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FLORISTIC QUALITY ASSESSMENT ALONG AN OLD-FIELD CHRONOSEQUENCE

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ABSTRACT. Floristic Quality Assessment (FQA), a protocol for quantifying plant community quality relative to one that retains remnant natural condition, has been successfully applied to a suite of natural community types and ecological restoration projects. This study, performed in east central Indiana, examined floristic quality in a natural old-field succession chronosequence. Sites ranged in age from 1 to 50 years. Differences in species richness, mean conservatism, and floristic quality index were assessed at both transect and quadrat level. As hypothesized, richness of non-native species decreased while all other metrics increased with post-disturbance time. The mean conservatism for native species (at both transect and quadrat level) was ca. 2–3 for sites over 30 years of age. Floristic quality index for native species ranged from ca. 9–15 (transect level) and 4–7 (quadrat level). Given FQA expectations in the literature, 50 years of old-field succession was insufficient for mean conservatism or the floristic quality index to even reach levels associated with a degraded remnant natural community.

Keywords: Floristic Quality Assessment, old-field, ecological succession, mean C, FQI, vegetation monitoring

Floristic Quality Assessment (FQA), developed by Swink & Wilhem (1994), is a protocol used for quantifying the ecological condition of plant communities, i.e., the degree to which a community retains the species composition and richness characteristic of the pre-European settlement landscape. Uses for FQA include identifying areas of high natural value (Young 1994), monitoring change of remnant natural communities (Bacone et al. 2007), and monitoring habitat restorations (McIndoe et al. 2008).

In order to implement FQA, each species known to occur in a regional flora must be assigned a coefficient of conservatism or C value (Swink & Wilhelm 1994; Rothrock 2004). Conservatism is the likelihood that an individual species comes from a habitat with little modification by human activity from pre-European settlement condition. A species with a high fidelity to undisturbed presettlement conditions is assigned the maximum ranking of ten. A species that tolerates much disturbance and may, in fact, thrive under human disturbance would be ranked at zero. Conservatism values should be calibrated by state or region and are available for Indiana (Rothrock 2004), the location of this study.

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Based upon the species present within a habitat, several basic metrics may be calculated, namely mean C (MC) and floristic quality index (FQI). Typically MC ranges from 3.5–5 or higher in sites that retain remnant natural quality (Swink & Wilhelm 1994; Rothrock 2004). FQI is a function of MC and species richness. As a result, its interpretation is dependent upon size of area being evaluated and habitat diversity at a site. Small, high quality remnant communities are likely to have FQI of 30 or higher, while a large site with a mosaic of communities may have an FQI of over 60 (Rothrock & Homoya 2005).

In most studies FQA has proven efficacious in assessing plant community quality relative to gradients of human impact. FQA has been applied to wetlands (Fennessy et al. 1998; Lopez & Fennessy 2002; Mushet et al. 2002; Matthews 2003; Herman 2005), woodlands (Francis et al. 2000), grasslands (Bowles & Jones 2006; Jog et al. 2006), and lakes (Alix & Scribailo 2006; Bourdaghs et al. 2006). In dry tallgrass prairie, FQA responded to a disturbance gradient but with less sensitivity than alternative metrics (Bowles & Jones 2006). In some studies the concepts implicit to FQA have been supported but modifications to the standard FQA protocol have been recommended (e.g., Alix & Scribailo 2006; Bourdaghs et al. 2006). Since its development for Indiana, the regionalized database of C values has been tested for nature preserve checklists (Rothrock & Homoya 2005) and with a longitudinal dataset from a tallgrass prairie restoration (McIndoe et al. 2008). Additional examples validating the performance of FQA both in Indiana and elsewhere are needed.

