservative native plants that is being indexed.

A set of coefficients can be formulated for any given geographic area, no matter how large or small.[4] One must keep in mind, though, that the coefficients must be assigned by considering the relative fidelity or conservatism of each species with respect to all other species in a defined geographic area, and without regard to the abundance, distribution, and ecology of the plant outside this area. This process of determining coefficients of conservatism for a flora is the single most critical step in the development of a floristic quality assessment system. A thorough knowledge of each species' ecological role in the local vegetation is required, and *C* values must reflect only this, without regard for factors such as showiness, desirability, size, physiognomy, ease of identification, and other factors that are wholly unrelated to vegetational conservatism.

It is important to emphasize that the numerical values assigned to the native species of the Chicago Region were derived from the observed behavior of populations in this defined area. Clearly, as one travels away from the region, locally applied values may become decreasingly valid and are not recommended for use outside the Chicago region. The more remote one is from that region, the more likely it will be that the conservatism values will **not** reflect local conditions. Use of Chicago region values in remote areas can render spurious evaluations. It is highly recommended that a database be tailored to the state or region in which the system will be used.

The Mean C Value ($\overline{C}$)

Eighty-nine percent of our native plants have been given a value of 4 or higher. These conservative plants accommodate a wide array of specialized plant community contexts. Eleven percent of the native flora have a *C* value of 3 or less; these comprise the least conservative taxa, and are shared by many plant communities. Theoretically, an area high in natural quality would

[4] Coefficients of conservatism for vascular plants have been developed for several geographic areas, such as Kane County, Illinois (Wilhelm 1978), northern Ohio (Andreas 1993), and the states of Missouri (Ladd in prep.) and Michigan (Herman *et al.* in prep.).

have an array of plants adapted to a diversity of micro-habitats and internal system interactions and responses. Such an area would include plants with C values ranging from 0 to 10, comprising a matrix with a mean C ($\overline{C}$) of 5 or greater.

When an area is degraded to the point that the habitat context is changed, most of the first plants lost will be from the high end of the conservatism spectrum. The $\overline{C}$ diminishes as conservative plants of the matrix are lost and are replaced either by non-conservative species, or by weeds (or by no plants). If an area that once registered a $\overline{C}$ value of 5 now has a $\overline{C}$ of 4.5, it can be demonstrated that degradation has occurred. Such a measurement can be meaningful in an area as small as a quarter of a square meter or as large as 100 acres or more.

Figure 1 is a model that illustrates a declining $\overline{C}$ as degradation occurs. Each of the three matrices represents a plant community with an array of native species, the integers represent C values and asterisks represent introduced elements. As degradation occurs, the habitat is changed to the point that it no longer is suitable for some of the species very conservative to that site. These conservative elements disappear in accordance with the extent of habitat change. The holes in the matrix left in their absence may be filled by weeds, non-conservative natives, or by nothing. The $\overline{C}$ diminishes accordingly.

Figure 1. Model showing conditions of three remnant landscapes. Integral values of matrices equal C values; asterisks represent weeds.

Intact $\overline{C} = 5$

0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10	10	10

Slightly Degraded $\overline{C} = 3.5$

*	*	*	*	*					
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
2	2		2	2	2	2	2	2	2
3	3	3	3	3	3	3		3	3
4	4	4	4	4	4	4	4	4	
5	5	5		5	5	5		5	5
6	6	6	6	6		6		6	6
	7	7		7	7	7	7	7	7
	8	8	8	8	8	8	8		8
		9	9	9		9	9	9	
10		10			10				10

Severely Degraded $\overline{C} = 1.3$

*	*	*	*	*	*	*	*	*	*
*	*	*							
0	0	0	0	0	0	0	0		0
1	1	1		1	1	1	1	1	1
2		2	2	2	2	2		2	2
3		3		3	3	3		3	3
4		4	4		4	4			4
5							5	5	5
	6		6		6			6	6
7			7		7				
		8							

The Floristic Quality Index Value (FQI)

Arithmetically, there are cases where both large and small areas can be shown to have equivalent $\overline{C}$ values. If one is developing priorities for conservation, or attempting to evaluate the level of intrinsic biodiversity, there must be a method of discriminating among areas that have similar $\overline{C}$ values, but otherwise differ significantly. Generally, all other factors being equivalent, a larger area will support more species, but land area is not by itself the determining element. For example, a 1-acre prairie remnant, containing 75 native species with a $\overline{C}$ of 5, may be surrounded by 500 acres or more of agricultural land, shopping malls, and golf courses, none of which adds to increased conservative species diversity. On the other hand, an area containing a similar prairie remnant, but also including a 10-acre fen, a 40-acre remnant woodland, and a 10-acre sedge meadow, containing a total of 300 or more native species, may also have a $\overline{C}$ of 5, even though this land area is much smaller. If $\overline{C}$ for all plant species present is multiplied by the square root of the number of native species (n), then a floristic quality index (*FQI*) is obtained:

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

In the first instance, the isolated prairie remnant [$\overline{C}$ = 5, n = 75] would have an *FQI* of 43, while the second complex, which includes a similar prairie, [$\overline{C}$ = 5, n = 300] would have an index of 87. Clearly, the place with less actual land mass but with more of it occupied by remnant natural land registers a higher index.

By comparison, the isolated prairie seems to rate low in quality, but when compared to another scenario--a 1-acre pasture, degraded by overgrazing and the planting of forage crops, also containing 75 native species (growing among the weeds), will have a $\overline{C}$ closer to 2, resulting in an *FQI* of 16. If the size of the pasture is increased to 100 acres and an additional 75 native species are added, the $\overline{C}$ would remain near 2, and the *FQI* would rise only to 24. The index is not likely to rise significantly with increases in area unless the area includes remnant lands with resident conservative species and the biodiversity that such conservatism implies.

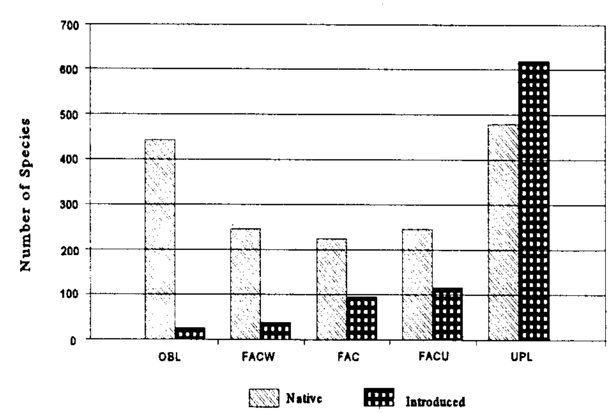
National Wetland Categories

The National Wetland Categories used in this database were designated by Reed (1988) for the United States Fish and Wildlife Service, Region 3. This region includes most of the north central part of the United States. Plants are designated as *Obligate Wetland, Facultative Wetland, Facultative, Facultative Upland,* and [obligate] *Upland*. These categories are defined as follows:

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

The distribution of these categories for the native and introduced plants in our flora is shown in Figure 2. Note that for native species there is a symmetrical distribution across the hydric catena, while a high proportion of introduced species is adapted to upland soils.

Figure 2. National Wetland Categories



For about 20% of our flora, "+" or "-" signs have been attached to the three *Facultative* categories to express exaggerated tendencies for those species. The "+" sign denotes that the species generally has a greater estimated probability of occurring in wetlands than species having the general indicator category, but a lesser estimated probability of occurring in wetlands than those having the next highest general indicator. The "-" sign denotes that the species generally has a lesser estimated probability of occurring in wetlands than species having the general indicator status, but a greater estimated probability of occurring in wetlands than those having the next lowest general indicator.

The wetland categories were assigned to plants based upon observations on their behavior throughout this region. *Panicum spretum,* for example, is designated UPL by Reed (1988) for Region 3, but the few locations at which it grows in the Chicago region are moist to wet sandy flats or even shallow sandy ponds; locally, then, it must be acknowledged that 100% of the time it occurs in wetlands (*i.e.*, OBL). In cases like this, the category has been modified to one which best describes the plant in the Chicago region area. In cases like this the category has been enclosed in brackets [ ] to indicate that it differs from the Region 3 designation.