The 145-acre (59-hectare) Taylor University Arboretum in east central Indiana affords an excellent opportunity to apply FQA protocol to a series of sites in stages of old-field succession ranging from 1 year to approximately 50 years. Details of ecological succession vary from one geographic region to the next due to individualistic life histories of species in varying climates and competitive environments (Walker & Chapin 1987). Nonetheless, a general pattern emerges (Keever 1983; Vankat & Snyder 1991). In the Midwestern region, one finds that annual and biennial species (e.g., *Ambrosia artemisiifolia, Setaria* spp. and *Erigeron annuus*) dominate during the first two years after release from cultivation, perennials (e.g., *Symphyotrichum pilosum* and *Solidago altissima*) by year five, and woody plants (e.g., *Rubus* spp., *Rosa* spp., *Fraxinus americana,* and *Prunus serotina*) after several decades. Given the concept of conservatism and the expected sequence of plant species, we hypothesize that FQA metrics, MC and FQI, will increase with years since cultivation. The results of this study will also provide performance expectations for FQA metrics that can serve as benchmarks for other monitoring studies.

METHODS

Study sites.—The study sites were located west of the central Taylor University campus in Upland, Grant County, Indiana (T23N, R9E, Sec. 9; N40° 27.5′ W85° 30.7′; Fig. 1). Plots of 1–5 years post-disturbance were created by spring rototilling to a depth of ca. 12 cm of an area immediately west of the Randall Environmental Center over a 5-year cycle. In 1980 two fields, approximately 20 acres (8 hectares) in size, were allowed to go fallow after a history of cultivation in row crops, rotating among corn, soybeans, and winter wheat. The north field experienced natural recovery over a 27-year period, when the sampling was performed for this study. A portion of the south field experienced a single deep tilling in 1990 followed by 17 years of natural recovery before sampling. Two additional sites (located in the Arboretum Addition) were chosen. These support an abundance of woody species characteristic of early successional stages. The species include *Carya ovata, Cornus drummondii, Crataegus mollis, Fraxinus americana, Prunus serotina, Elaeagnus umbellata,* and *Rosa multiflora.* Based upon estimated counts of annual growth rings from selected woody species, the ranges of post-disturbance age were estimated at 35–40 years for one site and 50 years for the second.

Sampling and data analysis.—Sampling for species and aerial cover was performed during June 2006 (old field plots) and 2007 (woody plots). Transects consisted of 20 quadrats. Herbaceous species were sampled with 0.25 m^2 quadrats at 5 m intervals. Woody plants (shrubs above 1.5 m and trees greater than 2.5 cm dbh) were sampled from contiguous 5×5 m quadrats. A total of 21 transects were sampled: 1 for each of the first five year plots; 2 for the 17-year site; 10 for the 27-year sites; 3 for the 35–40-year site; and 2 for the 50-year site. The year-4 transect was deleted since its proximity to a prairie planting added atypical species into the old-field succession sequence. Ten transects were sampled in the 27-years sites since site size allowed an assessment of variation due to factors such as proximity to potential seed sources. Nomenclature and coefficients of conservatism follow Rothrock (2004). Data analysis was performed using *Floristic Quality Assessment Computer Programs*, Version 1.0 (Wilhelm & Masters 2000). The program generates the following metrics: species richness, MC, and FQI. These are computed with and without non-native species and at both transect as well as quadrat levels. For transect level metrics, MC and related metrics are based upon the roster of species observed along the entire transect. For quadrat level analyses, metrics are first calculated for each quadrat independently, then averaged. Thus, in quadrat level analysis, but not in transect level analysis, species frequency is important. Linear regression analyses were performed in Excel®.

RESULTS

Community descriptions.—The pattern of community change and the species encountered across the 50-year chronosequence were as expected. During Years 1–3 of the chronosequence the