APPLICATION

The emphasis in this assessment procedure is not on individual species. In the application of this method, there are conceptually only eleven categories of native plants in our flora, each plant having been assigned a C value from 0 to 10. As an area is inventoried, a mathematical picture of the conservatism of plants present begins to emerge. During a thorough, representative accounting of the plants in a given area, the $\overline{C}$ tends to stabilize even as new plants are recorded and included with the total. The density, apparent dominance, or frequency of individual plant species are not relevant factors when considering the qualitative value of a site. Abundance and frequency are often artifacts of the season or year, and may fluctuate greatly. Some species which are "dominant" (big or obvious) in spring can be scarcely evident in fall, replaced by species which were scarcely evident earlier in the year. Regardless of size, comeliness, or ease of identification, every species at a site provides information relative to the quality of that site. The collective data from all species inhabiting a site provide a concise, real measure of the extent to which the site represents a unique and irreplaceable element of our landscape. One can have much more confidence that an area is of natural quality if informed that there are 50 different plant species with a $\overline{C}$ of 5, than if informed that there are 50 individuals of a particular plant with a C of 5. Similarly, the presence of 50 species with a $\overline{C}$ of 5 provides more insights into the potential quality of an area than being informed that a supposed "keystone" or "dominant" species has a cover value of 50%.

There are four commonly used applications for the floristic quality assessment system:[5] (1) identification of natural areas, (2) facilitation of comparisons among different sites, regardless of community type, (3) long-term monitoring of remnant natural area quality, and (4) monitoring of *de novo* habitat restoration. These are discussed in the following sections. In each of these applications the methodology may be used as an overall inventory where all of the known plants of a site are analyzed to determine general floristic quality, providing information regarding the natural quality potential. It can also be used in certain sampling protocols; plants present in individual quadrats established along a transect may be analyzed to determine variances in floristic quality across a site. This may be used to establish baseline data with an eye toward monitoring changes in floristic quality in site restoration or rehabilitation efforts.

Identification of Natural Areas

In order to determine the extent to which a site preserves natural plant community quality, an inventory of relevant portions of the area is required. The surveyor compiles as complete a plant inventory as possible, then calculates $\overline{C}$ and *FQI* values. Generally, if the $\overline{C}$ for the site is 3.5 or higher or has an *FQI* of 35 or more, one can be fairly confident that the site has

[5] It has been used increasingly to evaluate and monitor the quality and potential of remnant and restored lands (Andreas 1993, Herman 1993, Heumann *et al.* 1993, Ladd & Heumann 1993, and Young 1986).

sufficient floristic quality to be at least of marginal natural area quality. If the $\overline{C}$ is 4.5 or higher, or has an *FQI* of 45 or more, then it is almost certain that the remnant has natural area potential.

We have not arrived at these threshold values arbitrarily. The best efforts of *de novo* ecosystem restoration attempts rarely achieve $\overline{C}$ values higher than 3.5 or *FQI* values higher than 35. It then follows that when an area with higher values or indices is destroyed it cannot be replaced by an area of equal value and, therefore, is basically an unmitigable event. The difficulties in restoring areas of high quality lie in our inability to assemble the complex diversity of biotic and abiotic factors needed in order to support a full component of species conservative to that habitat.

An approximation of the $\overline{C}$ can be obtained with a fairly cursory inventory, and the question of whether or not the site has natural area potential can be answered quickly. For example, brief but representative inventories are conducted for hypothetical areas X, Y, and Z; the data are presented in Table 1. With a $\overline{C}$ as low as 1.7 for Area X, it can be concluded that it is highly unlikely that it is a natural area. For such an area to achieve an *FQI* of 35, more than 420 native species would have to be discovered--an impossibility given the distribution of *C* values in the universe of native species if it is assumed that the $\overline{C}$ has stabilized.

The $\overline{C}$ = 3.7 of Area Y suggests that the site has remnant natural quality, and probably deserves a more intensive survey to determine the extent to which conservative species are present in the area. Area Z yields a $\overline{C}$ of 6.0, leaving no doubt that the area is a relatively intact natural area with high floristic quality. There is no need to survey Area Z further if one wishes only to know if the area is of natural area quality. There is, however, a likelihood that rare, threatened, or endangered species are present, so additional surveys might be warranted.

Table 1. Comparison of $\overline{C}$ values for three different areas, X, Y, Z. Each native species is preceded by its *C* value. Adventive species are not included in the analysis.

Area X		Area Y		Area Z	
0	Acalypha rhomboidea	0	Acalypha rhomboidea		Achillea millefolium
	Achillea millefolium		Achillea millefolium	5	Andropogon gerardii
	Agrostis alba	5	Andropogon gerardii	5	Andropogon scoparius
0	Aster pilosus	5	Aster ericoides	9	Aster laevis
1	Cornus racemosa	0	Aster pilosus	10	Carex bicknellii
	Daucus carota	8	Baptisia leucantha	9	Hypoxis hirsutus
2	Helianthus grosseserratus		Cirsium arvense	0	Oenothera biennis
0	Lepidium virginicum	2	Helianthus grosseserratus	8	Parthenium integrifolium
0	Oenothera biennis	4	Juncus dudleyi	9	Petalostemum purpureum
	Poa pratensis	0	Oenothera biennis	3	Physalis heterophylla
5	Silphium laciniatum	5	Panicum virgatum		Poa pratensis
1	Solidago canadensis	8	Parthenium integrifolium	5	Rosa carolina
4	Solidago graminifolia		Poa pratensis	6	Salix humilis
4	Solidago rigida	5	Silphium integrifolium	5	Silphium laciniatum
3	Teucrium canadense	1	Solidago canadensis	1	Solidago canadensis
	Trifolium repens	4	Solidago rigida	5	Sorghastrum nutans
0	Veronica peregrina	5	Sorghastrum nutans	10	Sporobolus heterolepis
$\overline{C}$ = 20/12 = 1.7		$\overline{C}$ = 52/14 = 3.7		$\overline{C}$ = 90/15 = 6.0	

Comparisons Among Different Sites

What is not clear from the $\overline{C}$ is the relative importance of each area from a conservation priority standpoint. If areas Y and Z each are inhabited by about 100 native species, then *FQI* = 37 for Area Y and 60 for Area Z. Clearly Area Z would stand in comparison as the higher-quality remnant. If, on the other hand, Area Y was a very large but degraded site with many conservative species growing in diffuse and scattered populations, then the conservation priorities between the two areas could be less decisive.

If this were the case, and Area Y provided the habitat for 250 native species with a $\overline{C}$ of 3.7, then the *FQI* would be 59. Such a condition could make it a conservation priority of comparable value with Area Z, especially if the latter area was a small, isolated fragment with only 100 species. Conservation biologists, evaluating the preservation status of Area Y, may be unimpressed by a diffuse density exhibited by the native species and a too obvious inhabitance by weeds, but would be ill advised to dismiss it as unworthy of conservation attention. Such areas, with regular fire management, for example, have been known to develop into impressive, high-quality remnant systems, their historical abuses scarcely evident.

By the same token, the biological integrity evident in Area Z, however small and comparatively depauperate in native plants, is so high and evidently so complex that to foreclose a preservation priority on its behalf would be to eliminate an utterly singular remnant of the earth's living surface. Unfortunately, an ecological postulate that is too popular today is that such areas, while acknowledged as "unique," are "too small to be viable." Yet, areas such as Area Z are remnants that are so obviously complex in their biotic and abiotic interactions as to warrant their destruction not only unmitigable but unconscionable. With 100 species at a $\overline{C}$ of 6, the implications about the presence and manifest viability of conservative insects, spiders, fungi, mycorrhizae, and soil organisms are compelling. No other group of organisms has the collective genetic memory representing the distillation of thousands of generations of adaptation and selection pressures for the vicissitudes of site, process, and environment at this particular locus on the planet. In actuality, remnant areas with *FQI* approaching 60 or higher are very rare, and occupy a minute fraction of the remaining vegetated land surface of the region. The concentration of local genetic diversity in such areas will one day provide the germ material for restorationists who look toward attempting to reclaim and revitalize our depleted and battered landscapes.

Long-Term Monitoring of Natural Quality

Managers of remnant landscapes contend with the problems of rehabilitating degraded areas or maintaining relatively intact areas. The questions most commonly asked are:

> What is the overall floristic quality of the site?
>
> Is floristic quality distributed more or less evenly throughout the site, or are there areas which are more degraded than others?
>
> To what extent is management, such as controlled burning, cutting brush, weeding, or passive neglect affecting floristic quality?