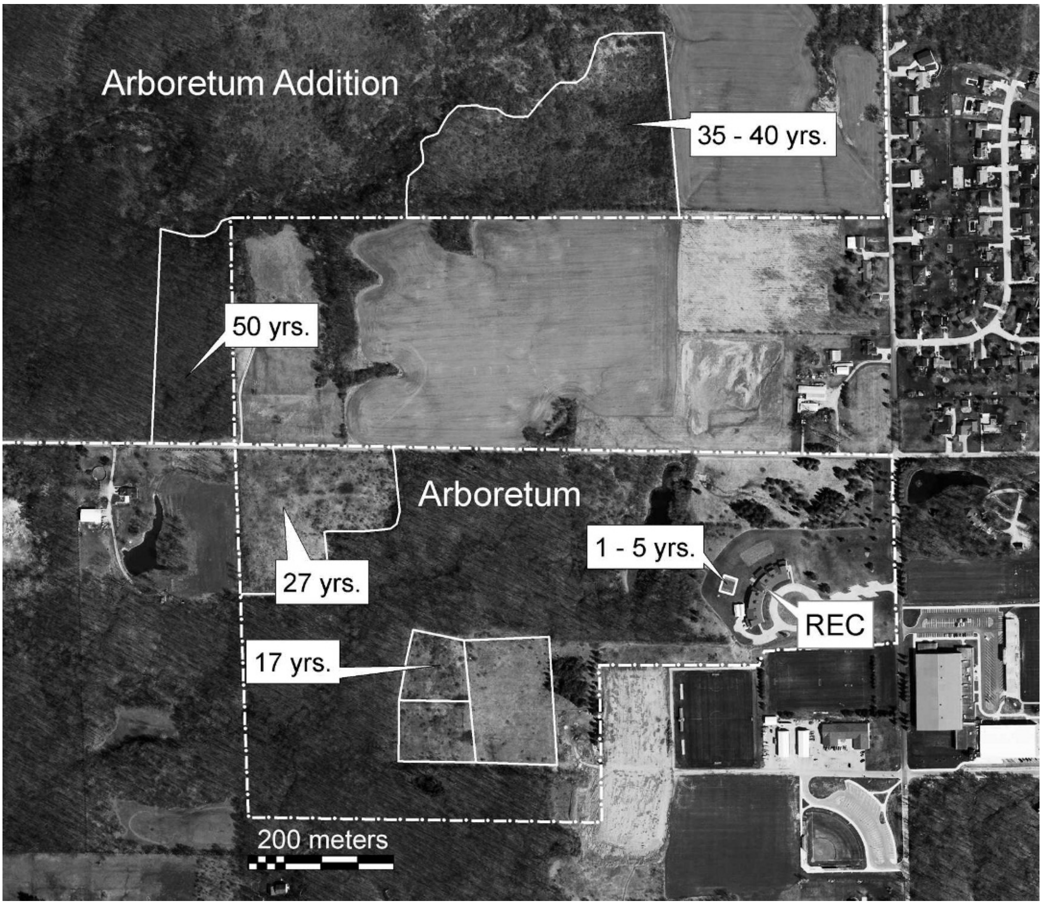
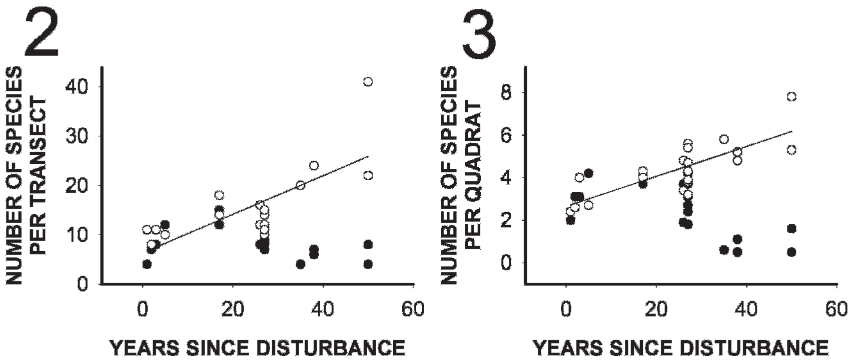


Figure 1.—Aerial photograph of Taylor University Arboretum study area. REC = Randall Environmental Center situated on the west-edge of campus and east side of the Arboretum. The 2006 Arboretum Addition is north and west of the original Arboretum. Years indicates estimated lapse between fallow and sampling.