An answer to the first question can be obtained by conducting intensive inventories, usually involving several surveys over one or two growing seasons. The result is a fairly complete census of the universe of species extant in the area; $\overline{C}$ and *FQI* values can be calculated to determine the level of resident floristic quality. Monitoring could consist simply of repeating these inventories at a regular interval to verify whether or not the qualitative values are being sustained. Unless the site is very small, it may be practical to divide it into several smaller units, perhaps along plant community lines if such can be determined, each of which can be inventoried more thoroughly. If a thorough inventory reveals an area to have a $\overline{C}$ value of 4.5 and an *FQI* of 45, assuming proper stewardship, one could expect that these values would remain essentially constant over time.

An answer to the second question is a little more involved. Generally, sampling transects are established in the area of concern, each transect consisting of a series of small quadrats, usually from 0.25 m^2 to 1 meter square. An inventory of the plants in each quadrat is taken, from which the$\overline{C}$ and *FQI* are calculated.[6] If the quadrats are laid out at regular or known intervals, the floristic quality values for each quadrat can be plotted on a graph, with quadrat numbers on the X-axis and either $\overline{C}$ or *FQI* on the Y-axis. In large remnants, where degraded areas are intercalated among high quality areas, the degradation can be illustrated graphically, and related to known or supposed disturbance histories. It is often helpful to plot the values after having averaged them sequentially. For example, the value plotted for quadrat 1 is obtained by deriving the mean of quadrats 1 and 2, the value plotted for quadrat 2 is the mean of quadrats 1-3, the quadrat 3 value is the mean of 2-4, and so forth. This smoothes out the "noise" in the sampling, making it easier to see essential qualitative differences along the various segments of the transect.

In order to determine the extent to which management is having an effect, negative or positive, on the floristic quality of a site, two different analyses can be used. One analysis involves repeated floristic inventories taken at annual or periodic intervals. A second type of analysis employs the establishment of transects through representative portions of a site and repeated on a regular basis. Many unmanaged remnant areas often are dominated by a few of the more conservative resident taxa, and the early results of management--controlled burning, brush-clearing, etc., can increase the presence of other species in the system, conservative and non-conservative. For either type of analysis this is often registered by a drop of 0.1 or 0.2 in the $\overline{C}$, which may be offset by an increase in *FQI* due to an increase in the total number of native species. If, after 5 years or so of management, however, the $\overline{C}$ begins to register another decrease by 0.2 or 0.3, the manager should be alert to the fact that current stewardship of the site may be having detrimental effects. If the management is efficacious, the $\overline{C}$ either stabilizes or gradually obtains its original value, almost always with a concomitant increase in the *FQI*.

In the assessment of the data gathered in monitoring transects, quality can be looked at two different ways. First, the overall floristic quality can be determined through an analysis of all the species which appeared in the quadrats along the transect. The index and mean conservatism of the total transect flora are designated respectively as FQI_t and $\overline{C}_t$. Second, the floristic quality of individual quadrats along the transect can be determined based upon the $\overline{C}$ and *FQI* values from each quadrat. The $\overline{C}$ of each quadrat is viewed as a derived coefficient of conservatism (*C*) for that point and expressed as C_q; similarly, the floristic quality index for each quadrat is expressed as FQI_q. The quadrat values are averaged across the transect and are expressed as $\overline{C}_q$ and $\overline{FQI}_q$. These values can then be compared at regular time intervals, such as each year or every several years, depending upon the intensity of the monitoring. Analysis of variance, or

[6] Commonly, each species in a quadrat inventory is assigned either a Braun-Blanquet cover-abundance coefficient, usually 1-5, or a percent cover value, so that importance values can be calculated for each of the species present.

even a calculation of the standard deviation among the quadrat values, can be used as a metric to determine how variable the quality is across the transect; variability can also be compared over time to determine the extent to which quality is equilibrating across the site.

Another useful metric is the ratio of the $\overline{C}_q$ and $\overline{C}_t$ values obtained from transect analysis. If $\overline{C}_q$ is notably lower than $\overline{C}_t$, it indicates that conservative species are under-represented in any given unit area within the system. In this case, if $\overline{C}_t$ is 4.0 or more, there is the potential for conservative species to coalesce into a higher quality system. In some high-quality systems with a prevalence of conservative species $\overline{C}_q$ may exceed $\overline{C}_t$, indicating that non-conservative plants, though present, are not as prevalent in the system.