dominant plant species included the annuals *Setaria faberi, Ambrosia artemisiifolia* and biennials *Daucus carota* and *Dipsacus fullonum*. The perennials *Symphyotrichum pilosum* and *Melilotus officinale* were among the dominant species by Years 2–3. By the fifth year, annual species were replaced by perennials, especially *Poa pratensis, Solidago altissima,* and *S. pilosum.* Transects in the 17-year old-field remain dominated by *Solidago*. Woody species also were present, but none were among the dominant species. By Year 27, some woody species – *Rubus occidentalis* and *Toxicodendron radicans* – were locally dominant. Sites 35–40 years of age displayed high cover by *Crataegus* spp. and, in one transect, *Ulmus americana.* The oldest site, an estimated 50 years post-disturbance, had developing canopies of either *Carya ovata* or a mix of *Fraxinus americana* and *Prunus serotina*. In the oldest site the common woodland species *Sanicula odorata* and *Parthenocissus quinquefolia* were among ground layer dominants and the common old-field perennial *Solidago altissima* was almost completely absent. Across the chronosequence we observed an increase in the number of native species both per transect (Fig. 2) and per quadrat (Fig. 3). Initially, non-native species were as numerous as native species (Figs. 2,3) but after about 20 years of old-field succession, the numbers of these non-shade tolerant species declined.

Changes in mean C and FQI.—MC at both the transect and the quadrat level increased across the chronosequence (Figs. 4,5; $r^2 = 0.68$–0.78, $P < 0.0001$). During the first five years, transect MC ranged between 0.8–1.3 for native species (Fig. 4). After 35 years this same metric



Figures 2,3.—Changes in number of species during 50 years of old-field succession. 2. Species per transect: open circles = native species, closed circles = non-native species; regression line for native species has $r = 0.74$ ($P = 0.0001$). 3. Average number of species per quadrat: open circles = native species, closed circles = non-native species; regression line for native species has $r = 0.78$ ($P < 0.0001$).

had increased to 2.3–3.1. When non-native species were included in the calculation, MC along the chronosequence was lowered on average by 0.6 units. At the quadrat level, the trends were similar (Fig. 5). MC during the first five years was low, 0.3–0.8, and increased to 1.3–3.0 after 35 year. Inclusion of non-native species lowered the MC an average of 0.4 units.

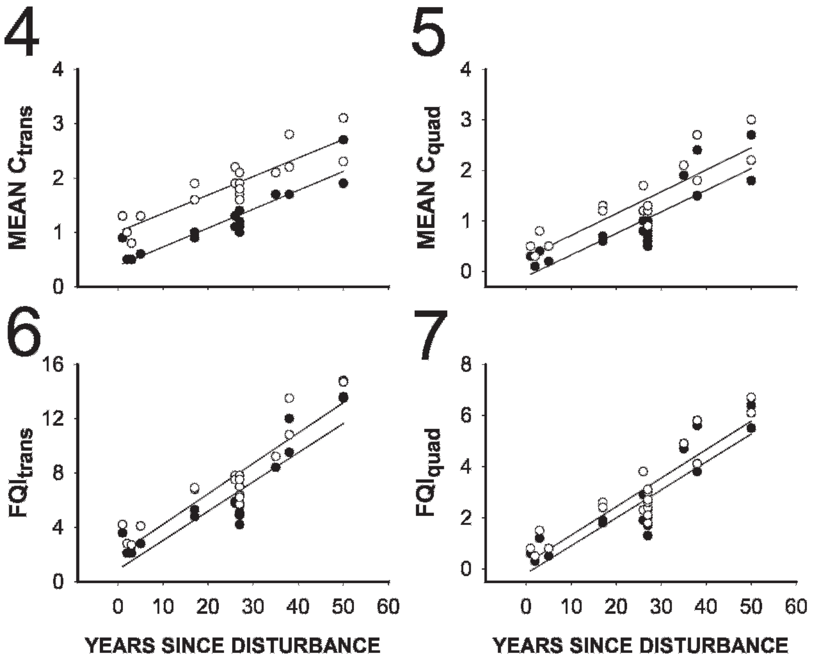
Since MC and native species richness both increased across the successional chronosequence, FQI also increased (Figs. 6,7; $r^2 = 0.75–0.81$, $P < 0.0001$). At the transect level (Fig. 6), sites five years or younger had an FQI for native species that ranged from 2.7–4.2. After 35 years this increased to 9.2–14.8. The inclusion of non-native species in the metric lowered transect FQI values along the chronosequence by approximately 1.5 units. Quadrat FQI values (Fig. 7) were approximately 0.5–1.5 during early succession and increased to 3.8 and above after 35 years.

DISCUSSION

The old-field chronosequence in the Taylor University Arboretum exhibited a pattern of species change similar to that previously reported for the Midwestern U.S. region (Quarterman 1957; Hopkins & Wilson 1974; Hoyle et al. 1979; Vankat & Snyder 1991). The earliest successional species were common ruderal annuals (especially non-native species) followed by perennials, *Solidago altissima* and *Symphyotrichum pilosum*. All had C values of 0–1 (Rothrock 2004). After several decades, dominant species were still those with very low C values (C = 0–1). Less frequent species contributed to the slow rise in MC. These included perennials such as *Fragaria virginiana*, *Parthenocissus quinquefolia*, *Carex cephalophora*, and *Vitis vulpina* (C = 2–3) and a few species with C = 4 (Table 1). Woody species (e.g., *Fraxinus americana* and *Carya ovata*) and several woodland perennials (including *Galium circaezans* and *Packera obovatus*) with C values as high as 7 were observed in the oldest sites (Table 1). As the time since disturbance increased, the number of native species also increased; this further contributed to the increases observed in FQI over time.

Our results indicate a strong relationship between MC or FQI and time since disturbance. Swink & Wilhelm (1994) have suggested that transect MC = 3.5 or higher signifies that a site possesses some remnant natural quality. The highest MC observed in the Taylor University Arboretum successional sites was 3.1, clearly below this threshold. However, given the linear regression trend in our study, we would estimate that the 3.5 threshold potentially could be reached over a period of 70–90 years post-disturbance.

The rate of change of MC and FQI can be influenced by availability of seed rain and post-disturbance management. For example, within our 27-year transects the lowest FQI value was recorded for a transect furthest from woodland seed sources. We also observed that an area of the TU Arboretum planted with *Poa pratensis* shortly after fallowing has had low rates of perennial and woody invasion after 27 years. Here quadrat MC and FQI do not exceed a meager 0.6 (unpublished data). In contrast, in a study of the floristic quality of a prairie restoration where a species-rich seed mix was



Figures 4–7.—Changes in mean C and FQI during 50 years of old-field succession; open circles = native species, closed circles = total species (native + non-native). 4. Mean C per transect: both regression lines have $r = 0.87$ ($P < 0.0001$). 5. Average mean C per quadrat: regression lines have $r = 0.84$ for native species and 0.86 for total species ($P < 0.0001$). 6. FQI per transect: regression lines have $r = 0.88$–0.90 ($P < 0.0001$). 7. Average FQI per quadrat: regression lines have $r = 0.87$–0.89 ($P < 0.0001$).

Table 1.—Species with C value of 4 or higher and years when present in transect sample.

Species	Years when present	C value
None in years 1–5		
Acer saccharum	17–50	4
Crataegus crus-galli	17–50	4
Liparis loeselii	17	4
Galium triflorum	27–50	5
Ophioglossum vulgatum	27	4
Lactuca floridana	35–50	5
Carex amphibola	38	8
Carex radiata	38	4
Rubus occidentalis	38	4
Smilax lasioneuron	38	4
Fraxinum americana	38–50	4
Leersia virginica	38–50	4
Asimina triloba	50	6
Carya ovata	50	4
Galium circaezans	50	7
Packera obovata	50	7
Prunus serotina	50	4
Ranunculus recurvatus	50	5
Symphyotrichum shortii	50	6

sown, McIndoe et al. (2008) reported MC and FQI values for a prairie restoration whose floristic quality after 6 years were comparable to our old-field after 35 or more years.

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