Experience has shown that, even with management, both $\overline{C}_q$ and $\overline{C}_t$ are very often slow to change, although the $\overline{FQI}_q$ and FQI_t can rise substantially for the first five or ten years as additional species, whose presence previously had been depressed or unnoted, are observed in the area. The $\overline{C}$ values are evidently fundamental measurements of site quality. Once a site has been degraded to register, for example, a $\overline{C}_t$ of 3.0, there is little evidence that modern management techniques can move it more than a few tenths of a point, unless there is a substantial and successful attempt to create a habitat which will retain reintroduced conservative species.

There is an often-expressed belief among some ecologists that damaged ecosystems, if merely left alone long enough, can "recover" through "natural succession." Those who make this claim seem to rely on the idea that so long as the "structure" of a system is present, the "system" is present, or perhaps base the claim on the belief that all of the original genetic components of the system are still "around," and need only to be "dispersed," back to the site. We have seen little hard evidence that this is the case in the contemporary landscape. Rather, it seems that our remnant natural areas are less like the segments of worms, and more like the nerves of human beings--once they are severely damaged they rarely grow back. If too much nervous tissue is damaged, the corporal structure degrades catastrophically; once too many conservative species have been eroded, or scraped away, or dissipated through fire suppression, or diminished by other changes in ecological processes, the natural area degrades irretrievably to a much more simplified system, very often one which cannot reproduce itself. In the final analysis, our native systems are defined substantially by their conservative biota. There is more to a woodland than trees, and to a prairie than grasses. Nature does not seem to be obedient either to the learned theories and elaborate models of the day or to the wishful thinking of well-meaning land managers.

Monitoring Habitat Restoration

The monitoring of a newly vegetated restoration area can be accomplished in the same manner as described for natural area monitoring. A baseline suite of transects or a quadrat matrix is laid out in the restoration area, then repeated on a regular basis. One of the most common types of restoration today is wetland creation attempted as a mitigation effort mandated by various resource agencies. In well designed and implemented projects, the $\overline{C}_q$ and FQI_q values rise relatively steadily and begin to stabilize after 4 or 5 years. By the end of the first complete growing season it is not uncommon to have $\overline{C}$ values of 1 or less and *FQI* values of 4 or 5. After 5 years one can expect $\overline{C}$ values between 3.0 and 3.7, with *FQI* values ranging from 25 to 35. Only rarely, and under special circumstances, have higher values been recorded.

One of the reasons it is so difficult to achieve values which are equivalent to those measured in natural wetlands is that we have been unable to develop a habitat context so well conceived and established as to recruit and sustain the growth of a diverse cohort of conservative species. A critical factor is that most contemporary wetland mitigation efforts involve a substantial percentage of surface water in their hydrologic schemes, and most of our presettlement wetlands and their component species were adapted either to minerotrophic groundwater or ombrotrophic surface water.

SUMMARY

Based upon 15 years of application of this assessment system to all types of land in the Chicago region, certain patterns have emerged. We have found that the $\overline{C}$ values in the preponderance of our open land range from 0 to 2. In light of the fact that 89% of our native flora has a C value of 4 or greater, and has a $\overline{C}$ value of 7.3, it is evident that the principal elements of our native systems are virtually uninvolved in the Chicago region landscape today.

The vast majority of land in the region registers *FQI* values less than 20 and essentially has no significance from a natural area perspective. Areas with *FQI* values higher than 35 possess sufficient conservatism and richness to be of profound importance from a regional perspective. Areas registering in the 50's and higher are extremely rare and of paramount importance; they represent less than 0.5% of the land area in the Chicago region.

Once a framework of coefficients of conservatism is established for an area, the system provides a dispassionate, cost-effective, and repeatable methodology. Anyone with a reasonable field knowledge of vascular plants, now or a hundred years from now, can apply these techniques and obtain comparable evaluations. The application of this method to the monitoring of natural areas is especially appealing. Clearly, a chronic decline in floristic quality index values over a period of years would indicate a dissipation of natural area quality and the need to modify management protocols. On the other hand, stable or steadily increasing values indicate that current management is optimizing the synecological potential of the site.

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